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Effect of pond aeration on growth and survival of *Penaeus monodon* Fab.

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Abstract
The effect of paddle wheel aeration on shrimp growth and survival were studied at a commercial farm at Chandipur coast of Orissa, India, at different stocking densities of *Penaeus monodon*. Four different aeration patterns were adopted and evaluated. Influence of individual aeration pattern on average survival rate was not highly significant ($p<0.05$) at different stocking densities, while different aeration patterns had significant influence ($p<0.001$) on survival rate of *P. monodon*. It was also estimated that 1.77 hp (aerator) is needed for every 1000 kg shrimp biomass which corresponds to 1 hp/565 kg biomass of shrimp. Higher growth rate was mostly observed during 63-98 days of culture, when six 2 hp aerators were in use. Size variation in growth was higher during initial stage of rearing, while it was reduced to significant level towards the last phase of rearing as number of aerator and hour of operation increased.

Key words: *P. monodon*, Semi-intensive, Aeration, Paddle wheel

Introduction

Aeration play a key role in semi-intensive shrimp farming and reflect the pond out put as it helps in diffusing atmospheric oxygen in to the pond water and maintain dissolved oxygen level, keep the feeding zone clean and accumulate sediment at the centre, uniform water circulation (Sanares *et al.* 1986), mobilize nutrients in water column, enhancing the growth of phytoplankton and decompose organic matter due to highly facilitative aerobic environment (Mohanty 1997). Aeration is required in semi-intensive ponds when organic loading from feed drives the pond ecosystem from autotrophy to heterotrophy, as heterotrophic ponds exhibit negative net oxygen production due to excess oxygen consumption. Therefore, aeration serves to counter act oxygen depletion and stabilize diurnal dissolved oxygen level. This study however, examined the effects of paddle wheel aerator on growth, survival rate and yield of *P. monodon*, examined the effects of paddle wheel aerator on growth, survival rate and yield of *P. monodon* at different stocking density and evaluated optimum aeration requirements.

Materials and methods

The present study was carried out at "Shrimp Culture Pilot Project" at Chandipur coast Orissa, India during 1996-97. Three ponds of 7500m^2 each (P_1, P_2, P_3) and three ponds of 600m^2 each (P_4, P_5, P_6) were selected for proposed study. Stocking density of *P. monodon* was 35, 25, 15, 30, 20, and 10 PL for pond no. P_1, P_2, P_3 P_4, P_5, and P_6 respectively, through out the four crop of experimental periods. Artificial high energy supplemental feed (NOVO feed, Thailand) was used through out the experimental periods, while periodic water exchange (2-30%), liming, fertilization and pond aeration using paddle wheel aerator was a regular practice. Four different aeration patterns were evaluated (one pattern/crop) to study the utility of aerators, its operation timing and effects on growth and survival of *P. monodon*.

Physioco-chemical parameters of pond water e.g. dissolved oxygen (DO), temperature, pH, turbidity, CO_2 and salinity were monitored *in situ* every day between 0700-0800 hours and 1500-1600 hours. Weekly analysis of other physioco-chemical parameters of pond water, discharge water and monthly analysis of pond soil and sediment samples were carried out using standard methods (APHA 1989, Biswas 1993, Dash and Pattanaik 1994). Field test instruments were in use to analyze water pH (Checker 1, HANNA, USA), soil pH (DM 13), water salinity (S 10, ATAGO, Japan) and DO (YSI 55, USA).

Weekly growth study was carried out by sampling prior to feeding, so that complete evacuation of gut was ensured. Growth performance and factors affecting growth were statistically analyzed. Weekly condition factor were analyzed as described by Bal and Rao (1990). Weekly average body weight, average daily growth, survival rate, biomass, feed requirement, % feed used, amount of check tray feed, feed increment per day and FCR was estimated using formulas as described by Mohanty (1997).

Results and discussion

During the four crop experimental period the mean maximum and mean minimum of various physioco-chemical parameters of pond water were recorded (Table 1). As the day of culture increased, increased trend of H_2S, NH_3 and BOD, and decreased trend of turbidity was observed which may be due to increased feed input (Fugimura 1989), metabolic waste, increased biomass and organic load (Mohanty 1997). The average values of soil pH, EC, organic carbon, $CaCO_3$, available-N and P were gradually increased as the days of culture increased. Correlation of shrimp yield with soil pH, soil salinity and organic carbon contents was found significant at 5% level, while with available-N, it was highly significant ($P<0.01$). Growth performance, yield and survival rate at different stocking density and aeration pattern was recorded (Table 2). The feed conversion ratio (FCR) was recorded highest (1.649) in P_1, crop-II and lowest (1.285) in P_6, crop-IV. Overall growth performance was good at stocking density of 20-30 pcs/m^2, while overall yield and survival rate was higher under 3rd pattern of aeration (Table 2).

Table 1. Crop-wise mean maximum and minimum values of physioco-chemical parameters

Parameters	1st crop 1996		2nd crop 1996		3rd crop 1997		4th crop 1997	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Temp. (^{0}C)	3.18	23.0	27.7	15.9	32.1	22.6	26.9	15.6
DO (mg/l)	8.2	4.7	7.1	4.2	.3	3.9	8.8	3.8
pH	8.3	7.0	8.3	6.6	8.4	6.8	8.4	6.6
Salinity (mg/l)	28.0	16.0	10.0	3.0	29.0	13.0	17.0	2.0
Turbidity (cm)	80.0	18.0	73.0	11.0	84.0	13.0	65.0	9.0
Total alkalinity (mg/l)	143.0	91.0	143.0	76.0	152.0	86.0	139.0	78.0
Free CO_2 (mg/l)	3.91	0.8	5.84	1.2	3.12	0.93	2.96	0.89
H2S (mg/l)	0.13	0	0.16	0	0.13	0	0.13	0
NH_3 (mg/l)	0.2	0	0.12	0	0.2	0.002	0.1	0
P (mg/l)	0.076	0.05	0.11	0.06	0.088	0.062	0.14	0.057

Table 2. Pond-wise crop result at different aeration pattern

Pond no.	Crop I			Crop II			Crop III			Crop IV		
	ADG (g)	Yield (t/ha)	SR (%)	ADG (g)	Yield (t/ha)	SR (%)	ADG (g)	Yield (t/ha)	SR (%)	ADG (g)	Yield (t/ha)	SR (%)
1	0.24	8.75	70.9	0.23	1.22	13.5	0.25	9.0	90.01	0.26	5.44	47.64
2	0.24	6.4	83.7	0.23	2.13	32.04	0.25	6.74	89.04	0.27	5.07	57.94
3	0.26	3.72	73.24	0.22	1.07	28.35	0.27	3.58	75.01	0.25	3.17	70.31
4	0.25	7.75	70.15	0.22	1.94	27.71	0.24	8.3	93.0	0.27	5.81	56.62
5	0.25	4.98	85.87	0.22	1.58	32.96	0.26	5.17	77.1	0.26	4.38	59.69
6	0.25	1.84	70.1	0.21	1.11	48.72	0.27	2.83	80.08	0.28	1.84	53.02

ADG = Average daily growth, SR = Survival rate

Ponds can be aerated continuously during night time or an emergency basis. Day time aeration is generally not necessary and could be counter productive (Sanares *et al.* 1986) but heavily fed ponds may require continuous aeration to mix water and to avoid anaerobic bottom condition where, aeration hour is generally increased from 12 h/night to 24 h/day as the rearing period increases. In some instances, aeration does not result in increased production and drive production cost to economic non-viability (Stern *et al.* 1991). However, in the present experiment, it was observed that, influence of individual aeration pattern on average survival rate of *P. monodon* was not highly significant at different stocking densities (Table 3), while third aeration pattern showed better performance over other patterns (Table 4), which was also found economically viable to reduce production cost/kg shrimp.

Table 3. Crop-wise aeration pattern

Days of culture	Aerators/ha	Hours of mechanical aerator operation			
		1st crop	2nd crop	3rd crop	4th crop
1-15	4, 2 HP	10	8	9	8
16-30	4, 2HP	12	10	11	10
31-45	4, 2HP	14	12	13	12
46-60	4, 2HP + 2, 1HP	16	14	15	14
60-75	6, 2HP	17	15	16	15
76-90	6, 2HP	18	16	17	16
91-110	8, 2HP	19	17	18	18
111-130	8, 2HP	22	19	20	20
Above 131	8, 2HP	22	19	20	20
	Results	Pattern A	Pattern B	Pattern C	Pattern D
	Survival rate (%)	70.1-85.8	13.5-48.7	75-93	47.6-70.3

Table 4. Influence of different aeration pattern on average survival rate (%) of *P. monodon* at different stocking densities (ANOVA)

Sources of variation	Degree of freedom	Sum of squares	Mean square	Calculated F value	Tabulated F value	P value	Significant level
Between SD	5	236.79	47.36	0.57	2.9	<0.05	NS
Between aeration pattern	3	10104.60	3368.20	40.70	9.3	<0.001	*
Error	15	1241.24	82.75	-	-		

CV = 14.68%, Standard error of treatment mean = 5.25, Standard error of differences of two means = 7.43, Critical difference value = 15.82

Aeration requirement in semi-intensive shrimp ponds vary depending upon stocking density, feeding rate, days of culture and biomass. Fugimura (1989) suggested that, supplemental aeration is required only when shrimp biomass exceeds 0.2 kg/m^2. Sandifer *et al.* (1988) recommended 0.79 hp (aerator)/1000 kg shrimp while, Wyban and Sweeny (1991) recommended 1.33 hp/1000 kg shrimp. However, in the present study 16 hp/ha were needed to get the maximum production of 9.01 t/ha, which corresponds to 1.77 hp/1000 kg shrimp or 1 hp/565 kg shrimp, whereas, Aekapan (1995) recommended 1 hp aerator for every 400 kg of shrimp biomass. Growth performance of *P. monodon* in term of average daily growth and size variation was better under third pattern of aerato schedule against that of 1st, 2nd and 4th (Figs. 1 and 2). Different aeration pattern showed significant influence ($p<0.001$) on average survival rate of *P. monodon* (Table 2) and survival rate ranged between 70.1-85.8, 13.5-48.7, 75.0-93.0 and 47.6-70.3 under 1st, 2nd, 3rd and 4th pattern of aeration (Table 3). However, pond-wise and crop-wise culture performance indicated better survival and growth in crops-I and III than crops-II and IV, probably due to seasonal variation (Imai 1977), low temperature, salinity and pH (Law 1988), high turbidity (Mohanty 1996) and poor phytoplankton population (Chien 1992). Crop-wise weekly mean maximum and minimum DO level in pond water were 8.2-4.7, 7.1-4.2, 8.3-3.9 and 8.8-3.8 ppm during 1st, 2nd, 3rd and 4th crop respectively. However, comparative analysis indicated better survival of *P. monodon* in 3rd crop at 3rd pattern of aeration (Table 4). Irrespective of stocking density, higher growth rate was mostly observed during 63-98 days of culture when 6-2 hp aerators/pond were in use, which closely agrees to the findings of Wyban *et al.* (1989) as overall management practice were same for all the ponds. Size variation in growth was higher in initial stages of rearing while it was reduced to significant level towards last phase of raring (Figs. 1 and 2), probably due to increased number of aerator and hour of aeration.

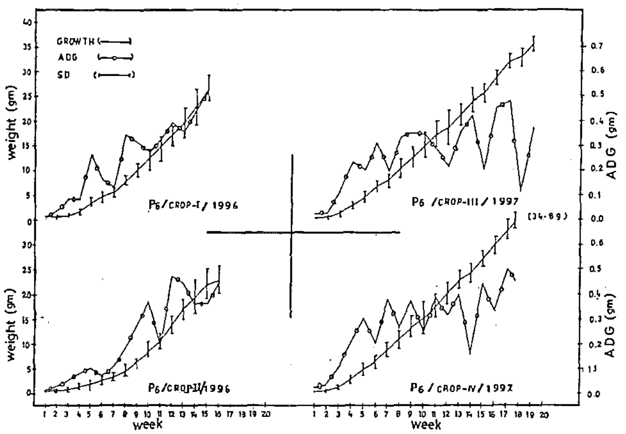


Fig. 1. Growth performance of *P. monodon* in pond-6, during four crops (SD, 10pcs/m^2)

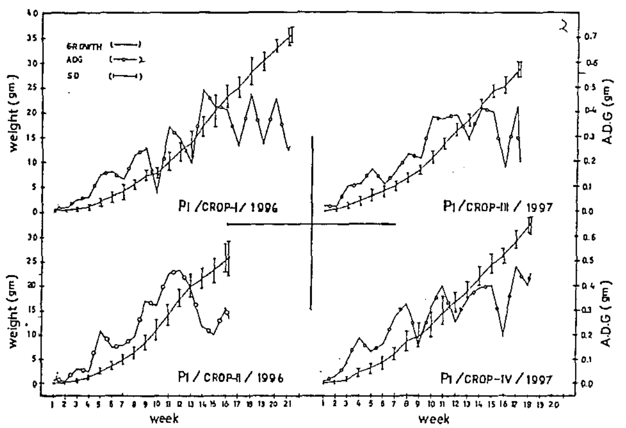
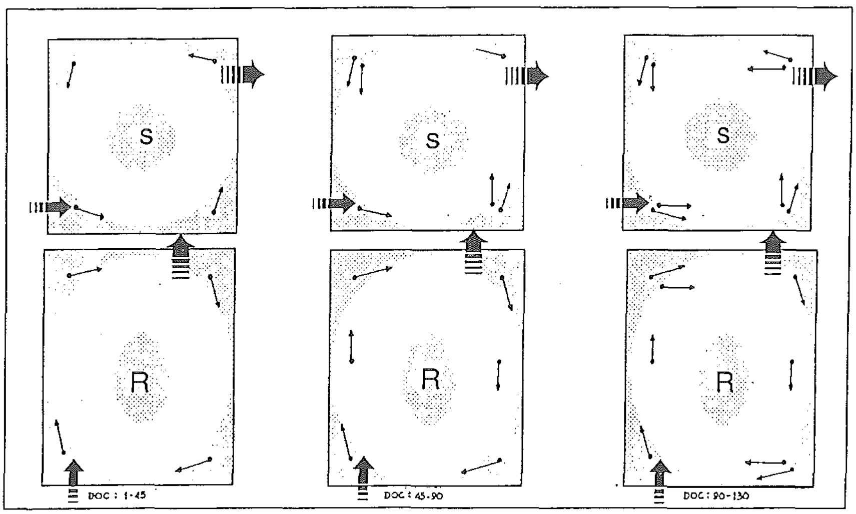


Fig. 2. Growth performance of *P. monodon* in pond-1, during four crops (SD, 35pcs/m^2)

Continuous aeration is not desirable, when DO level remains above desirable limit, especially during day times in the early days of culture and should continue during the period of low pH and plankton dei-off (Mohanty 1997). During later stage of culture when biomass and organic load in pond increase (Aekapan 1995), oxygen consumption rate increases. To supplement the oxygen requirement at this stage, additional use of aerator (approximately one 1 hp aerator for every 565 kg increase in biomass) is required. However, rational use of aerator and its position (Fig. 3) is of critical importance in managing pond bottom condition and reducing operational cost. Keeping the experimental results (Table 3) and economics of the culture operation in view, aeration hour (without affecting the survival rate of *P. monodon*) can be restricted to 9 h/day at 1-15, 11 h/day at 16-30, 13 h/day at 31-45, 15 h/day at 46-60, 16 h/day at 61-75, 17 h/day at 76-90, 18 h/day at 91-110 days of culture and 20 h/day at 111 to date of harvesting.



S = SQUARE POND, R = RECTANGULAR POND, ⁄ = AERATOR, ⊡ SEDIMENT,
IIII➧ = OUTLET, III➪ = INLET

Fig. 3. Recommended position of aerators at moderate (20-30 pcsm/m2) stocking density.

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References

Aekapan, R., 1995. Pond and water management in aquaculture. *Aqua. International*, May: 26-27.

APHA, 1989. Standard Methods for Examination of Water and Waste Water, 17th Edition. American Public Health Association, Wasington DC, USA.

Bal, D.V. and K.V. Rao, 1990. Marine Fisheries of India. Tata McGraw-Hill Publishing Company Ltd., New Delhi, India. 472 pp.

Biswas, K.P., 1993. Fisheries Manual. Bhagabat Press and Publishing, Cuttack, India. 436 pp.

Chien, Y.H., 1992. Water quality requirements and management for marine shrimp culture. *In*: Proc. Special Session on Shrimp Farming (ed. J. Wyban). World Aqua. Soc., Baton, Rouge, LA: pp. 30-42.

Dash, M.C. and P.N. Patnaik, 1994. Brackishwater prawn culture. Palani Paramount Publications, Madras, India. 233 pp.

Fugimura, T., 1989. Management of shrimp farm in Malaysia. *In*: Proc. S-E Asia Shrimp Farm Management Workshop (ed. D.M. Akiyama). American Soybene Assoc., Singapore: pp. 22-41.

Imai, T., 1977. Aquaculture in Shallow Seas. Amerind Publications Co. Pvt. Ltd., New Delhi, India. 615 pp.

Law, A.T., 1988. Water quality requirements for *Penaeus monodon* culture. *In*: Proc. Seminar on Marine Prawn Farming in Malaysia. Malaysia Fish, Soc.

Mohanty, R.K, 1996. Effects of turbidity and its management in application. *Fish. World India*, 3(9): 24-25.

Mohanty, R.K, 1997. Studies on scientific management of semi-intensive culture of black tiger shrimp, *Penaeus monodon* at Balasore-Bhadrak coast of Orissa state (India). Ph.D Thesis, Sambalpur University, Orissa, India. 193 pp.

Sanares, R.C., S.A. Katase, A.W. Fast and K.E. Carpenter, 1986. Water quality dynamics in brackishwater shrimp ponds with artificial aeration and circulation. *In*: First Asian Fisheries Forum (eds. J.N. Maclene, L.B. Dizon and L.V. Hosillos). Asian Fisheries Soc., Manila, Philippines: pp. 83-86.

Sandifer, P.A., J.S. Hopkins and A.D. Stokes, 1988. Intensification of shrimp culture in earthen ponds in south Carolina: progress and prospects. *J. World Aqua. Soc.*, 19(4): 218-226.

Stern, S. E. Letellier and H.D. Daniels, 1991. Production of *Penaeuis vannamei* in high densities with and without aeration: a case study. 22nd World Aquaculture Soc. Conf., San Juano, Puerto Rico.

Wyban, J.A. and J.N. Sweeney, 1991. Intensive shrimp production technology. The Oceanic Institute Shrimp Manual. Oceanic Institute, Honolulu, Hawaii, USA.

Wyban, J.A., G.D. Pruder, K.M. Leber and L. Burzell, 1989. Paddle wheel effects on shrimp growth, production and crop value in commercial earthen ponds. *J. World Aqua. Soc.*, 20(1):

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