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Survival, Growth and Production of *Penaeus monodon* in Modified- Extensive and Semi Intensive Culture Systems of Andhra Pradesh, India

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Abstract : An analysis was made on the stocking density, survival, growth and production of *Penaeus monodon* in semi intensive (SI) and modified extensive (ME) shrimp culture ponds located in East Godavari district of Coastal Andhra Pradesh, India. Survival of shrimp in the ME systems with low stocking densities is higher (56 - 88%) than in the SI systems (12.3 – 52%) with higher stocking densities. Growth of shrimp is dependent not only on the stocking density but also on the management practices. Although the percent survival is more in ME system the growth is much faster in SI system owing to better management practices. Weight gain of shrimp was more rapid in the SI system than in the ME system initially up to 90 days of culture (DOC) but the trend was reverse in the later age of culture period. The optimum stocking density for achieving maximum production in the area is suggested as 10-15 individuals / m^2 in SI ponds and 3-5 individuals / m^2 in ME ponds.

Key words: Shrimp, Stocking density, weight gain, Biomass production

INTRODUCTION :

Penaeus monodon is a fast growing euryhaline and eurythermal shrimp, cultured on a large scale in many Asian countries including India. Production of the shrimp in the culture system depends on a wide range of factors, the most important being the stocking density, which influences the growth and survival rates of the stock (Allan and Maguire 1992, Martin *et al.,* 1998, Ahmed et al., 2000 and Soundarapandian & Gunalan, 2008). An inverse relationship is known to exist between the stocking density and the survival and growth rates (Sandifer & Smith, 1976, Emmerson & Andrews 1981, Ahmed *et al.,* 2000). The susceptibility of shrimp to diseases increase with increase in stocking density (Hanson and Goodwin 1977, Baticados *et al.,* 1986, Doubrovsky *et al*., 1988) and the increase of density also increases the pressure on natural food resources (Hopkins *et al.,* 1988). Although low stocking densities tend to be risk free and are economically not viable. On the other hand, stocking the ponds beyond their carrying capacity is risky and may lead to total failure. A detailed analysis of the relationship between the stocking densities and the survival rates, growth and production of shrimps in culture ponds in a defined locality would prove especially useful in determining the optimum stocking densities to be adopted in the culture ponds as relevant to the prevailing conditions in the locality.

In India, where brackish water shrimp culture has expanded as a major industry, spread over vast area (85,000 ha), three types of culture activities are in operation, designated based on their stocking densities, as extensive, modified extensive and semi intensive types.

An investigation has, therefore, been undertaken to compare the survival rates, growth and production of *P. monodon* in semi intensive (SI) and modified extensive (ME) types of culture ponds located in East Godavari district of Andhra Pradesh (India).

Materials and Methods

Culture ponds

Eight culture ponds, four of them belonging to SI type and the rest to ME type, located in Chollangi village (East Godavari district) of Andhra Pradesh, India were selected. For convenience the selected ponds were designated as SI A, SI B, SI C, SI D (Semi–Intensive) and ME1, ME2, ME3 and ME4 (Modified - Extensive). The physico-chemical characters of the selected ponds were broadly similar except for minor differences. The rate of water exchange in ME ponds was 13-16 % per week, whereas it was 19-26 % per week in SI ponds. The feed conversion ratio (FCR) also varied from 1.3 to 2.9 in ME ponds and 1.96 to 3.8 in SI ponds. The quantities of inputs used were much higher in SI ponds as compared to ME ponds (Tables 1 & 2). All the ponds were stocked with post larvae (PL 20 stage) produced in hatcheries.

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TABLE 1 : ***Stocking densities, water exchange rates, fertilization, FCR, survival and growth in SI ponds at Chollangi***

	Ponds			
	SI A	SI B	SI C	SI D
Area (ha)	1	0.55	0.6	1
Initial Stocking density/m^2	15	20	20	15
Survival (%)	46.5	12.3	25.6	42
Biomass Kg/(ha)	2575	772	1583	2225
Feed used (Kg)	5055	1636	2183	5505
Feed conversion ratio (FCR)	1.96	3.8	2.29	2.39
Shrimp growth/ week/ g	1.98	2.4	2.03	1.55
Biomass (Kg/ha/day)	17.4	6.44	13.2	15.6
Water exchange (%)	19	26	20	24
Culture period (days)	148	120	120	142
Length of prawn at harvest (Cm)	16.5	15.2	15.0	15.4
Weight of shrimp at harvest (g)	38	32	29.5	20
Cao (Kg)	3000	450	240	3300
Lime (Kg)	1520	920	800	720
Urea (Kg)	64	42	56	28
Di Ammonium Phosphate (DAP) (Kg)	16.5	12	10	15
Dolomite (Kg)	1000	410	510	1230
Zeolite (Kg)	125	75	75	75
$KMnO_4$ (Kg)	-	-	-	10
Vitamin C (Kg)	0.3	0.08	0.09	0.38
Malachite green (Kg)	0.2	-	-	1.2
Probiotics (Kg)	43.5	15	12	50

Sampling

Sampling commenced from 30th day of post-stocking in ponds, and continued at fortnightly intervals till the day of harvesting. At each sampling time, data was collected on the survival, growth rates and production of shrimp in each pond. Data has been collected for a single crop which fell between February to May 2008.

Survival rates

Random sampling method employing cast net operation in the pond was used for the estimation of percent survival rates, using the formula.

Percent survival (%) =

$$\frac{\text{Actual number of shrimps caught/m}^2}{\text{Expected number of shrimp/m}^2} \times 100$$

Growth rate and Biomass production

Growth rate was estimated from the average body weight of shrimp obtained during each sampling time. Biomass Production was estimated at different days of culture period by multiplying the % survival with the average weight of shrimp.

TABLE 2 : Stocking densities, water exchange rates, fertilization, FCR, survival and growth in modified extensive (ME) ponds at Mulakuddu

	Ponds			
	ME 1	ME 2	ME 3	ME 4
Area (ha)	1.3	0.8	1.0	0.4
Biomass Kg/(ha)	500	1125	912	687
Stocking density (Individuals/m^2)	3	3.5	5.4	3.75
Biomass (Kg/ha/day)	3.7	8.85	6.37	4.6
Water exchange (%)/week	13	16	15	14
Culture period (days)	135	125	143	150
Survival (%)	56	88	71	43
Feed used (Kg)	887	1200	1370	816
Feed conversion ratio (FCR)	1.36	1.3	1.5	2.9
Shrimp growth / week / g)	2.349	2.04	1.98	1.91
Length of shrimp at harvest (cm)	14.8	14.8	15.8	18.0
Average weight of Shrimp at harvest (g)	29.0	29.1	36.4	42.0
Urea (Kg)	20	25	35	11
Superphosphate (Kg)	25	20	25	15
Dolomite (Kg)	290	125	150	150
Lime (Kg)	150	150	200	100
Zeolite (Kg)	50	-	-	2.5
Planktamin (Kg)(Mineral supplement to enhance growth of phytoplankton)	1	1	1	1

Feed conversion ratio

It is the ratio between the feed intake and weight gain. It was estimated on the basis of total feed used during the culture period and the corresponding production at the time of harvest.

Feed conversion ratio = Total Feed used / Weight gain

Statistical analysis

ANOVA and student's t- test were employed to determine the significance of difference in the growth rates of shrimp within and between farms. The extent of relationship between stocking densities and survival rates were determined by applying Karl Pearson's correlation coefficient (r). The significance level was set at P = 0.05.

Results

The stocking densities in SI ponds ranged from 15 to 20 / m^2 while those of ME ponds were within the range of 3- 5 /m^2. Details of the characteristic features of the selected ponds are furnished in Tables 1 & 2. The survival, growth and production varied markedly between SI and ME ponds ($P<0.05$).

***Survival* rates**

Semi-intensive ponds (SI): The percent survival rates were low ranging from 12.3 % (SI B) to 52% (SI D) at 120 days of culture (Fig.1). There was a gradual decline of survival rate in all the ponds, whereas in SI B, a rapid decline in survival rate was observed from 45th day onwards due to low dissolved oxygen level. Differences in the survival rates of shrimp in the four SI ponds at different times of culture are significant

(P<0.05). Further, a negative correlation was observed between stocking density and survival rates (r = - 0.9).

Modified extensive ponds (ME) (Fig. 2): Survival rates of shrimp in all ponds were high, ranging from 56 to 88% at 120 days of culture. The percent survival remained almost uniform throughout the culture period in ME 2 pond where as gradual decline was noted in the other ponds. Differences observed in the survival rates of shrimp in the four ponds at different ages are significant (P <0.05).

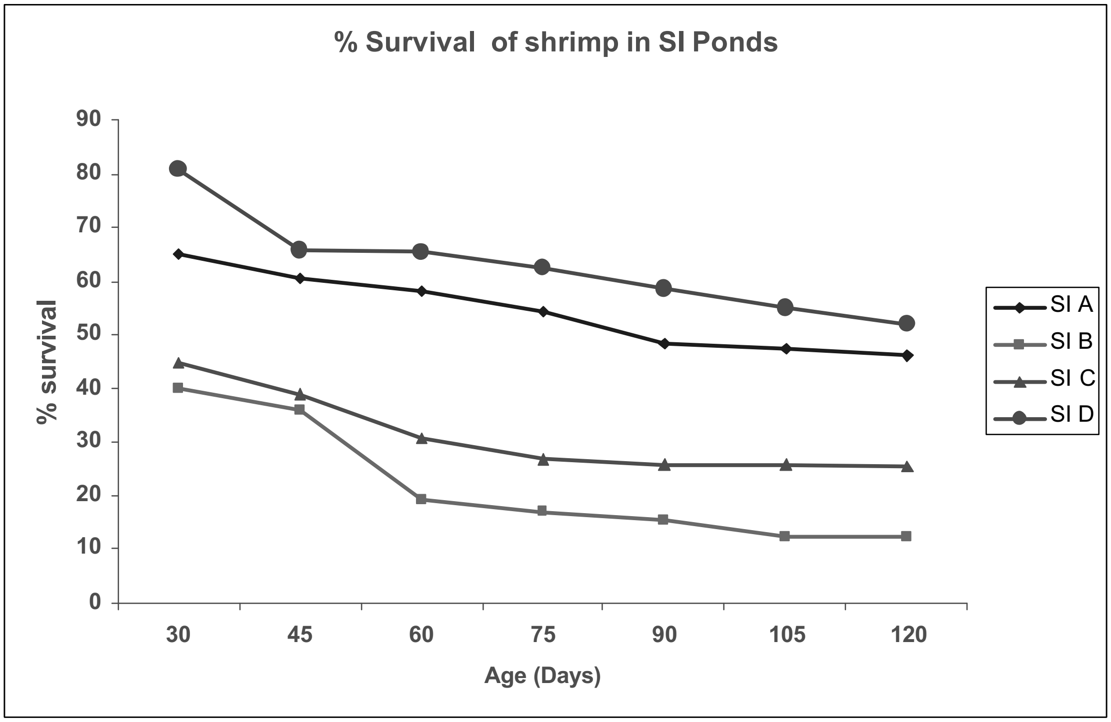

Fig. 1 : Survival rate of shrimp in Semi - Intensive ponds

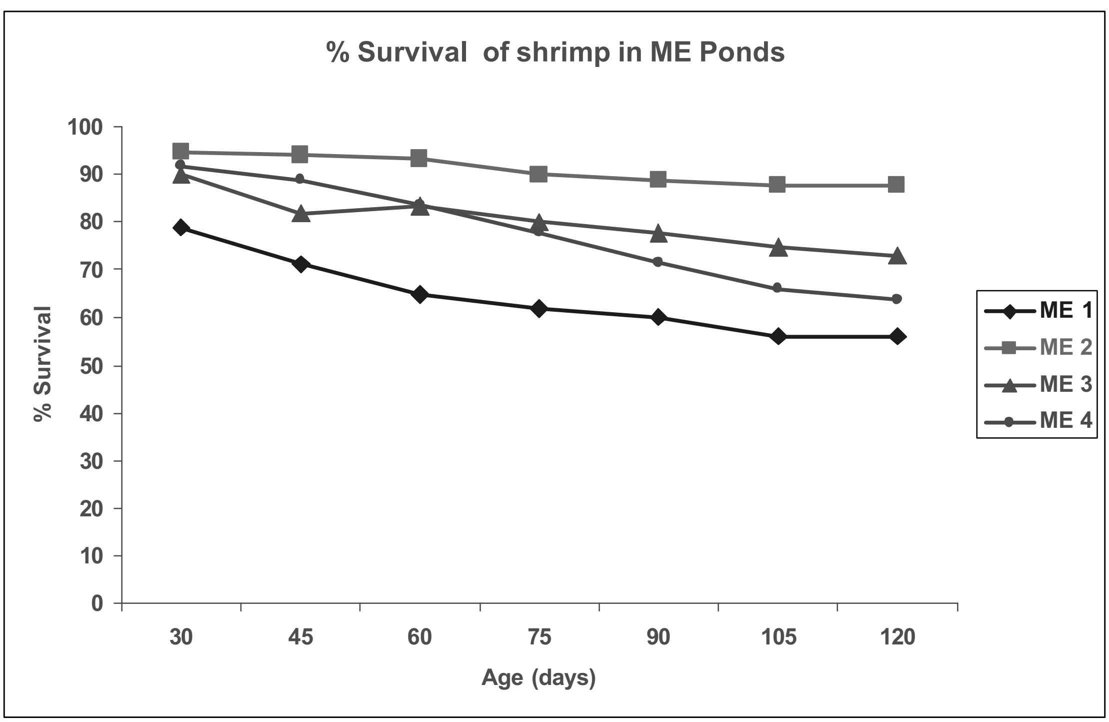

Fig. 2 : Survival rate of shrimp in Modified-Extensive ponds

Growth ***rates***

In all the eight ponds, growth rate was assessed by average weight of shrimp, which showed a linear relationship with age giving a positive correlation (r = 0.99 to 1.0). Whereas, a negative correlation was observed between the weight of the shrimp and % survival (r = - 0.9). Initially, the growth rate was similar in all ponds up to 45 days of culture, except in ponds ME 2 and ME 3 where the % survival was maximum. ANOVA of data resulted significant differences in the weights of shrimp in both SI and ME ponds (P < 0.05).

SI ponds (Fig. 3)*:* The growth rates varied

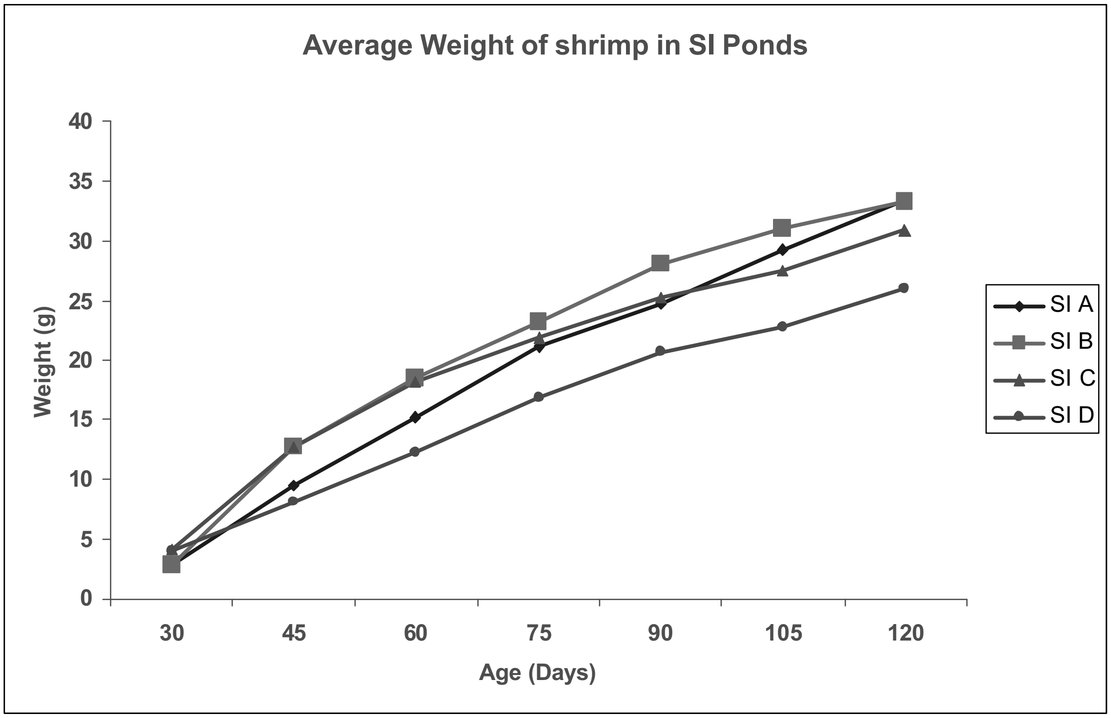

Fig. 3: Growth rate of shrimp in Semi-Intensive ponds

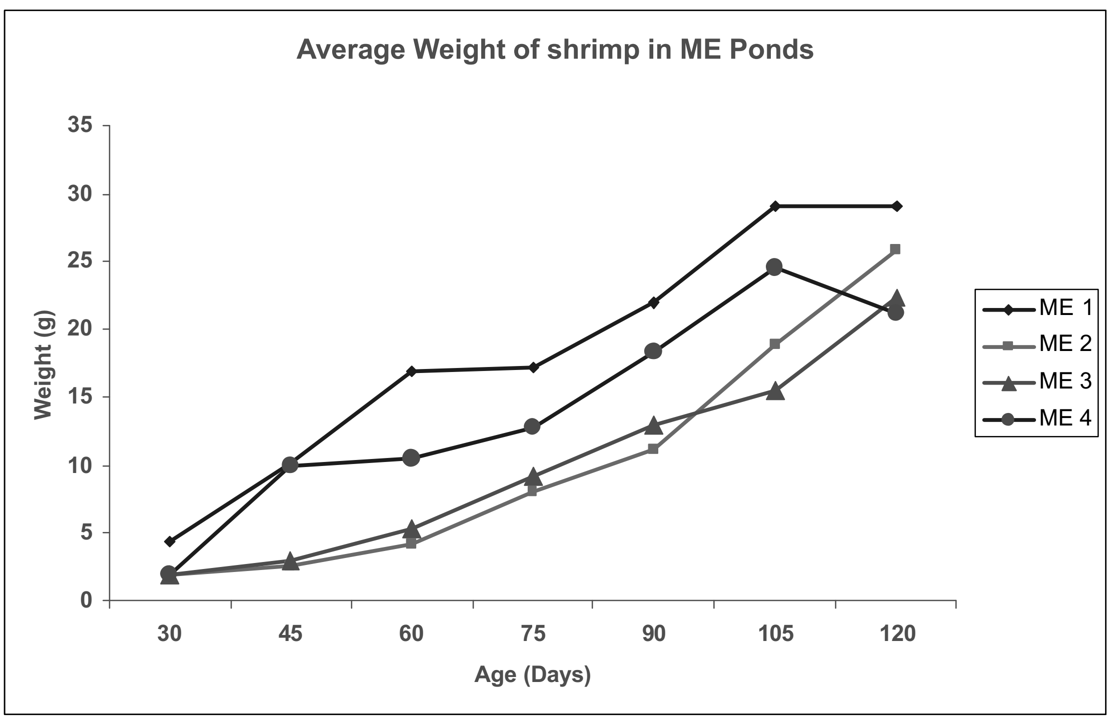

Fig. 4: Growth rate of shrimp in Modified - Extensive ponds

significantly between ponds at all ages. Paired comparison of weights taken from sample of shrimp from the all the four ponds at 120 days of culture, revealed that the average weight of shrimp from pond SI D to be significantly lower than that of shrimp from other ponds. Data subjected to ANOVA revealed that there was significant difference in the weights of shrimp between and within ponds.

ME ponds (Fig. 4): The growth rates varied considerably at 120 days of culture. Comparison of weights of shrimp from the four ponds at the age of 120 days revealed that the average weight of shrimp in pond ME 4 to be significantly lower than that of shrimp in other ponds.

Weight gain

SI ponds (Fig. 5)*:* The weight gain of shrimp in SI B was higher initially before the occurrence of dissolved oxygen problem (45 days of culture), but it fell down since then and showed influence throughout the culture period. Data subjected to ANOVA revealed the significant difference in the weight gain of shrimp between ponds $P < 0.05$.

ME ponds (Fig. 6)*:* The weight gain of shrimp is minimum in case of ME 4 pond (6.6 g) at 120 days of culture. ANOVA revealed that there was no significant difference in the weight gain of shrimp between and within ponds ($P > 0.05$).

Biomass Production

In SI ponds, the production varied form 772 – 2575 kg/ha and the daily production varied from 6.44 kg (SI B) to 17.4 kg/ha (SI A: Table 1). Production in ME ponds varied from 500-1125 kg/ha. The daily increase in biomass was highest in ME 2 (8.85kg) and lowest in ME1 (3.7 kg) and those of ME 3 and ME 4 were 6.37 kg and 4.6 kg respectively.

Discussion

Stocking density is one of the major limiting factors which influence the growth and survival rates of shrimp in a culture system. Very few studies were ,however, devoted to analyze this relationship in the culture systems with respect to the production. Foster & Beard (1974) and Willis *et al*. (1976) observed the survival and growth of some species of juvenile prawns to be better at lower stocking densities. Sandifer & Smith (1976), Emmerson & Andrews (1981) and Ahmed *et al*. (2000) also found that survival and growth varied inversely with population density. A similar trend was also noted during the present study with more growth in low stocking densities. The survival rate being very high in the ME ponds under conditions of

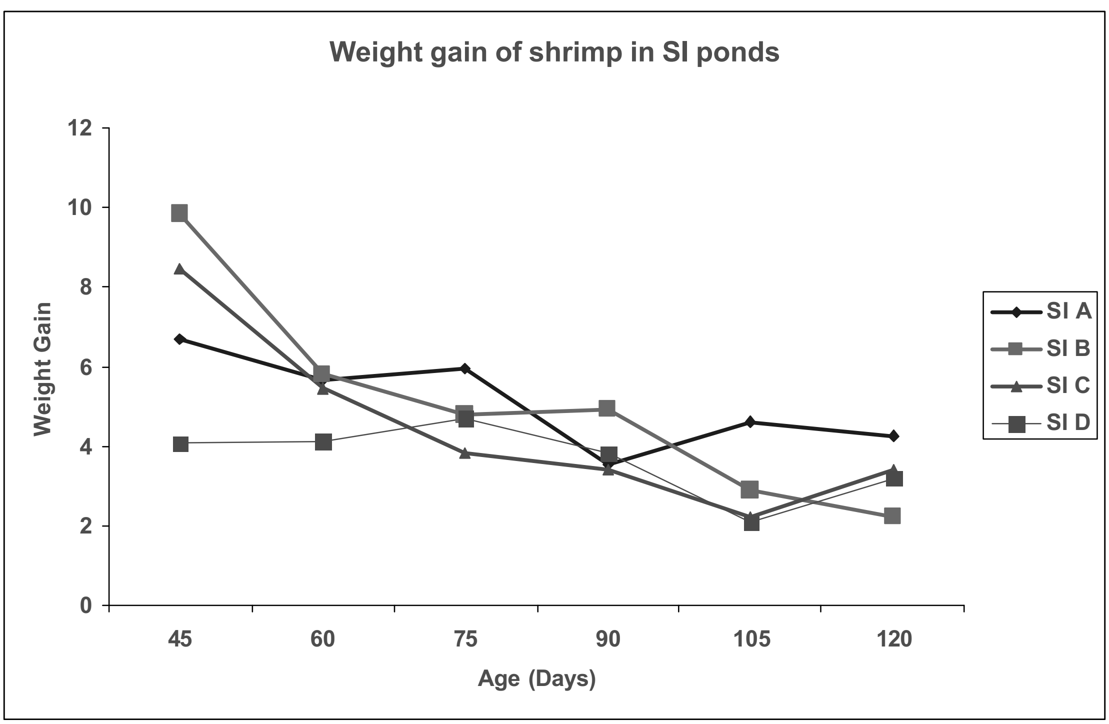

Fig. 5: Weight gain of shrimp in Semi-Intensive ponds

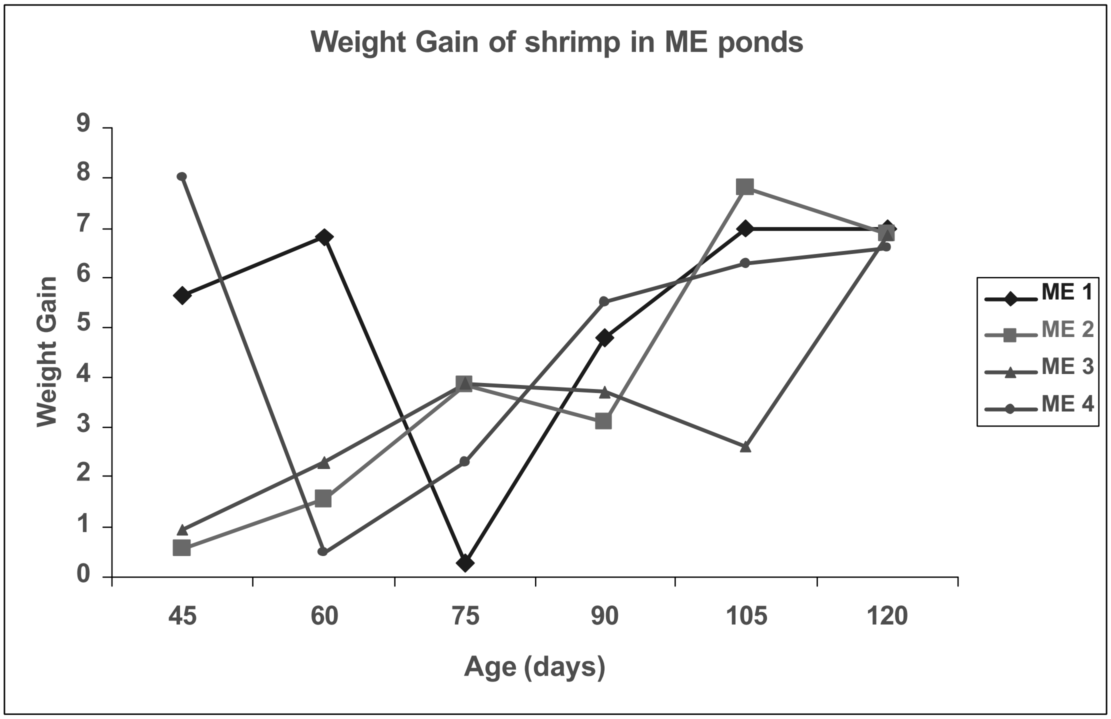

Fig. 6: Weight gain of shrimp in Modified - Extensive ponds

low stocking density as compared to low survival with higher stocking densities in SI ponds. In general, the survival rates recorded during the present study were higher than those reported by earlier workers from other localities in India and other countries (Chakraborty *et al.,* 1985, 1997., Eldani & Primavera,1981 and Ahmed *et al.*, 2000). This seems to be a reflection of the progress achieved in the management practices adopted in culture systems. During the present study, a clear relationship was noted between stocking density and survival rates. Among the four SI ponds, two ponds with lower densities showed fairly high survival rates of 46 % to 52%. Apart from the stocking density, the survival rates apparently depend on other factors including the quality of seed, the pond environmental quality, the quality and quantity of feed used, the rate of water exchange and other management practices.

The growth is dependent on large quantities of fertilizer inputs, abundant natural feed and also on the supplementary feed besides management practices. Growth rate of shrimp depends mainly on the stocking density, the feed utilization and the availability of natural food (Tidwell *et al.*, 2004). Subrahmanyam (1973) has observed growth of *P. monodon* affected by low temperature under laboratory conditions. Verghese *et al*. (1975) observed rapid growth of *P. monodon* coinciding with increase of temperature. During the present study, it was found that slight temperature fluctuations in the course of production cycle were not significant enough to have any role on pond production. Karplus *et al.* (2000) recommended that a grow out period of minimum 140 – 150 days for shrimp to achieve maximum production.

The role of salinity in affecting growth has been suggested by several authors. Subrahmanyam (1973), Verghese *et al.* (1975) and Liao (1977) have observed the direct influence of salinity on growth of *P. monodon.* Chakraborty *et al.* (1986) have observed that the growth was stunted during the period when the salinity was low. In the present study, in both the farms the growth of shrimp was arrested at 30-45 days when the stock had to pass through lower salinities caused by heavy monsoon.

An inverse relationship between stocking density and growth rate was observed by Wyban *et al.* (1987). Total daily feed according to the body weight must be given to the shrimp but the frequency of feeding has no effect on either the growth rate or survival of shrimp (Smith *et al*., 2002). It is found that the growth rates of shrimp in SI ponds is more but the weight gain was high in ME ponds owing to the lower stocking densities.

An analysis of growth rates reported for the various species of shrimp revealed wide variations. Trimble (1980) reported that *P. vannamei* grew 1.28 g

/week at a stocking density of 2.5 shrimp/m^2. Wyban *et al.* (1987) found growth rate to be 1.72 g / week at a stocking density of 5 shrimp/m^2. Liao (1977) and Sundararajan *et al*. (1979) observed faster growth rates have been recorded for *P. monodon* (0.32 to 0.39/g/day).

In our study, the growth rate of 1.9 – 2.3 g/shrimp/week was recorded in the ME ponds with densities of 3-4 shrimp/m^2. In SI ponds, with stocking densities of 15-20/ m^2 almost similar growth rates (1.6 – 2.4) were obtained through judicious use of feed and fertilizers. It is observed that the outbreak of disease in the SI B pond could be due to high stocking density well supported by earlier researchers (Hanson & Goodwin 1977, Baticados *et al*., 1986 and Doubrovsky *et al*., 1988). Martin *et al.* (1998) suggested that the stocking density between 10-20 pls / m^2 is ideal for successful shrimp culture. In the present study, the survival and production was poor in the ponds stocked with more than 20 shrimp /m^2. In the ME ponds stocked with 3 – 5 shrimp/m^2, the survival and growth rates were higher but production was low (500 – 1125 kg/ha). Finally, our study revealed that the maximum production was obtained in ponds with low stocking densities and high survival rates. Based on our study, it is recommended that the ideal stocking density in SI and ME systems to be 10-15 and 3-5 individuals/m^2 respectively.

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