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Effect of artificial aeration on the growth and survival of Indian major carps

M M VIJAYAN and T J VARGHESE
University of Agricultural Sciences, College of Fisheries, Mangalore 575 002, India
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Abstract. An experiment was conducted to study the effect of artificial aeration on the growth and survival of *Catla catla* (Ham.), *Labeo rohita* (Ham.) and *Cirrhinus mrigala* (Ham.). Aeration was effected by means of an air-lift system, which sucks water from the bottom and splashes the oxygenated water at the surface, thus facilitating circulation and aeration. All the 3 species of fish recorded slightly better growth in aerated cisterns when compared to the controls. However, the difference observed was marginal and statistically not significant due to the shorter duration of the experiment. Rohu and mrigal exhibited higher survival in aerated cisterns, while catla did not show much variation between the two sets. The overall computed fish production and the average rate of survival were significantly higher in the aerated cisterns when compared to the control.

Keywords. Aeration; air-lift system; *Catla catla*; *Labeo rohita*; *Cirrhinus mrigala*.

1. Introduction

Dissolved oxygen is the most critical factor in intensive fish culture and it significantly affects the production of fish. Application of huge amounts of fertilisers and fish feeds in heavily stocked fish ponds upsets the dynamics of dissolved oxygen. This becomes more pronounced in the early morning hours and on cloudy days resulting in severe depletion of dissolved oxygen of pond water. In addition to the problem of dissolved oxygen, toxic intermediates formed in the transformation of organic matter also inhibit growth of fish. These two factors which limit the production of fish in intensive culture, can be effectively controlled by the use of artificial aeration.

Many scientists have studied the effect of aeration on the growth and survival of fishes. Aeration was found to improve the water quality and increase fish production in white catfish (Loyacano 1974). Carp and tilapia yields were increased many folds by applying aeration (Marek and Sarig 1971; Rappaport and Sarig 1975). Hollerman and Boyd (1980) reported higher production and survival of channel catfish in ponds with aeration. Plemmons and Avault (1980) also obtained 6 tons of catfish/acre with continuous aeration. Singh *et al* (1980) reported aeration to favour feed utilisation and growth in common carp. There has been no work on the effect of aeration on Indian major carps. In view of this, the present study was undertaken to ascertain the effect of aeration on Indian major carps.

2. Materials and methods

The experiment was conducted for a period of 120 days at the fish farm of the College of Fisheries, Mangalore. Six uniform sized cement cisterns, each having an area of 50 m^2 (10 × 5 × 1 m), were used for the polyculture of Indian major carps. Water in a set of 3 cisterns was artificially aerated, while the second set of 3 cisterns without aeration acted as controls.

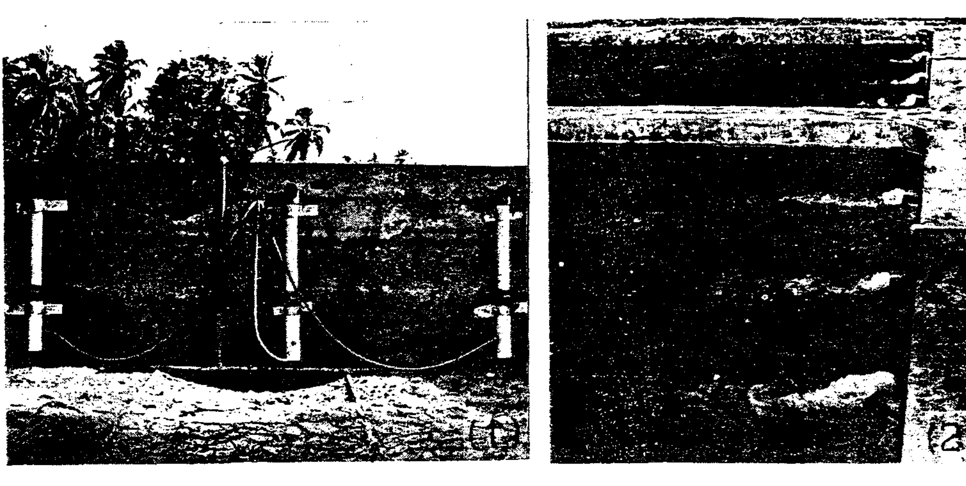
2.1 *Air-lift system*

The air-lift system used in the experiment consisted of two PVC pipes of different diameters united together and fixed vertically. The lower pipe was of a larger diameter (3″) while the upper bend was slightly smaller ($2\frac{1}{2}$″). Compressed air was supplied at the bottom of the vertical pipe from a 3 HP compressor through a GI pipe, which was connected to the air-lift system by a rubber tubing ending in an airstone. The flow of air through the rubber tube was regulated by means of a regulator. The air, injected at the bottom of the pipe, forms bubbles and rises resulting in an air-water mixture, which being lighter than water, gets discharged from the upper end of the pipe. The constructional and operational details of the aerating system is shown in figures 1 and 2. Three such air-lift systems were fixed in each of the 3 cisterns. Aeration was done daily for 8 hr from 23·00–07·00 hr.

2.2 *Stocking and sampling of fishes*

Prior to stocking, all the cisterns were fertilised initially with 1000 kg/ha of poultry manure on dry weight basis. Later, fortnightly application was done at the rate of 500 kg/ha. Fingerlings of catla, rohu and mrigal were stocked in each cistern at the rate of 10,000 nos/ha with a stocking ratio of 2:2:1, respectively. The fishes were fed with the conventional feed comprising of a mixture of rice bran and groundnut oil cake in equal proportion by weight at the rate of 5, 3, 2·5 and 2% in the first, second, third and fourth months, respectively.

Water and plankton samples from each cistern were analysed weekly, the results of which are being published separately. Fish sampling was done every fortnight, when a minimum of 50% of the stock was caught and individual length and total weight of



Figures 1 and 2. **1.** Full view of the air-lift system fitted in a cistern. **2.** Side view of the air-lift system showing the water being splashed.

each species recorded. On termination of the experiment, water was drained from each cistern and the surviving fishes were measured for their length and total weight. The growth and survival of Indian major carps with and without aeration were tested statistically using the analysis of variance technique (Snedecor and Cochran 1967).

3. Results and discussion

3.1 *Fish growth*

3.1.1 *Catla catla*: The average length and weight attained by catla during the experimental period in aerated and control cisterns are shown in table 1. The average length of catla in the aerated cisterns increased from 54·9 ± 0·95–229·5 ± 7·35 mm, while in controls it increased from 54·6 ± 0·70–228·2 ± 14·67 mm. The daily average increment in length was 1·46 mm in aerated and 1·45 mm in control cisterns. The average weight of catla increased from 2·0 ± 0·2–172·8 ± 19·03 g during the experiment in aerated cisterns, while in the control it increased from 2·0 ± 0·23–164·7 ± 31·81 g. The daily average increment in weight was 1·42 g in aerated and 1·36 g in control cisterns. Figure 3 shows the growth of catla in the two sets of cisterns. It can be seen that the growth of catla was marginally higher in the former. Of the 3 species cultured, catla exhibited significantly faster growth.

3.1.2 *Labeo rohita*: The data on the growth of rohu is presented in table 2. During the experimental period, the average length increased from 62·8 ± 2·16 – 221·2 ± 12·63 mm in aerated cisterns, with a daily average increment of 1·32 mm. In the control, the average length increased from 65·2 ± 2·55 – 210·7 ± 6·47 mm with a daily average increment of 1·21 mm. The average weight of rohu increased from 2·6 ± 0·15 – 131·4 ± 23·62 g in aerated cisterns and from 2·7 ± 0·17 – 103·9 ± 6·26 g in control, the average daily increment in weight being 1·07 g and 0·84 g in aerated and control cisterns, respectively. The fluctuations in the average weight of rohu over the experimental period is shown in figure 4. It can be seen from the figure that the growth of rohu was better in aerated cisterns than in controls, especially towards the later half of the experiment. The faster growth of rohu in aerated cisterns might be due to the abundance of plankton in these cisterns. Further, aeration might have favoured feed utilisation as reported by Singh *et al* (1980).

3.1.3 *Cirrhinus mrigala*: Average length and weight of mrigal obtained in aerated and control cisterns are presented in table 3. Mrigal grew from an average length of 67·2 ± 0·45–231·9 ± 10·81 mm in aerated cisterns and from 66·8 ± 1·00–226·9 ± 6·08 mm in controls. The daily average increment in length was 1·37 mm in aerated and 1·33 mm in control cisterns. The average weight increase was from 3·7 ± 0·17–125·5 ± 14·53 g and from 3·9 ± 0·46–114·1 ± 8·09 g in aerated and control cisterns, respectively. The daily average increment in weight was 1·02 g in the case of aerated cisterns and 0·92 g in control. Figure 5 depicts the growth of mrigal in terms of weight. It can be seen that the growth was faster in aerated cisterns throughout the experimental period. However, the difference became more pronounced only from the 56th day. The faster growth rate under aeration might be due to better feed utilisation. The difference in fish growth between aerated and control cisterns was statistically insignificant (table 4), probably due to the shorter duration of the experiment.

Table 1. Average growth of catla in aerated and control cisterns*.

Treatment	Growth	Days after stocking 0	14	28	42	56	70	84	98	112	120	Daily increment
Aerated	Length (mm) ± SD	54·9 ± 0·95	92·2 ± 3·11	117·5 ± 6·56	142·5 ± 6·21	157·1 ± 6·19	177·5 ± 4·83	193·1 ± 5·28	215·3 ± 6·29	226·8 ± 5·67	229·5 ± 7·35	1·46
	Weight (g) ± SD	2·0 ± 0·2	10·8 ± 1·50	24·2 ± 5·05	38·2 ± 4·60	51·9 ± 4·34	75·8 ± 10·37	111·2 ± 7·56	142·2 ± 12·67	165·8 ± 18·09	172·8 ± 19·03	1·42
Control	Length (mm) ± SD	54·6 ± 0·70	96·5 ± 9·52	119·9 ± 14·80	137·7 ± 16·66	155·5 ± 21·01	176·5 ± 18·22	199·7 ± 17·91	215·3 ± 11·32	224·8 ± 13·01	228·2 ± 14·67	1·45
	Weight (g) ± SD	2·0 ± 0·23	13·2 ± 5·03	25·4 ± 10·15	36·4 ± 15·44	52·0 ± 22·26	77·5 ± 28·57	120·7 ± 27·72	138·2 ± 24·22	157·3 ± 27·42	164·7 ± 31·81	1·36

*Average of 3 cisterns

Table 2. Average growth of rohu in aerated and control cisterns.*

Treatment	Growth	Days after stocking 0	14	28	42	56	70	84	98	112	120	Daily increment
Aerated	Length (mm) ± SD	62·8 ± 2·16	87·3 ± 4·08	115·5 ± 3·17	138·6 ± 4·90	156·0 ± 6·23	176·6 ± 6·05	193·0 ± 9·56	202·5 ± 8·50	213·9 ± 12·22	221·2 ± 12·63	1·32
	Weight (g) ± SD	2·6 ± 0·15	10·0 ± 1·74	21·0 ± 1·12	33·0 ± 4·26	48·4 ± 6·47	67·7 ± 8·07	85·3 ± 10·01	106·9 ± 18·07	124·4 ± 23·54	131·4 ± 23·62	1·07
Control	Length (mm) ± SD	65·2 ± 2·55	86·8 ± 2·05	114·8 ± 3·41	137·5 ± 7·72	153·0 ± 7·26	170·9 ± 3·99	185·3 ± 3·42	194·8 ± 3·67	202·7 ± 3·50	210·7 ± 6·47	1·21
	Weight (g) ± SD	2·7 ± 0·17	9·1 ± 1·2	20·8 ± 3·10	33·3 ± 5·42	46·8 ± 6·99	62·2 ± 5·34	79·1 ± 3·68	90·6 ± 7·32	97·8 ± 5·90	103·9 ± 6·26	0·84

*Average of 3 cisterns

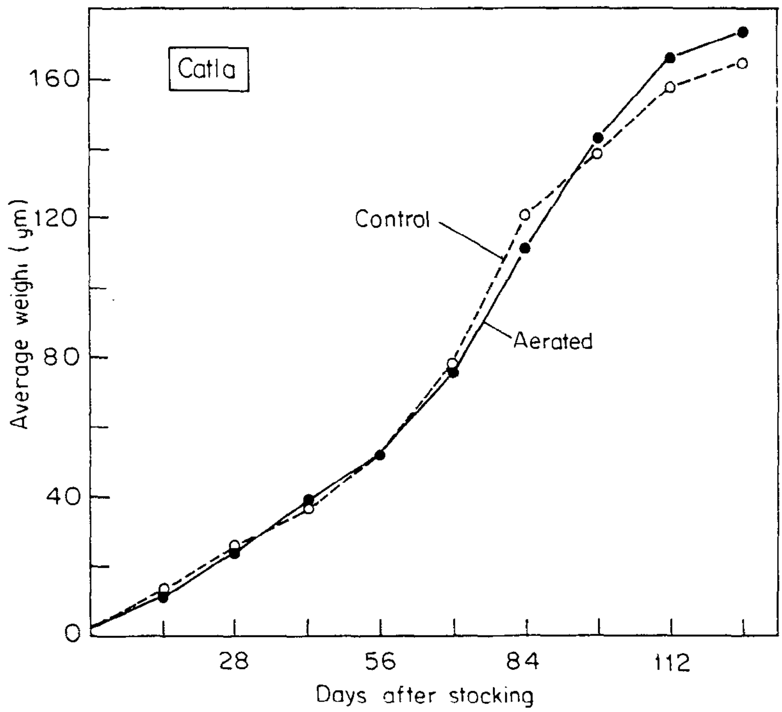


Figure 3. Average weight (g) attained by catla in the aerated and control cisterns.

3.2 *Survival and production*

The average survival of the 3 species, catla, rohu and mrigal was 84·5% in the aerated cisterns, while it was only 71·1% in the control. The survival in aerated cisterns was found to be significantly better when compared to the controls (table 4).

The average survival of catla was slightly higher in the control, where it was 93·3% while in aerated ponds it was 91·7%. Among the species, catla exhibited the best survival in both the sets; this might be because of its surface dwelling nature due to which it is not prone to severe oxygen depletion. The survival of rohu was significantly higher in aerated cisterns, where it was 75·0% while in control it was only 36·7%. This could be attributed to the higher dissolved oxygen concentration in the aerated cisterns, especially at the bottom. Since rohu is a column-bottom dwelling fish, dangerously low levels of dissolved oxygen at the bottom might have resulted in the mortality of this species in the control cisterns, especially towards the later half of the experiment. Mrigal also showed slightly higher survival in aerated cisterns (86·7%) as compared to the control (83·3%). The higher dissolved oxygen concentration in aerated cisterns might have been responsible for the better survival of mrigal in these cisterns. In comparison to rohu, the better survival of mrigal in unaerated cisterns indicates that the former species is more sensitive to oxygen depletion.

Data on the average net computed fish production are presented in table 5. The computed net average fish production in aerated cisterns was 3,710·63 kg/ha/year, while in the control it was only 2,809·82 kg/ha/year, the difference being significant.

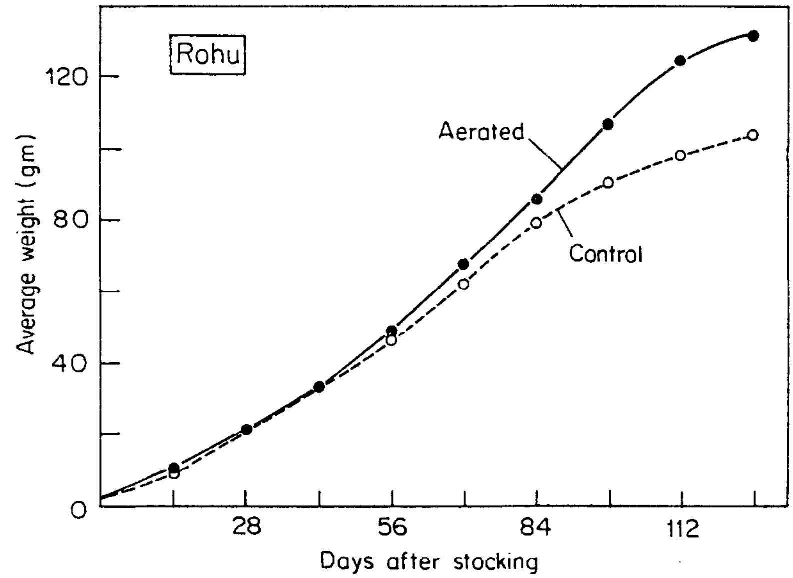


Figure 4. Average weight (g) attained by rohu in the aerated and control cisterns.

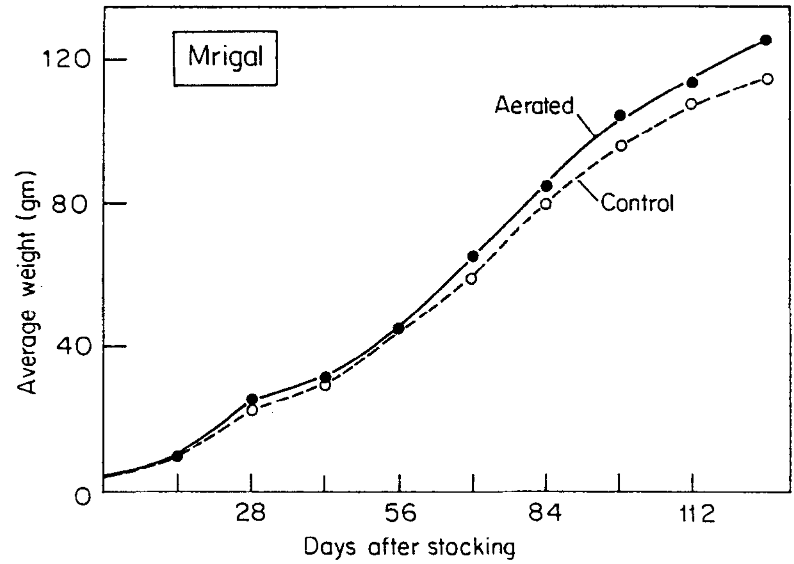


Figure 5. Average weight (g) attained by mrigal in the aerated and control cisterns.

The highest percentage contribution to the production was by catla in both the aerated (51·41%) and control cisterns (64·94%), followed by rohu (31·36%) and mrigal (17·24%) in aerated cisterns and mrigal (19·83%) and rohu (15·23%) in control cisterns.

Based on the results obtained, it can be concluded that the growth of catla, rohu and mrigal can be improved by aerating the ponds. Experiments carried out in Israel

Table 3. Average growth of mrigal in aerated and control cisterns.*

Treatment	Growth	Days after stocking 0	14	28	42	56	70	84	98	112	120	Daily increment
Aerated	Length (mm) ± SD	67·2 ± 0·45	88·5 ± 2·87	127·2 ± 3·22	144·8 ± 0·99	161·8 ± 5·39	183·9 ± 2·00	193·1 ± 2·72	210·3 ± 10·26	219·7 ± 5·69	231·9 ± 10·81	1·37
	Weight (g) ± SD	3·7 ± 0·17	9·7 ± 0·26	24·7 ± 2·52	31·6 ± 0·36	45·2 ± 3·01	64·9 ± 1·01	83·9 ± 1·33	104·0 ± 10·0	113·3 ± 13·32	125·5 ± 14·53	1·02
Control	Length (mm) ± SD	66·8 ± 1·00	87·5 ± 3·91	123·1 ± 3·38	140·6 ± 4·68	157·4 ± 9·05	177·5 ± 2·84	186·4 ± 3·14	203·5 ± 6·26	217·3 ± 3·33	226·9 ± 6·08	1·33
	Weight (g) ± SD	3·9 ± 0·46	9·4 ± 0·51	22·8 ± 10·58	29·7 ± 2·06	44·8 ± 6·30	58·9 ± 3·98	79·5 ± 3·12	95·3 ± 5·64	107·1 ± 5·28	114·1 ± 8·09	0·92

*Average of 3 cisterns

Table 4. Analysis of variance for survival and growth of catla, rohu and mrigal.

Source of variation	d.f.	Mean sum of squares: Survival	Mean sum of squares: Growth	F-ratio: Survival	F-ratio: Growth
Between replications	2	0·39	767·27	0·19	2·59
Between treatments	1	34·72	1117·07	17·45*	3·77
Between species	2	149·56	5254·72	75·16*	17·72*
Interaction between treatment and species	2	26·89	160·93	13·51*	0·54
Error	10	1·99	296·52		
Total	17				

*Significant at 5% level.

Table 5. Net production (kg/ha/year) in different cisterns.

Treatments	Catla	Rohu	Mrigal	Total carp production
A1	1963·94	1435·42	677·81	4077·17
A2	2010·42	1232·18	653·59	3896·19
A3	1719·82	860·18	578·53	3158·53
Average	1898·06	1175·93	636·64	3710·63
C1	2054·16	369·87	493·24	2917·27
C2	1620·36	557·84	534·12	2712·32
C3	1810·40	348·70	640·76	2799·86
Average	1828·31	425·47	556·04	2809·82

showed that carp and tilapia yields could be increased several folds by aeration of pond water (Marek and Sarig 1971; Rappaport and Sarig 1975). Similarly, aeration of pond water resulted in increased production and survival of channel catfish (Hollerman and Boyd 1980; Plemmons and Avault 1980). The marginal difference observed in the growth of fish between the two sets in the present study, seems to be mainly due to the shorter duration of the experiment. It was seen that the rate of survival could be significantly enhanced by aerating fish ponds. The overall carrying capacity and fish production from ponds under intensive polyculture could be significantly increased by resorting to aeration. Further aeration experiments using all the 6 species of carps viz catla, rohu, mrigal, silvercarp, grass carp and common carp at a higher stocking density should yield more useful information on the utility of this technique for enhancing fish production from intensive aquaculture.

References

Hollerman W D and Boyd C E 1980 Nightly aeration to increase production of channel catfish; *Trans. Am. Fish. Soc.* **109** 446–452

Loyacano H A 1974 Effects of aeration in earthen ponds on water quality and production of white catfish; *Aquaculture* **3** 261–271

Marek M and Sarig S 1971 Preliminary observations of super-intensive fish culture in the Berth-Swan valley in 1969–1970; *Bamidgeh* **23** 93–99

Plemmons B and Avault J W Jr 1980 Six tons of catfish per acre with constant aeration; *La. Agric.* **23**

Rappaport U and Sarig S 1975 The results of tests in intensive growth of fish at the Gunosar (Israel) station ponds in 1974; *Bamidgeh* **27** 75–82

Singh S B, Ghosh S R, Reddy P V G K, Dey R K and Mishra B K 1980 Effect of aeration on feed utilisation by common carp fingerlings; *J. Inland Fish Soc. India* **12** 64–69

Snedecor G W and Cochran W G 1968 Statistical methods; (Calcutta: Oxford and IBH Pub. Co.) p 593