

Briggs M.R.P. and Brown J.H., 1991. The effects of nursery rearing postlarval *Penaeus monodon* at different densities on their subsequent on-growing performance in net cages.

ABSTRACT

Juvenile *Penaeus monodon* produced from a concrete nursery tank system at a range of stocking densities were on-grown in net cages at a common stocking density (125 m^{-2}) to examine the effects of nursery rearing conditions on their subsequent on-growing performance.

Five replicated groups of one thousand juvenile shrimp nursed at four different stocking densities in concrete nursery tanks and one density in net cages were stocked into ten 8m^2 net cages located in a brackishwater pond and on-grown for ten weeks.

Results suggested that small juvenile shrimp produced from concrete nursery tanks stocked at high densities (up to $1,000 \text{ m}^{-2}$) showed high specific growth rates of up to 7% of body weight per day. This increased growth allowed these shrimp to compensate for previous stunting, within one month of subsequent on-growing when compared with large juveniles produced from low (125 m^{-2}) density nursery tanks on-grown under similar conditions.

Juvenile shrimp produced in concrete tank nurseries at moderately high densities (500 m^{-2}) performed significantly better than those produced from net cage nurseries stocked at similar densities when subsequently on-grown in net cages.

Shrimp growth rates thus seem to be determined not only by initial shrimp size, age or on-growing conditions, but also by conditions encountered during their nursery culture. This result indicates the advantages of intensive nursery tank systems yielding high quality, fast growing juvenile shrimp.

INTRODUCTION

In order to make a complete evaluation of the concrete nursery tank system tested at The Tinsulanonda Songkhla Fisheries College in Thailand, the on-growing potential of the juvenile *P. monodon* shrimp produced was examined with the use of fixed net cage grow-out trials.

The first trial (Trial 1, Appendix B.5.) completed in the nursery tank system examined the effects of stocking density on the production of juvenile shrimp from this system. On termination of this trial, juvenile shrimp varying significantly in mean weight were produced (depending upon their respective stocking densities). It was the aim of this trial to assess whether nursing shrimp at

high densities and thereby reducing their growth rate would permanently reduce their growth potential, or whether shrimp held back in this way would be able to compensate for this stunting by a subsequent increased growth rate when ongrown at lower densities.

The trial was conducted by stocking fixed net cages at a common stocking density in terms of numbers (1,000 per cage, 125 m⁻²) rather than biomass, but with different sized animals (0.30 to 0.89g) (table 1) produced from the various stocking density treatments of nursery tank trial 1 (Appendix B.5.). The performance of shrimp in these cages was evaluated with regard to changes in the growth, survival and feeding efficiency of shrimp ongrown in this system.

This is a preliminary account of the first ten weeks of this ongoing trial, prior to a complete analysis when the remaining data is obtained.

MATERIALS AND METHODS

Experimental animals

Juvenile shrimp, 50 days post larval metamorphosis (PL₅₀), were used in this trial. The shrimp utilised were samples of those produced from the four treatments of the first nursery tank trial (Trial 1, Appendix B.5.) examining the effect of stocking density on postlarval shrimp production. One batch of juveniles produced from the net cage nursery trial run simultaneously to the first nursery tank trial (from the same batch of postlarvae) were also used in this ongrowing trial.

Thus, five groups of juveniles with significantly different initial weights (table 1) due to nursery rearing at different densities were used in the five treatments of this trial.

Experimental Design

Replicate groups of juvenile shrimp (PL₅₀) from the four stocking density treatments of nursery tank trial 1 and one group from the net cage nursery trial were assigned to, and ongrown in ten net cages located in a fish pond for ten weeks. The cages measured 4 by 2m by 1.5m deep and were stocked at a common density of 1,000 juveniles per cage (125 m⁻²). The cages were fixed in position in the pond by attaching them to vertical poles of bamboo driven 1m into the substrate of the pond. The cages were made of green nylon mesh netting with a mesh size of 1cm. The cages had a freeboard of 30cm above water level at all times, and were resting partially on the bottom of the 1.2m deep pond. All nets were scrubbed clean weekly, or whenever they became excessively fouled to maintain water exchange through the cages. No supplementary habitats or substrates were used in the cages.

The pond used in the trial was located at the Tinsulanonda Songkhla

Fisheries College in Songkhla, Thailand. The pond was connected to the brackishwater Songkhla lagoon by a tidal channel with a total length of 500m. The pond was open to tidal water exchange (maximum range 50cm) through two narrow inlets which served as the only source of water exchange and aeration used in the trial.

Water Quality

Although water quality was not measured in individual cages due to a lack of access and manpower, a range of water quality parameters were monitored in the pond water adjacent to the cage site since all cages were exposed to a common water supply.

Measurements of dissolved oxygen, temperature, pH, salinity and water transparency were made twice daily at 07.30 and 18.30 h. Dissolved oxygen and temperature were measured with a WTW microprocessor Oxy 96 hand held oxygen/temperature meter ($\pm 0.1 \text{ mg l}^{-1}$ and $\pm 1\%$ saturation DO and $\pm 0.1^\circ\text{C}$ temperature). pH was measured with a WTW microprocessor pH 95 hand held pH meter (± 0.01 pH units). Salinity was measured with a hand held Atago refractometer ($\pm 0.5 \text{ ‰}$ salinity) and transparency with a secchi disc used where possible in the shade and expressed as depths in cm ± 1 cm.

Weekly, 600ml water samples were taken in clean plastic screw top bottles. These samples were filtered under vacuum in a Buchner flask through pre-weighed Whatmans 7cm GFC filter papers to collect suspended solids. The filter papers were then dried to constant weight overnight in an oven at 80°C and reweighed. These weights were used to calculate the load of suspended solids ($\pm 0.1 \text{ mg l}^{-1}$) in the samples.

Filtered water samples were immediately frozen at -15°C before being taken to the water quality analysis laboratories of the National Institute of Coastal Aquaculture (NICA) in Songkhla. There, weekly analyses of total ammonia nitrogen, nitrite and nitrate nitrogen, total orthophosphate were carried out by standard methods (APHA, 1974) and the results expressed in $\text{ug l}^{-1} \pm 0.1$. Hydrogen sulphide was measured weekly by Hach kit Hydrogen sulphide test papers ($\text{mg l}^{-1} \pm 0.1$).

Diets

Shrimp of all treatments were fed a common diet of Aquastar number 2 shrimp pellets containing 42% protein and 3% lipid. Shrimp were fed equal portions of pellets twice daily at 07.00 and 19.00 h according to the following schedule: week 0-2 10%, week 2-4 9%, week 4-6 8%, week 6-8 7% and week 8-10 6% of total biomass daily estimating 5% mortality per fortnight. Pellets were fed on a single 50cm diameter 1mm nylon mesh feeding tray per cage for 13 days per fortnight.

Sampling Procedure

At the initiation of the trial a sample of 100 shrimp from the 1,000 stocked into each cage were starved for 24 h, blotted dry and individually measured (total length $\pm 0.1\text{mm}$) using a measuring board and group weighed on a six figure microbalance to $\pm 0.01\text{g}$. Subsequently, on the 14th day of every fortnight until termination of the trial on week 10, 30 shrimp were sampled from each cage using a standardised netting technique with the aid of a 50cm diameter sample net. The sampled shrimp were individually measured and group weighed as above before being returned to their respective cages.

Statistical Analysis

Growth, survival and feeding efficiency treatment group comparison data was subjected to statistical analysis to test for statistical differences. These analyses were conducted using one-way ANOVA, and, where appropriate, regression analysis and Duncan's multiple range test (Steel and Torrie, 1960) to determine statistical differences between treatment means. Results were considered significant at the $P < 0.05$ probability level.

RESULTS AND DISCUSSION

Water Quality

Water temperature over the trial period was stable with a mean of $30.4\text{ }^{\circ}\text{C}$, and optimal for juvenile shrimp growth. Salinity was also high with an average of $26.0\text{ }‰$. Salinity was invariably higher than the optimum range of $15\text{-}25\text{ }‰$ for juvenile *P. monodon* production, except during the last two weeks of the trial and may thus have slowed the growth rate to below optimal. All cages were, however, exposed to the same salinity, allowing direct comparison between treatments. pH was stable and at the lower end of the optimal range, at an average of 7.61. Secchi disc readings were very high, ranging from 84 to 130 cm, with an average of 101.9 due to the low algal biomass in the pond, although natural feeding was available from the rapidly-fouled net cage walls of all treatments. DO levels were very stable ranging from 5.0 to 7.3 mg l^{-1} , with a mean of 6.0 mg l^{-1} (92.5% saturation), allowing good growth of shrimp at all times. These oxygen measurements were, however, recorded outside the net cages and maintenance of DO levels within the cages was dependant on regular (weekly) scrubbing of net walls to remove excess fouling and increase water transmission through the cages.

Levels of suspended solids in the pond water were low and constant at a mean of 90.6 mg l^{-1} . Dissolved nutrient levels of NH_3 , NO_2 , NO_3 , P and H_2S were also monitored and were generally stable and within tolerable limits for juvenile *P. monodon*. Mean levels of these nutrients over the trial period were 0.359, 0.003, 0.114, 0.035 and 0.0 mg l^{-1} respectively. NH_3 levels did, however, rise from the generally safe mean of 0.36 mg l^{-1} to a possibly toxic high of 0.6

TABLE 1: Performance of shrimp in cage on-growing trial 1*

Parameter	Treatment				
	1	2	3	4	5
Previous Stocking Density (No.m ⁻²)	125	250	500	1,000	521 (cage)
Initial L. (mm)	52.85 ^{a**}	46.44 ^b	43.26 ^c	38.18 ^d	42.24 ^c
Final L. (mm)	75.06 ^a	78.36 ^a	82.87 ^a	75.91 ^a	84.60 ^a
Initial Wt. (g)	0.8873 ^a	0.5502 ^b	0.4126 ^c	0.3039 ^d	0.4960 ^e
Final Wt. (g)	2.4724 ^a	2.6707 ^a	3.3660 ^a	2.4228 ^a	3.7021 ^a
Total Wt. gain (g)	1023.87 ^a	1514.25 ^a	2189.32 ^b	1568.92 ^a	2365.72 ^b
Percent Wt. gain	178.65 ^a	385.41 ^b	715.80 ^c	697.24 ^c	646.40 ^c
SGR (%Body Wt.d ⁻¹)	1.46 ^a	2.26 ^b	3.00 ^c	2.97 ^c	2.87 ^c
F C R	7.77 ^a	4.63 ^b	3.49 ^c	3.48 ^c	1.95 ^d
P E R	0.32 ^a	0.51 ^b	0.69 ^c	0.68 ^c	1.23 ^d
F C E	0.14 ^a	0.22 ^b	0.29 ^c	0.29 ^c	0.52 ^d

* Based on the mean of two replicates

** For single criterion, mean values in the same row bearing the same superscript are not significantly different (P<0.05).

Figure 1:

The effect of previous stocking density on subsequent mean length (+SE) of shrimp with time.

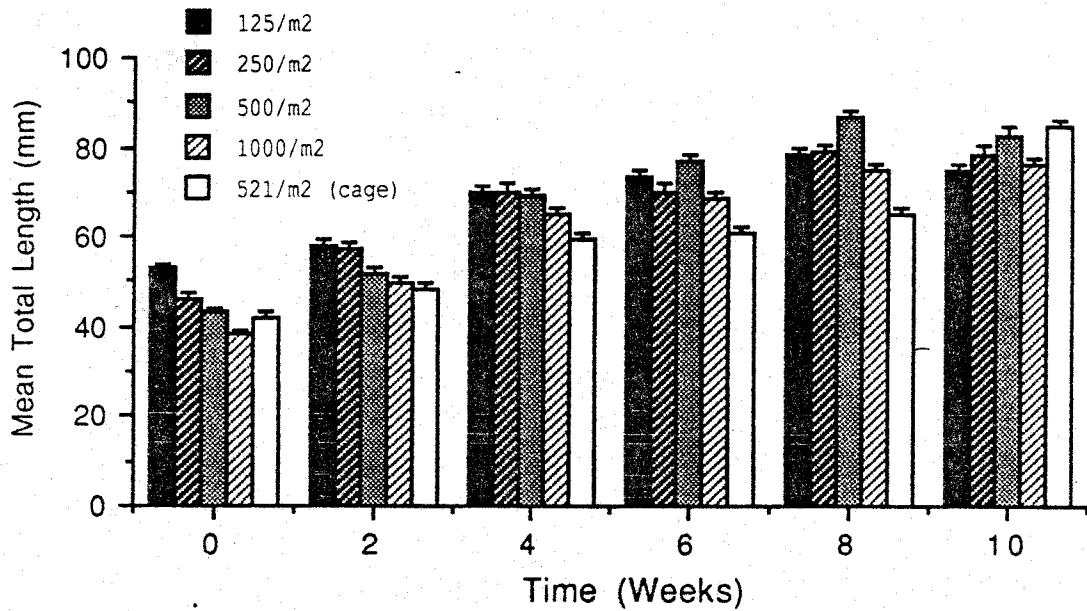


Figure 2:

The effect of previous stocking density on subsequent mean weight (+SE) of shrimp with time.

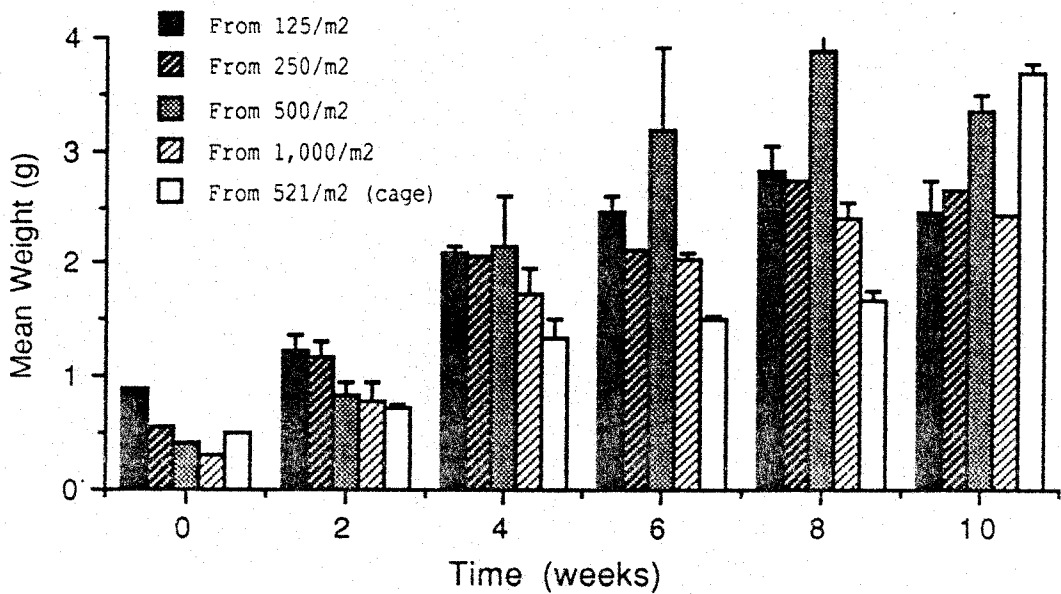


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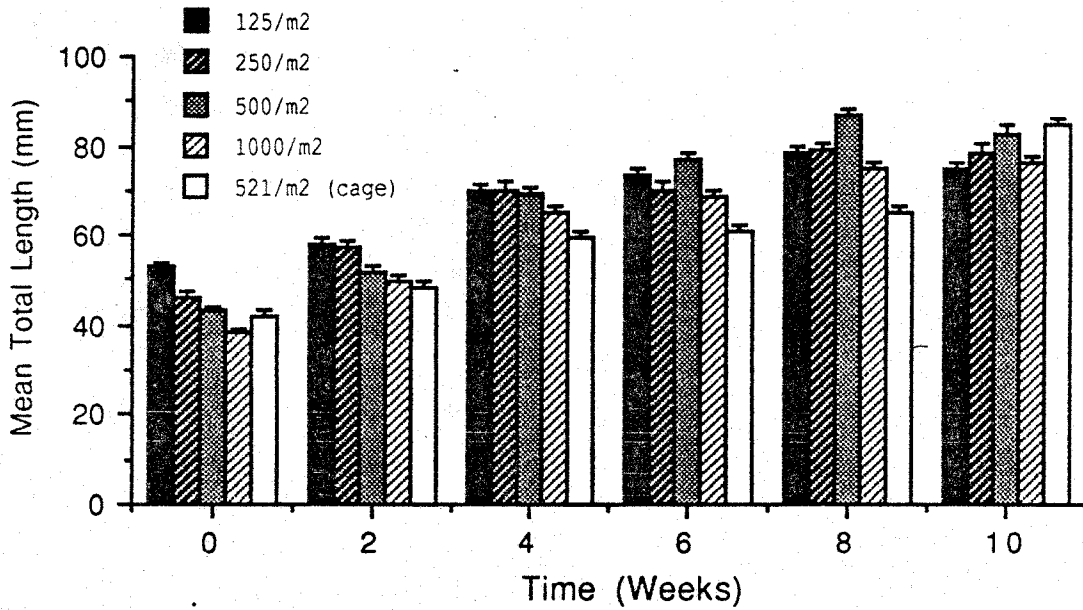


Figure 2:
The effect of previous stocking density on subsequent mean weight (+SE) of shrimp with time.

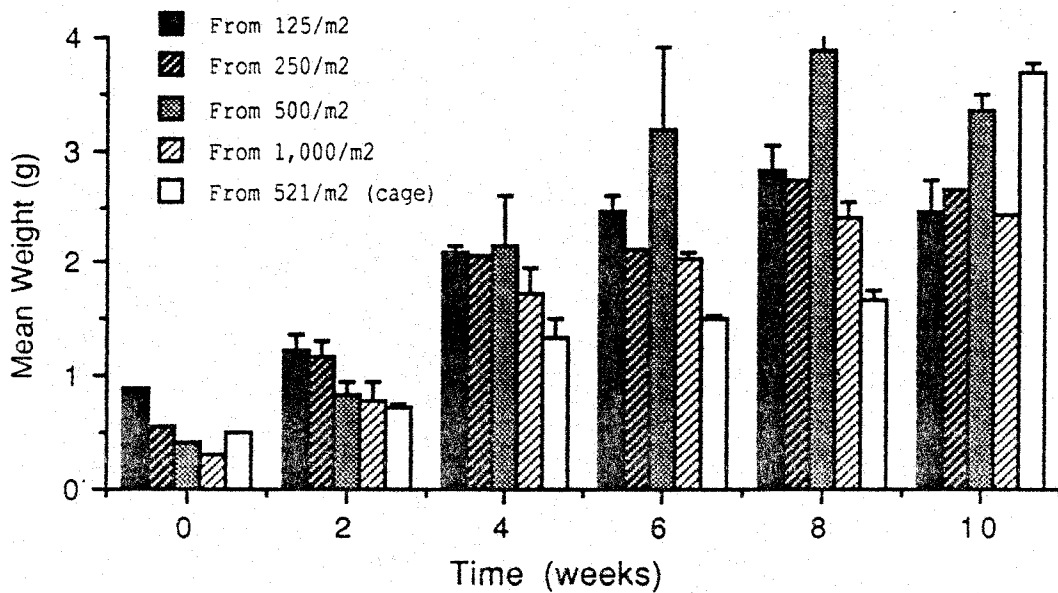


Figure 3

The effect of previous stocking density on subsequent percentage weight gain (+SE) of shrimp with time.

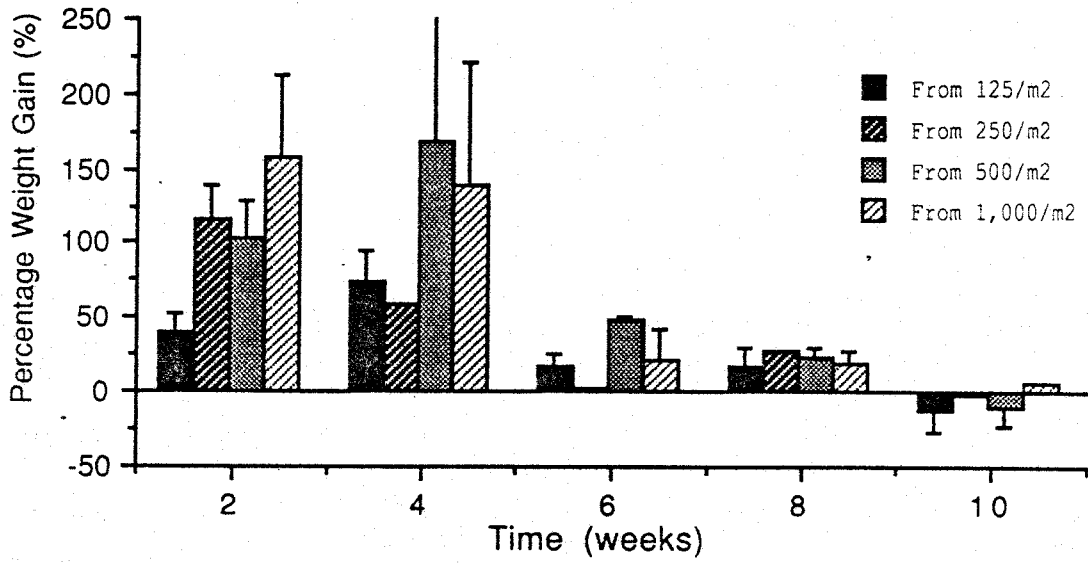
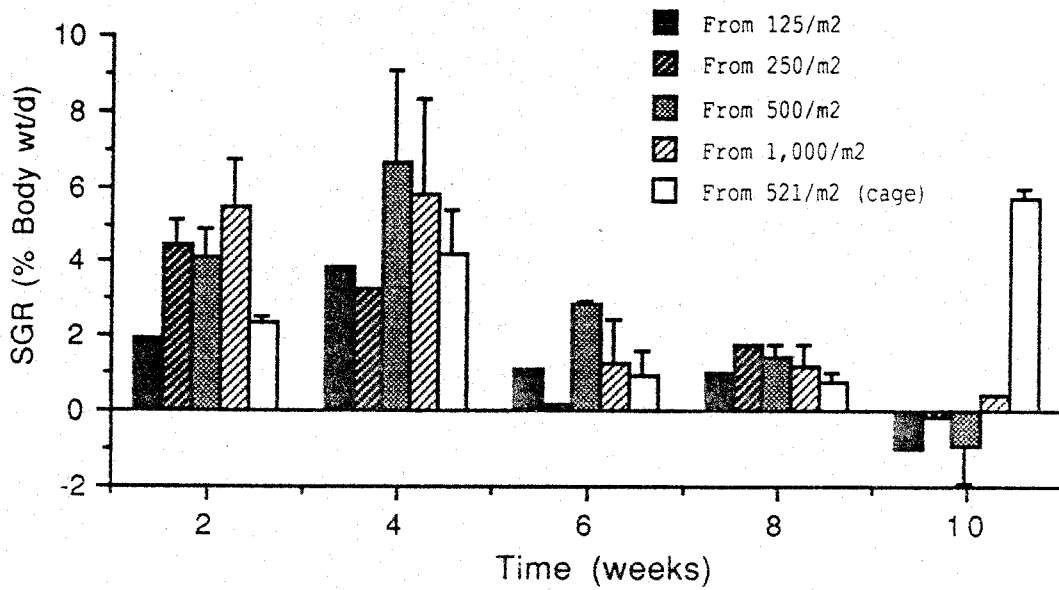


Figure 4:

The effect of previous stocking density on subsequent SGR (+SE) of shrimp with time.



mg⁻¹ in week 4, probably as a result of the other cage farming activities in the pond utilised in this trial. Mass mortalities as a result of this ammonia level were not, however, evident during the trial period. Overall, the water quality of the pond housing the net cages presented no problems to the growth of shrimp in this trial.

Growth, Survival and Feeding Efficiency

Both mean shrimp length and weight were significantly ($P < 0.05$) different between treatments on day 0 of the trial. Mean length varied from 53 to 38 mm and mean weight from 0.89 to 0.30g for treatments 1 to 4 respectively (Table 1 and figures 1 and 2). By week four, and onwards to termination of the trial on week 10, however, the mean lengths and weights of shrimp from all treatments were not significantly ($P < 0.05$) different, suggesting that the smaller shrimp were indeed growing more rapidly than the larger ones. These results were confirmed by the significantly ($P < 0.05$) higher percentage weight gain and SGR of shrimp over the first month in the treatments using smaller individuals (Table 1 and Figures 3 and 4). This trend was particularly noticeable for treatment 3, from the nursery tank stocked at 500 m⁻² which produced the largest shrimp of any treatment from week 6 onwards.

Shrimp in treatment 5, originating from the cage nursery stocked at a similar density to tank nursery treatment 3, performed significantly worse than those in treatment 3 (Table 1 and Figures 1-4) apart from an apparent growth spurt over the final two weeks of the trial, which may have been due to mortality of shrimp in this treatment. This result suggests that better quality juvenile shrimp were produced from the concrete tank system used in the nursery stages of these trials.

Although smaller shrimp might be expected to grow faster than larger ones (as growth rate is inversely proportional to shrimp size), from week four onward, to the end of the trial on week 10, there were no significant differences in mean shrimp length between treatments. Shrimp in treatment 3, however, attained a significantly larger final mean weight than those of other treatments. This suggests that the shrimp were even over-compensating for their earlier stunting (as a result of being raised at high density) by subsequent faster growth, particularly in the early stages of ongrowing.

Overall, shrimp growth rate in all treatments slowed after the first four weeks and was even negative by the end of the trial period. This was probably due to total shrimp biomass reaching the carrying capacity of the cages used by this stage of the trial.

Feeding efficiency followed a similar pattern to growth rate, tending to be inversely related to initial weight. FCR improved significantly ($P < 0.05$) from 7.77 to 3.49 and 4.48 for treatments 1 to 3 and 4 respectively (Table 1). This was probably due to the initially smaller biomass in treatments 3 and 4 allowing more space

for shrimp and improved feeding from natural sources within the cages. Shrimp in treatment 5 from the net cage nursery displayed the best FCR of 1.95. This may have been due to their previous adaptation to conditions in the cage, particularly with regard to use of the natural food available within the cage environment. It may also have been effected by the possible, unquantified mortality in this treatment towards the end of the trial period, allowing sudden rapid growth of the less densely stocked shrimp.

Survival was not measured during the trial due to the stress involved in complete sampling at each fortnightly period and, unfortunately could not be recorded at the termination of the trial after 10 weeks since severe flooding at this time allowed most of the shrimp to escape.

CONCLUSIONS

From the data of the first ten weeks of this cage trial, it seems likely that the initial stunting of shrimp growth by high density culture in nursery systems is not permanent, but can be compensated for within a month by subsequent increased growth of shrimp when ongrown under less crowded conditions. Once the previously stunted shrimp have caught up with the growth rate of shrimp nursed at low densities, no further growth advantage is conferred. The results of this trial show that shrimp growth rate is not determined solely by ongrowing conditions and shrimp size or age, but depends to a large extent on their previous culture history, particularly with regard to stocking densities used during the nursery phase of their culture.

This result, if confirmed, would allow increased stocking density and hence production of shrimp in concrete tank nurseries and lead to increasingly profitable, highly intensive nursery systems yielding good quality, fast-growing juvenile shrimp.

The performance of shrimp reared in both nursery and ongrowing cages (treatment 5) requires further comparison with the respective stocking density treatments from concrete tank nursery systems (treatment 3) as results from this trial were inconclusive. It appears that shrimp nursed in concrete tanks may have a greater growth potential than those from net cages. Net cage nurseries however, could offer a cost saving measure for shrimp nursery systems stocked at relatively low densities if comparable growth rates can be achieved in subsequent ongrowing.

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