Uttar Pradesh J. Zool. 21(3) : 197 - 202, 2001 **ISSN 0256 - 971X**

GROWTH RESPONSES OF FRY OF COMMON CARP AND MOURALA TO DIFFERENT ABSOLUTE SPACE FACTORS

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The influence of absolute space factor on growth performance of common carp (*Cyprinus carpio*) and mourala (*Amblypharyngodon mola*) that differ in their innate growth criterion was examined. Fifteen simulated pond systems that differ in absolute space by 7-fold (1.27, 2.86, 4.50, 6.20 and 9.11m^2) were used for both the test fishes for 90-day grow-out period. The pond fertilization and relative stocking density remained same (10/m^3) for both the species and for all tanks. Examination of average weight in common carp revealed that large and small fishes were skewed towards large and small tanks respectively. The average weight of common carp, at harvest, were significantly higher in largest tank than in the smallest one ($p < 0.05$), whereas spatial growth differences in mourala were not significant ($p > 0.05$). This suggests that the absolute sapace and food in the smallest tank did not act as stressor for mourala growth but clearly limited the growth of common carp. The amplitude of diurnal variations of dissolved oxygen of water acted as stressor in small tank but not in large tanks. It is proposed that large tanks provided not only more space but also provided more food produced as a result of interactions between water area and complex physico-chemical dynamics of water. It is also possible that the dispersion of fish metabolites or shift in metabolite dependent micro-niche caused by free movement of fish in larger tanks was perhaps responsible for enhanced fish growth mediated through better water quality and higher primary production of phytoplankton.

INTRODUCTION

Increase in fish stocking density beyond the limit of a given space often results in competition for food and space and eventually growth inhibition. Same relative density in different sized tanks may have different results on fish growth due to availability of absolute space factor. Stocking density of fish under similar cultural and management practices plays an important role on growth and survival of fish. Several studies have demonstrated the adverse relationship between the stocking density and survival and growth of fish or feed utilization (Anadu & Nwokoye, 1993; Sehgal & Toor, 1995; Inyang & Odo, 1996; Essa, 1996; Esquivel *et al.*, 1997; Kaiser *et al.*, 1997; Ronyai, 1997; Zakes, 1997; Sharma & Chakrabati, 1998; Tidwell *et al.*, 1998). On the contrary, Rowland *et al.* (1995) observed that stocking density did not significantly affect survival rate, daily growth rate, weight of harvest and food conversion ratio of Australian silver perch (*Bidyanus bidyanus* Mitchell).

The concept of space factor has long been recognized since the experimental study demonstrated the apparent growth inhibition of fish within the confines of an aquarium (Meske, 1985). Later, the space factor concept was divided into excretion, flow and intelligence factor (Willer, 1928) as well as differentiated into absolute and a relative space factor (Lechler, 1934). All these factors are eventually included in the space factor complex (Schaeperclaus, 1961).

It was realized later the size of tank is not critical, but the amount of water available is the essential factor for fish growth. von Sengbusch *et al.* (1965) observed surprisingly high growth of common carp from its initial 140 g to 7.5 kg after two years of stocking in a 40 l plastic tank provided with a constant water flow and regular supply of live food. The presence of specific skin excretion that inhibited the growth of fish (Rose & Rose, 1965; Schulze-Wiehenbrauck, 1977) was either diluted or removed by the water flow. This finally leads to development of recirculatory system technology.

Despite some experimental data demonstrating the dependence of growth on space or volume in some temperate fishes in small enclosures or aquria, information is hardly available about effect of absolute space factor on the growth performance of some tropical fishes that differ in their growth criterion resulting in large and small biomass at maturity. It is likely that the growth responses of fast growing species would be more adversely affected by absolute space criterion than the slow growing species when the relative space remained constant for both. The purpose of the present investigation was to examine the absolute space related growth of two tropical fishes that differ in terms of their innate growth criterion.

MATERIALS AND METHODS

Fifteen experimental tanks with absolute space factors that varied by a factor of 7.0 were selected for each species for the present investigation. Five groups of experimental tanks in triplicate, ranging from 1.27 to 9.11 m^2 were used. The water area of the medium size tanks were 2.86, 4.50 and 6.20 m^2; water depth was 70 cm for all the tanks. All the tanks were provided with 10 cm soil base and were filled with dechlorinated ground water (pH 7.2). The tanks were treated with lime @ 250 kg/ha, followed by fortnight alternate application of organic manure (cattle manure @ 10,000 kg/ha) and inorganic fertilizers (ammonium sulphate @ 60 kg/ha, single superphosphate @ 60 kg/ha and muriate of potash @ 10 kg/ha) during the 90-day culture period for both the species.

The selected fishes (common carp, *Cyprinus carpio*; mourala, *Amblypharyngodon mola*) have contrast growth potentials since adult mourala is several orders of magnitude lower than common carp. Two experiments were performed using average initial body weight of 3.0 ± 0.43 g in common carp and 90 ± 12 mg in mourala. Fry of both the fishes were procured from the local fish farm and acclimatized for a week prior to introduction. The total stocking density ranged from 13 to 91 according to absolute space of the culture tank, while the relative stocking density remained fixed at 10 m^2 for per both the species. No supplementary feeding was provided during the culture period.

Samples of water were collected from each tank at regular intervals and were analyzed for routine water quality parameters following the standard methods (APHA, 1989; Wetzel & Likens, 1991). All the fishes were harvested after 90-day culture period and their increments in body lengths and weights were recorded. At the time of harvest, the condition factor of each species of fish was determined according to the method described by Bagenal & Tesch (1978). The fish harvested from each tank were grouped into weight classes depending upon the distribution range for all the tanks. The percentage of occurrence were plotted against the respective weight classes.

The results were subjected to statistical evaluation. One way analysis of variance (ANOVA) was applied to find out the differences due to space factor in a particular species. The level of statistical significance was accepted at $p < 0.05$.

RESULTS

Average body weight and weight frequency distributions : The initial average body weight of common carp was 3.0 ± 0.43 g, grew to 7.0 ± 0.76 g in the smallest tank and to 9.8 ± 0.94 g in the largest one (ANOVA, $p < 0.05$) after 90-day culture period. At harvest, the mean body weight of mourala, on the other side, did not differ significantly (ANOVA, $p > 0.05$), ranging from 3.49 to 3.58 g in different tanks. Differences of net weight gain among the tanks were highly significant in common carp (ANOVA, $p < 0.05$), but not significant in mourala (ANOVA, $p > 0.05$). Further the

the net weight gain was highly correlated with absolute space in common carp ($r = 0.99$; $p < 0.05$), but not in mourala ($p > 0.05$).

The weight frequency distribution of common carp showed that large and small fishes were skewed towards large and small tanks, respectively (Fig. 1). For example, the weight class of 13 - 14 g were predominent in the largest tank, but was conspicuous by their absence from small tanks. On the contrary, small fishes are less common in the former but are common in the latter.

In mourala, the number of fishes in the weight groups between 2.8 - 3.0 g and 4.0 - 4.2 g increased with rise in absolute absolute space till fourth order, but no further rise was observed thereafter. The response of 3.4 and 3.7 g weight groups was, however, opposite. The largest group (4.3 - 4.5 g) was conspicuous by their absence from the lower sized tanks but increased gradually in numbers as the space factor increased (Fig. 1).

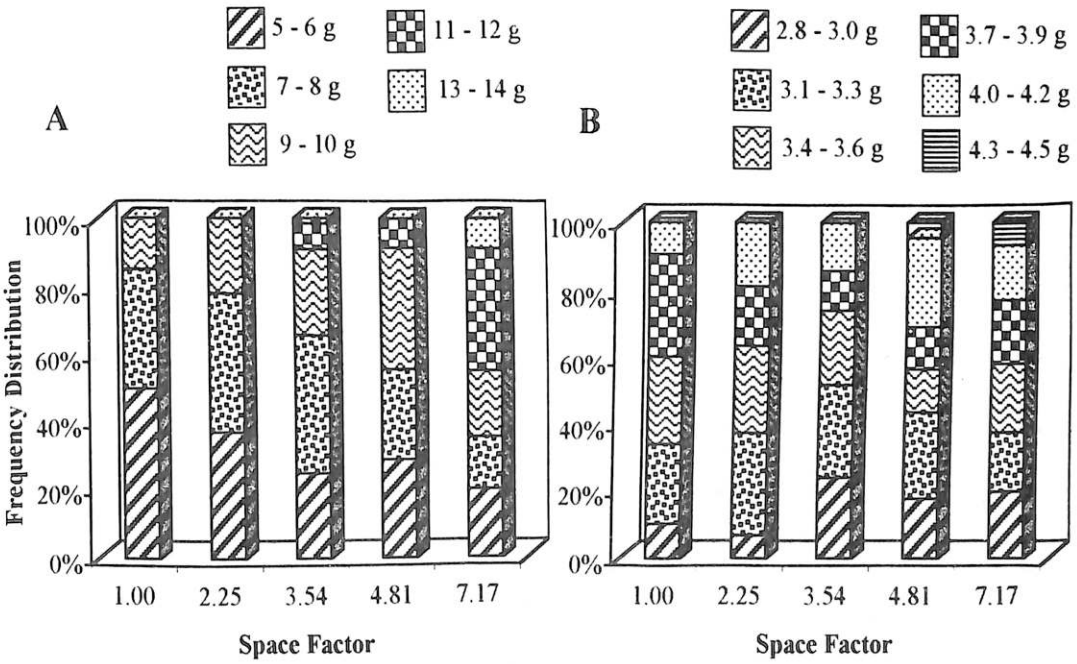

Fig. 1 : Frequency distribution of common carp (**A**) and mourala (**B**) in tanks with different absolute space that varied by a factor of 7.

Growth rate and condition factor : The daily growth of common carp (1.4 times) higher than mourala (0.09 g/day). The growth rate tended to rise as a function of absolute area of the culture tank ($r = 0.95$; $p < 0.05$) in common carp whereas no such relationship was observed in mourala ($p > 0.05$). Estudillo *et al.* (1998) observed that the growth rate of larvae of different species of brackishwater fishes was tank size dependent. Of the two species examined, the specific growth rate in mourala was several orders of magnitude higher than common carp.

The condition factor ranged from 1.70 to 1.90, showing the higher amplitude of variation in common carp than mourala (ANOVA, $p < 0.05$). The condition factor was direct ($r = 0.89$; $p <$

0.05) and inverse ($r = -0.79$; $p < 0.05$) functions of space in common carp and mourala, respectively.

Survival rate, normalized increased biomass and production : The survival rate was higher in common carp (80 - 100%) than mourala (56 - 91%) in different tanks. The rate of survival in common carp was distinctly higher (ANOVA, $p < 0.05$) in large tanks than in small tank which corroborate the study of Estudillo *et al.* (1998). Such differences were, however, not significant in mourala (ANOVA, $p > 0.05$). In common carp, normalized increased biomass (2.36 to 6.58) increased as a function of absolute space (ANOVA, $p < 0.05$). Spatial variations of normalized increased biomass in mourala were, however, not significant (ANOVA, $p > 0.05$).

Production variability was higher (1.65 fold) in common carp than mourala (1.33 fold). The production of common carp in the largest tank was 43 - 65% higher than in smallest tank.

Water quality parameters : Water temperature ranged from 16 to 33^{0}C during the culture period of investigation. Water pH remained within the range for fish culture varying from 7.54 to 8.2. The variability of dissolved oxygen (DO) of water was between 5.0 to 8.2 mg/l and 4.3 to 8.2 mg/l in different tanks of common carp and mourala, respectively. There was a gradual rise in DO content of water as the area of the pond increaded and *vice versa*. The amplitude of diurnal variation of dissolved oxygen of water became less with rise in tank area. Ranging from 0.10 to 0.23 mg/l, ammonium nitrogen tended to decline gradually in concentrations as the space of the tank increased (Table I).

Table I : Range of different physico-chemical and biological parameters during the culture period of test fishes in tanks with different absolute space that varied by a factor of 7.

Parameters	Common carp	Mourala
Temperature (^{0}C)	16.0 - 32.0	18.0 - 33.0
pH	7.7 - 8.2	7.5 - 7.9
Dissolved oxygen (mg/l)	5.0 - 8.2	4.3 - 8.2
Ammonium nitrogen (mg/l)	0.10 - 0.23	0.15 - 0.20
Net primary productivity (mg C/m^3/h)	50 - 150	50 - 112.5

Net primary production of phytoplankton : The spatial variability of both gross and net primary production of phytoplankton was well marked; both the values tended to rise rgradually with increase in absolute space of the culture tank (Table I). As a result, the saptial variability of weight gain of both the species of fishes was highly dependent upon the variability of net primary productivity of phytoplankton ($r = 0.57 - 0.96$; $p < 0.05$).

DISCUSSION

The study demonstrated a contrast absolute space and fish growth relationships between two test fishes that differ in their innate growth criterion. Since growth potential of mourala was lowest than that of common carp, there was no apparent growth inhibition of mourala even in the smallest tank examined because of their relatively less requirement of optimal space and food which were perhaps available even in the smallest tank provided. The situation was, however, different with common carp because of their high requirement of space and food. As primary productivity of phytoplankton increased as direct function of absolute space, it appears that it was not only the space but also the available food in the largest tank was conducive to fish growth and thus exhibiting minimal limiting effect on fish growth. As a result, frequency distribution of large and

small fishes were skewed towards large and small tanks, respectively. The growth increment in common carp was directly proportional to the space factor ($r = 0.94$; $p < 0.05$) but not mourala ($p > 0.05$). It appears that the absolute space and food acted as stressors on growth and survival of common carp in smallest pond, but not in mourala which exhibited almost uniform growth in all tanks. Several studies (Langhans & Schreiter, 1928; Walter, 1931; Mann, 1960) have established that lack of space was responsible for poor growth in some fishes, even though the system was provided with improved filtering system (Meske, 1985). However, growth performance of different species of fishes reared at same density in different sized brackishwater tanks, in a 14-day larval rearing experiment, showed that the survival rate of larvae of all the species (*Chanos chanos*, *Lates calcarifer*, *Siganus guttatus*) was highest in the largest tank (500 l) and lowest in the smallest tank (40 l) but the growth rate was tank size independent (Estudillo *et al.*, 1998).

Because of same relative stocking density of fish maintained in all tanks differing in absolute space, the skin secretion or fish metabolites which influenced considerably in certain cases with small volume of water (Rose & Rose, 1965; Schulze-Wiehenbrauck, 1977), did not cause differential growth responses in the present investigation. The culture system used was static and, thus there was hardly any possiblity of washing away of fish metabolites or any specific skin secretions. Nevertheless, the water quality examined remained well within the limits of carp culture because of use of moderate management protocol including stocking density. The amplitude of diurnal variation of dissolved oxygen was much more pronounced in small tank as compared to larger one resulting in much stress in the former. It is proposed that the large tank provided not only more space but also provided more food produced as a result of interactions between water area and complex physico-chemical dynamics. It is also possible that the dispersion of fish metabolites or shift in metabolite dependent micro-niche caused by free movement of fish in larger tanks was perhaps responsible for enhanced fish growth mediated through better water quality and high primary production of phytoplankton.

ACKNOWLEDGEMENTS

The author is thankful to Prof. B.B. Jana for his help in going through the manuscript and for offering useful suggestions. Thanks are also due to Dr. G. Sarkar for making valuable comments on the manuscript.

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