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Effects of stocking density and application of chicken manure and cowdung on the growth of Goldfish (*Carassius auratus*) post-larvae

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ABSTRACT

Determination of low cost feeds and optimum stocking density for semi-intensive goldfish rearing systems is vital for profit maximization. The effects of different ratios of chicken manure and cowdung or stocking density (SD), on the growth and survival of goldfish (*Carassius auratus*) post-larvae were studied during Day 0 to Day 21 period. In Experiment 1, each of the four treatments: T_1= Control (*Artemia*); T_2 = chicken manure and cowdung (1:1); T_3= chicken manure and cowdung (3:1); and T_4= chicken manure were triplicated in outdoor cement tanks (1 m^2). Liveweight, Total Length, Growth Rate, Specific Growth Rate and Condition Factor were determined by taking random samples of post-larvae (PL) from each replicate on Day 6, 11, 16 and 21. Growth of PL was significantly higher ($p<0.05$) in T_2 and the control (T_1). Organic manure was found to be more profitable than *Artemia* due to the high cost. In experiment II, PL were stocked at five different stocking densities 150, 350, 500, 650 and 800 /m^2 Growth and survival were found to be significantly higher ($p<0.05$) in 150 PL/m^2. Results indicated that SD had a negative effect on the growth and survival of goldfish PL. This study could be an advantage in planning profit-maximizing farming strategies for goldfish PL

Keywords: Goldfish, post-larvae, stocking density, culture, survival, chicken manure

INTRODUCTION

The fisheries sector has a tremendous potential to make a significant positive impact on the economic growth of Sri Lanka. Ornamental fish industry has attracted attention because of its aesthetic value as well as economic potential. Ornamental fish culture in Sri Lanka is a rapidly developing industry with a promising future and it could highly contribute to the national economy and provide job opportunities for the rural poor. Sri Lanka has both the suitable climate and water resources required for successful production of many species of fresh water ornamental fish. Availability of labour at a low cost is a great asset for expansion of the industry in rural areas. Thus, there is a vast potential to expand this industry by developing new technology.

Goldfish (*Carassius auratus*) is one of the most popular cultured fresh water ornamental fish in Sri Lanka. Of all the ornamental fishes exported, over 80% by weight are fresh water species and around 90% of them are cultured (Mee, 1993). Among cultured species, goldfish (*Carassius auratus*) is one of the most valuable (Mee, 1993). Goldfish larvae are grown under intensive conditions while other stages are

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cultured under semi-intensive systems. When reared under intensive systems, goldfish farmers generate low profits due to the use of costly feeds such as *Artemia* and formulated feeds. Therefore, determination of low cost culture methods with higher growth and survival has become mandatory.

The recycling of organic animal wastes for fish culture serves the duel purpose of cleaning the environment and providing economic benefits to the farmers. The recycling of animal dung or wastes in fish ponds for natural fish production is important for sustainable aquaculture and to reduce expenditure on costly feeds and inorganic fertilizer which form additional 50% of the total input cost for fish production (Dhawan and Kaur, 2002).

Research on the effectiveness of chicken manure and cowdung on fish culture has been performed in many parts of the world. Fang *et al.*, (1986) reported that chicken manure is better than pig manure for the growth of Common Carp, Bighead Carp and Silver Carp. Furthermore, Sumith Kumara *et al.*, (2003) reported that chicken manure is the best fertilizer for goldfish fry culture in outdoor cement tanks compared to cowdung and formulated feed. Therefore, treating outdoor cement tanks with chicken manure and cowdung may result in better performances of goldfish post-larvae than chicken manure or cowdung alone.

Stocking density is one of the essential determining factors in larviculture, affecting growth and survival performances of fish. Lower stocking density contributes to higher production cost under any culture system and hence farmers resort to higher stocking densities. Increasing stocking density has usually been reported to have a negative effect on the feeding and growth of fish (Holm *et al.*, 1990). Work reported on the stocking density of goldfish larviculture under semi-intensive system is scarce. Therefore, objectives of this study were to find out optimum density for highest growth performances and survival of fish in terms of numbers of fish per unit area under semi-intensive systems.

MATERIALS AND METHODS

Experimental facilities and tank preparation

The experimental tanks used in this study were located at the Department of Animal Science, University of Peradeniya, Sri Lanka. Outdoor cement tanks (1 m^2) were covered with bird nets. All tanks were separately aerated. Post-larvae used for the experiments were produced from the goldfish (calico) broodstock maintained at the fish breeding unit of the Department of Animal Science. Broodstock maintenance and breeding of goldfish were done according to Sumith Kumara *et al.*, (2002).

Experimental design

First experiment was designed to determine the effect of different feeding regimes on the growth and survival of goldfish post-larvae. In the second experiment, the effect of stocking density on the growth and survival of goldfish post-larvae was examined.

Experiment 1

In the first experiment, each of the four treatments: T_1 = Control (*Artemia*); T_2 = chicken manure and cowdung (1:1); T_3=chicken manure and cowdung (3:1); and T_4 = chicken manure at 100 g/m^2rate were triplicated. Tanks were kept for two weeks after manuring for plankton growth. Day-old post-larvae at a stocking density of 150 post-larvae/m^2 were introduced to each replicate. *Artemia* (Great salt lakes) were hatched following the method described by Bengaston *et al.*, (1991). *Artemia* was added adlibitum to the control treatment three times per day.

Experiment 2

Selected tanks were fertilized with chicken manure at 100 g/m^2 and kept for two weeks period. After that, day-old goldfish post-larvae were stocked at five densities; 150, 350, 500, 650 and 800 /m^2. Experiment was carried out for 21 days, covering the entire post-larval period. During the experimental period, dead larvae were counted and replaced from a similar culture tank in order to maintain the same stocking density throughout the experiment following the procedure of Baskerville-Bridges and Kling (2000).

Sampling of fish and water quality measurements

At stocking, live weight and total length of - larvae were measured from a random sample. Subsequently, samples from each replicate were obtained by randomly removing 10 post-larvae from each tank. For growth measurements, post-larvae were randomly sampled from each replicate on day 6, 11, 16 and 21. Liveweight (g) and total length (cm) of individual fish were measured. Survival was checked daily by removing the dead post-larvae from each rearing tank. At the end of the experiment, all survived fish were counted and individual live weight and total length were determined.

Ammonia, Dissolved Oxygen, pH, plankton (phytopankton and zooplankton) density and temperature were monitored at four day intervals in each experiment according to Sumith Kumara *et al.*, (2003).

Calculation and analysis of data

Percentage survival, Growth Rate, Specific Growth Rate and Condition Factor were calculated as growth parameters. Percentage survival was calculated using the following formula:

$$\text{Survival \%} = \frac{\text{Number of fish survived during the culture period} \times 100}{\text{Number of fish introduced}}$$

Specific Growth Rate (SGR) and Growth Rate (GR) were calculated according to the formula,

$$SGR = 100(\ln W_1 - \ln W_2)/\Delta t$$
$$GR = 100(W_1 - W_2)/\Delta t$$

Where W_1 and W_2 are Initial and Final Weights of post-larvae (g), and t is time (days).

Condition Factor (CF) was determined by:

$$CF = \frac{W}{L^3} \times 100$$

Where W and L are body weight and body length respectively.

Statistical analysis

A completely randomized design was used for each experiment. Mean Liveweight, Mean Total Length, Mean Growth Rate, Mean Specific Growth Rate, Survival and water quality parameters of fish in the various experiments were tested for significance using the one-way Analysis of Variance (ANOVA). If the Analysis of Variance was shown to be significant, mean separation was carried out using Duncan's New Multiple Range Test ($p<0.05$).

Table 1. Physico-chemical parameters of water in goldfish post-larvae reared in different feeding regimes

Parameter	Treatment1 (Mean± S.E.M)			
	T_1	T_2	T_3	T_4
PH	$7.8^{a} \pm 0.6$	$7.8^{a} \pm 0.2$	$7.9^{a} \pm 0.9$	$7.8^{a} \pm 0.8$
Temperature (^{0}C)	$25^{a} \pm 0.5$	$26^{a} \pm 0.7$	$26^{a} \pm 0.7$	$25^{a} \pm 0.3$
Dissolved Oxygen (mg/l)	$3.5^{a} \pm 0.2$	$4.0^{ab} \pm 0.9$	$4.6^{b} \pm 0.2$	$4.3^{b} \pm 0.1$
Plankton No. x 10^6/l	$0.76^{a} \pm 0.1$	$67^{b} \pm 1.6$	$60.8^{c} \pm 0.9$	$57.1^{d} \pm 1.1$

[1]T_1- *Artemia*, T_2- chicken manure and cow dung (1:1), T_3- chicken manure and cow dung (3:1) T_4 - chicken manure

[A,b,c] Within rows, means not sharing a common superscript are significantly different ($p<0.05$).

RESULTS

Water quality

Experiment 1

Temperature and pH did not show a significant difference ($p>0.05$) among the treatments (Table 1). However, plankton density, DO (Table 1) showed a significant difference ($p<0.05$) between the treatments. Significantly higher ($p<0.05$) plankton (phytoplankton and zooplankton) growth was observed in T_2 treatment than in the other treatments.

Experiment 2

Water temperature did not show a significant difference ($p>0.05$) among the treatments. However, pH value, ammonia level and DO showed a significant difference ($p<0.05$) with different stocking densities (SD) (Table 2). In addition, ammonia concentration showed a positive relationship with the increase in stocking densities. On the other hand, DO content showed a negative relationship with the increase in stocking densities.

Survival and growth parameters

Experiment 1

At the end of experiment, there was a significant difference ($p<0.05$) between % survival, Mean Liveweight, Mean Total Length, SGR, GR and CF of goldfish post-larvae (Table 3). Significantly higher ($p<0.05$) growth rate was observed in the *Artemia* treatment and chicken manure, cow dung (1:1) treatment (Figure 1). Significantly higher ($p<0.05$) survival rates were recorded in Artemia treatment.

Table 2. Physico-chemical parameters (Mean S.E.M) of water in different stocking densities.

Parameter	Treatment1 (Mean S.E.M)				
	150 PL/m^2	350 PL/m^2	500 PL/m^2	650 PL/m^2	800 PL/m2
Temperature (OC)	25± 0.5	25± 0.7	26± 0.7	25± 0.7	24.5± 0.8
pH	7.8 ab± 0.1	7.5 b± 0.0	7.9 ab± 0.1	8.0 ab ±0.1	8.3 a±0.2
Ammonia (mg/l)	0.052b± 0.0	0.056 b±0.0	0.098a±0.0	0.103a±0.0	0.115 a±0.0
Dissolved Oxygen (mg/l)	4.1 a± 0.2	3.8 a±0.2	3.2 b±0.1	3.2 b±0.0	2.8 b±0.1

[a,b] Within rows, means not sharing a common superscript are significantly different ($p<0.05$). PL= post-larvae

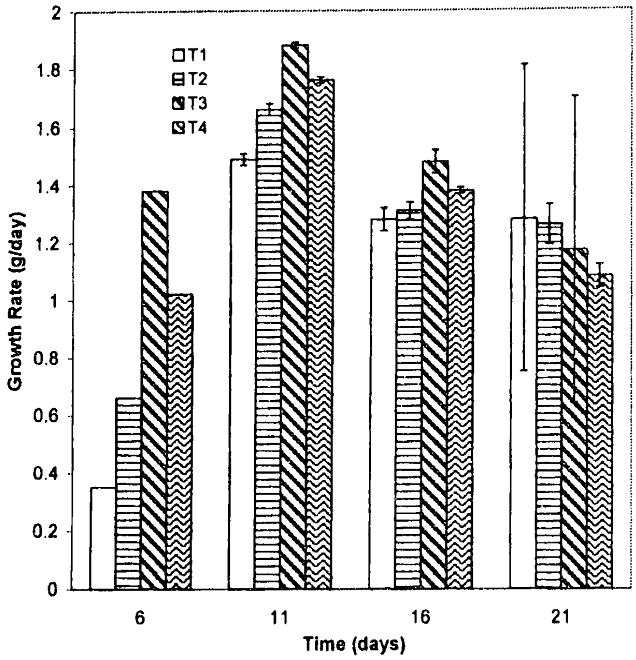

Figure 1. Growth Rate (Mean ± S.E.M) of goldfish post-larvae cultured with different feeding regimes.

T_1 - comtrol *(Artemia)*, T_2 - chicken manure and cowdung 1:1 ratio, T_3 - chicken manure and cowdung 3:1 ratio, T_4 - chicken manure

Experiment II

Mean Liveweight, Mean Total Length, SGR, GR, CF and % survival on Day 21, were found to be significantly different ($p<0.05$) among

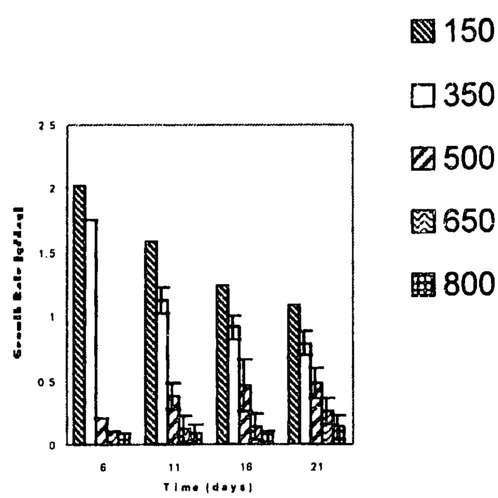

Figure 2. Growth Rate (Mean ± S.E.M) of goldfish post-larvae cultured with different stocking densities.

treatments (Table 4). Significantly higher ($p<0.05$) growth rate of post-larvae was observed with a stocking density of 150/post-larvae/m^2. During the experimental period (up to 21 days), increase in stocking density significantly affected the growth of post-larvae (Figure 2). Significantly higher ($p<0.05$) survival rate was received at the lowest stocking densities (Table 4).

Table 3 Growth performances of goldfish post-larvae cultured with different feeding regimes

Parameter[1]	Treatment[2] (Mean± S.E.M)			
	T1	T2	T3	T4
At harvesting				
MLW (g)	0.27 a±0.0	0.28 a±0.0	0.25 b±0.1	0.23c±0.0
MTL (cm)	3.0 a ± 0.1	2.9 a ± 0.0	2.3 b ± 0.0	2.4 b ± 0.0
SGR (%/day)	26.5 a ± 0.4	26.76 a ± 0.1	26.1 b ± 0.1	25.8 c ± 0.0
GR (g/day)	1.28 a ±0.0	1.26 a ±0.5	1.17 b ±0.1	1.08 c ±0.5
CF	1.05b ±0.1	1.12b ±0.1	2.03 a±0.4	1.64 ab ±0.3
Survival (%)	94.5 a ± 1.1	84 b ± 5.3	83 b ±1.7	84.3 b ± 3.5

[1] MLW- Mean Liveweight, MTL- Mean Total Length, SGR-Specific Growth Rate, GR Growth Rate, CF- Condition Factor.
[2] T_1 - control, T_2 - chicken manure and cowdung in 1:1 ratio, T_3 - chicken manure and cowdung in 3:1 ratio, T_4 chicken manure
[a,b,c] Within rows, means not sharing a common superscript are significantly different ($p<0.05$).

Table 4. Growth performances of goldfish post-larvae cultured under different stocking densities

Parameters	Treatment1 (Mean S.E.M)				
	150 PL/m2	350 PL/m2	500 PL/m2	650 PL/m2	800 PL/m2
At harvesting					
MLW (g)	$0.23^{a} \pm 0.0$	$0.17^{b} \pm 0.0$	$0.10^{c} \pm 0.0$	$0.05^{d} \pm 0.0$	0.03 e ± 0.0
MTL (cm)	$2.4^{a} \pm 0.1$	$2.3^{a} \pm 0.1$	$2.1^{ab} \pm 0.2$	$1.9^{b} \pm 0.1$	1.8 d± 0.1
SGR (%/day)	$28.5^{a} \pm 0.0$	$24.6^{b} \pm 0.2$	$22.1^{c} \pm 0.2$	$18.9^{d} \pm 0.5$	15.7 e± 0.9
GR (g/day)	$1.08^{a} \pm 0.0$	$0.79^{b} \pm 0.0$	$0.47^{c} \pm 0.0$	$0.25^{d} \pm 0.2$	0.13 e ± 0.0
CF	$1.7^{a} \pm 0.3$	$1.4^{ab} \pm 0.2$	$1.13^{bc} \pm 0.1$	$0.83^{cd} \pm 0.15$	0.49 d ± 0.1
Survival (%)	$85.3^{a} \pm 3.7$	$67.3^{b} \pm 1.9$	$52^{c} \pm 4.6$	$37.7^{d} \pm 2.2$	33 d ± 5.1

^{A,b,c} Within rows, means not sharing a common superscript are significantly different ($p<0.05$).

DISCUSSION

In this study the physico-chemical parameters of water in both experiments remained within the favorable range suitable for carp culture (Jhingram, 1991). Significantly higher survival was observed in control (T_1) treatment. Kaiser *et al.* (2003) obtained more than 96 % survival by feeding goldfish post-larvae with Artemia used as only source of feed. However, other treatments also had more than 83 % survival rates. The higher variability of fish survival usually has been found in conjunction with organic fertilizer addition (Fox, 1989). Dissolved Oxygen could be a key factor affecting survival in fertilized ponds. However, in this experiment each replicate was aerated and dissolved oxygen did not affect the survival of post-larvae.

Significantly higher growth of goldfish post-larvae was observed in chicken manure and cowdung ratio in 1:1 (T_2) and control (T_2) treatments ($p<0.05$).Results showed that highest plankton growth as well as post-larval growth were observed in T_2 treatment. Higher plankton growth was associated with higher survival and growth of post-larvae. Cladecera, Rotifer and Copepoda were found to be dominant in treatments having chicken manure and cowdung combination (http: // www . Inasp.org.uk/journals/vol/4abs.htm,2002). Michale (1998), reported that phytoplankton supplies oxygen to the pond water and encourages the growth of zooplankton, which provides excellent food for the goldfish. At the time of first feeding, fish larvae were quite small and may require live natural feeds. Presence of higher density of plankton in manured ponds would have given a better opportunity to ingest live feeds and digest easily, due to the presence of exogenous proteolytic enzymes (Hepher, 1988).

It was evident from the results that the stocking density of goldfish post-larvae significantly affected their survival rates. Water quality in the outdoor system was difficult to maintain at optimum levels and fluctuated throughout the day. Specially, DO content was significantly lower ($p<0.05$) at higher SD such as (500/ post-larvae/m^2), 650 post-larvae/m^2 and 800 post-larvae/m^2 during the early morning. This may be due to higher demand by all biota present. Lower survival rate at higher stocking densities was recorded in tilapia due to lower early morning DO and prolonged duration of low DO levels compared with treatments with lower stocking densities (Yang *et al.*, 1996). Pantino *et al.*, (1986) reported that crowding stress alone can have a significant effect on the physiology of Coho salmon.

Some fish species become aggressive at

low stocking densities and may show less aggression as the density is increased, while others may exhibit increasing levels of cannibalism as density is raised (Stickney, 1994). Usually cannibalism is observed with the increase in stocking densities in koi carps (Van Damme *et al.*, 1989) and African catfish (*Clarius gariepinus*) (Hecht and Appelbaum, 1988).However, cannibalism was not observed in this experiment.

Stocking density had a significant effect on the growth of goldfish post-larvae. Macintoch and De Silva (1984) observed similar results with tilapia larvae at higher stocking densities. In outdoor cement tanks, fish were fed only with natural feed and it may be the limiting factor at higher stocking densities. Increasing stocking density has usually been reported to have a negative effect on feeding and growth of fish (Holm *et al.*, 1990, Bjousson, 1994). Feeding and growth may be influenced by density dependent behavior such as social interactions, the development of hierarchies and establishment of territorial borders (Jobling, 1985). Stress response factor associated with high densities could also be the result of lower efficiency in search of food, fish having more difficulties in moving and reaching the food (Refstic and Kittelsen, 1976). Sharma and Chakrabarti (1999) compared the use of live zooplankton with dry feed at three stocking densities and found that larval *Cyprinous carpio* fed zooplankton at the lowest stocking density had the best growth and survival.

CONCLUSIONS

Chicken manure and cow dung in 1:1 ratio and *Artemia* resulted in significantly higher growth of goldfish post-larvae. In addition, Survival rate was significantly higher in *Artemia* treatment. Organic manure incorporated treatments were found to be more profitable than *Artemia,* due to high cost of feed. Desirable stocking density of goldfish post-larvae for optimum growth and survival in chicken manure fertilized tanks was 150 post-larvae/m^2. The results of this study could be used advantageously to plan profit-maximizing farming strategies for goldfish post-larval culture.

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