Effect of stocking density on pen reared pink shrimp *Farfantepenaeus paulensis* (Pérez-Farfante, 1967) (Decapoda, Penaeidae).

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Abstract

Once stocking density is an important factor that affects shrimp production in captivity, this paper aimed to analyze the growth and survival of pink shrimp *Farfantepenaeus paulensis* (Pérez-Farfante, 1967) stocked in pens at different densities. For each 3 pens(1 m^2 each), 30, 60, 90 and 120 juveniles (drained weight from 0.5 to 1.0 g) were randomly stocked. Shrimps were reared from 0.75 g (mean initial weight) to 6.39 g (general mean final weight) for 90 days. The results showed a negative correlation between growth and stocking density (ANOVA; $P<0.05$), although survival presented no statistical difference ($P>0.05$) for different densities, ranging from 85.8 to 95.0 %. The final biomass, however, was significantly higher (517.1 g/m^2) at 120 shrimps per m^2. The conclusion drew indicates it is possible to stock and rear *F. paulensis* in open systems at high densities.

Key words: Rearing, shrimp, stocking density, pen

Introduction

For the last 6 years, researchers of University of Rio Grande (Rio Grande do Sul State, Brazil) have developed several studies in order to create a shrimp culture package for Patos Lagoon estuary artisanal fishermen.

Alternative structures used in aquaculture, such as pens and cages set on the natural environment are widespread used on Southeast Asia. According to Genodepa (1999), the culture in alternative structures preserves the environment, once aquatic organisms are produced in their natural habitat. One reason for the development of this kind of culture is to offer waterside dwellers, as small fishermen and farmers, an alternative income with little investment. However, applied research must guide this activity in order to keep it sustainable.

In this context, the stocking density used plays an important role over the survival, growth and consequently over the biomass produced from a culture system (Wyban and Sweeney, 1991). The optimal stocking density is a function of each species, environmental conditions, system and management adopted. Throughout the world, most ponds are stocked with 1 to 5 shrimp/m^2 (extensive system) or 5 to 25 shrimp/m^2 (semi-intensive system), due to limitation of water exchange, fact that also limits the pond charge capacity. On the other hand, open cultures (pens and cages) can hold a higher number of animals per area due to its high water renewal, once currents maintain acceptable water quality. However, either pond as open systems have shown negative correlation between stocking density and crustacean growth rates. Lutz and Wolters (1986) detected reduced growth rates for the crawfish *Procambarus clarkii*

(Girard) stocked in densities varying from 1 to 16 animals/m^2. Sandifer *et al.* (1987) working with *Litopenaeus vannamei* (Boone, 1934) stocked at 10, 20 and 40/m^2 also verified that the latter density presented significant growth rate reduction.

Although it seems reasonably obvious that growth is affected as intraespecific competition increases, densities used on cultures must be as higher as the environment can hold in order to keep the business profitable. Allan and Maguire (1992) mention that cultures are only feasible if costs are reduced, being, so, maximum tolerable densities must be known for each species, what means that survival and growth rates are not affected for producing a higher cultured biomass. As earlier mentioned, shrimp are stocked into pens and cages in relative high densities, causing behavioral changes which can affect both growth and survival.

The present work had as objective to study the effects of stocking densities on the growth and survival of pen reared *F. paulensis*.

Material and Methods

The structures used for the experiment comprised of 12 iron framed (3/8") squared pens covered on sides and top with polyamide mesh (a=0.5 cm), for the avoidance of shrimp escape and predators entrance, each bearing a bottom area of 1 m^2 by 1.2 m in height. Pens were set with a water column of 0.70 m and buried 0.15 m deep into the sediment, in Patos Lagoon estuary, southern Brazil. For each 3 pens, 30, 60, 90 and 120 juveniles (drained weight from 0.5 to 1.0 g) were randomly stocked. Shrimps were produced through reproduction in laboratory accordingly to methods cited in Marchiori (1996), Cavalli *et al.* (1997) and Wasielesky (1999).

Shrimps were fed once at evenings with shrimp grow-out ration (Sibra[a]) at an initial feeding rate of 10% of total biomass, decreasing until a rate of 4% in the end of the experiment. Temperature, salinity, pH and dissolved oxygen were monitored daily.

Each pen was seined every 15 days to collect a sample of 20 shrimps, which were drained weighed to the nearest 0.01 g, until the 90th day of experiment, when survivors were counted. Immediately after sampling, shrimps were returned to their respective pens. Final weights and survivals in different replicates were submitted to variance analysis (ANOVA), regarding the necessary premises, and since no statistical differences ($P>0.05$) were found, replicates were grouped. Afterwards, mean data among treatments were also submitted to ANOVA in order to detect possible differences. Whenever statistical differences ($P<0.05$) were found, the Tukey test was applied. Based on these results, the mean biomass for each stocking density was then estimated.

Results

The mean physical-chemical parameters daily measured in water experiment were: Temperature 25.1°C; salinity 18.2; pH 8.01 and dissolved oxygen 6.01 mg/L.

Regression lines for pink shrimp growth was estimated based on drained weights and fit to the least square model, as shown in Figure 1.

The week growth rates (g/week) for each density were 0.59 (30/m^2), 0.46 (60/m^2), 0.38 (90/m^2) and 0.33 (120/m^2), thus demonstrating an inhibitory effect ($P<0.05$) of stocking density over growth. The daily growth coefficient (DGC) for each stocking density were 1.24 % (30/m^2), 1.09 % (60/m^2), 0.97 % (90/m^2) and 0.89 % (120/m^2), showing a similar pattern of the week growth rate. In spite of a lower growth, in the end of culture, the mean biomass within pens significantly increased ($P<0.05$) in function of higher densities, due to a statistically similar survival among treatments (Table I).

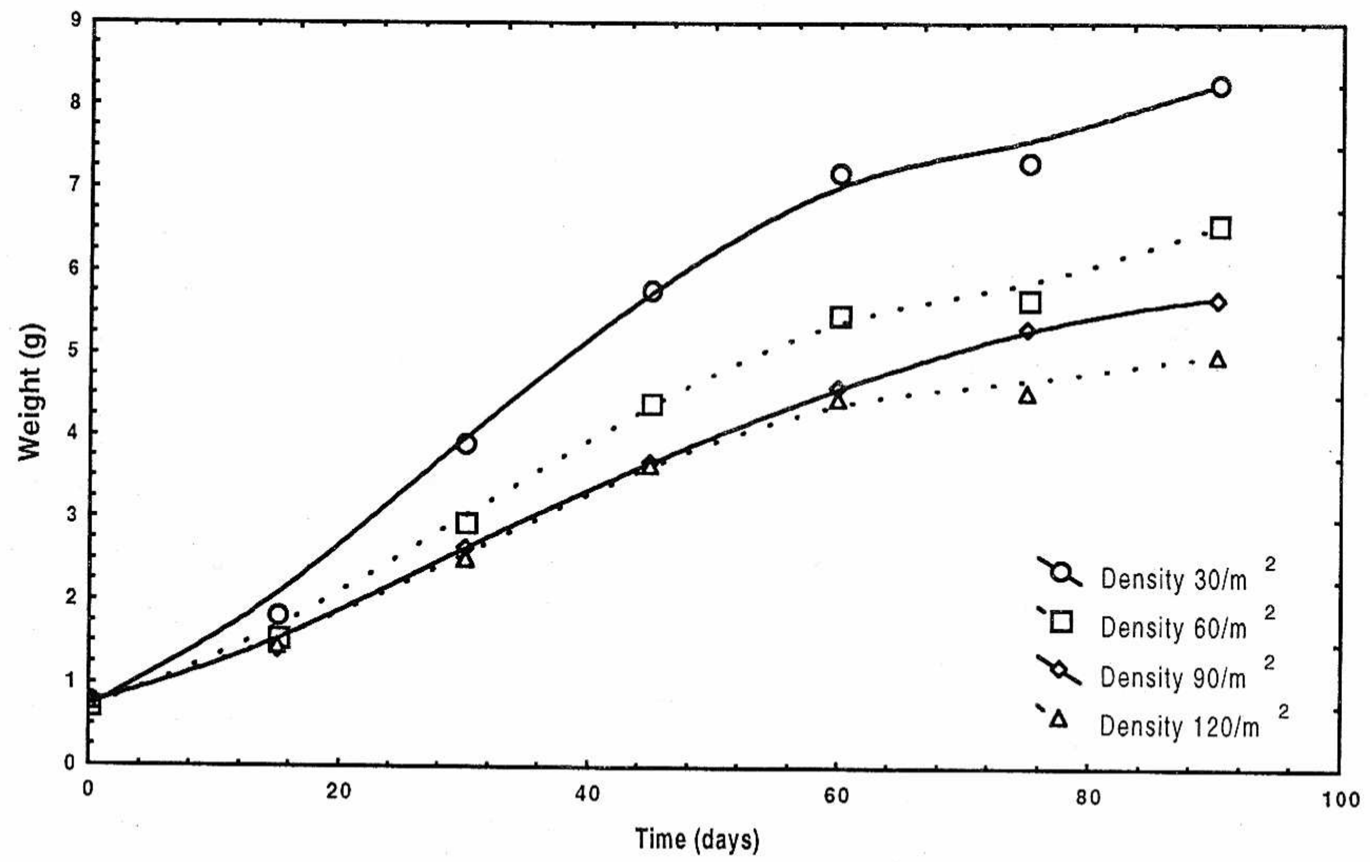

Figure 1: Growth of pen reared pink shrimp *F. paulensis* juveniles stocked at densities of 30, 60, 90 e 120 animals/m² (data adjusted to the least square model).

Table I: Initial number (IN), mean final number (FN), survival (S), initial weight (IW), mean final weight (FW) and mean final biomass (B)

Density	IN	FN	S (%)	IW	FW	B (g/m²)
30/m²	30	28	93.3 A	0.75±0.21 A	8.28±0.61 A	231.8±22.1 A
60/m²	60	57	95.0 A	0.72±0.16 A	6.57±0.71 B	374.5±27.5 B
90/m²	90	81	90.0 A	0.76±0.16 A	5.69±0.68 BC	460.9±39.4 C
120/m²	120	103	85.8 A	0.76±0.16 A	5.02±0.61 C	517.1±43.2 D
Probability	-	-	-	0.861	0.000	0.000

of pen reared pink shrimp *F. paulensis* juveniles stocked at densities of 30, 60, 90 e 120 animals/m². Data represent mean values ± SD. Similar letters indicate statistically similar means (P>0.05).

Discussion

Variations of pen water quality during the experiment are in accordance with the normal growth range for the species, therefore presented no deleterious effect on both growth and survival of reared shrimp, according differents experiments carried out by Wasielesky (1999).

As early mentioned the trend of higher stocking densities had been to affect survival. Ravichandran *et al.* (1980), rearing *Penaeus monodon* (Fabricius, 1798) at densities of 2.5, 5, 7.5, 10 and 15 animals/m² only detected higher mortality (70%) at 15 animals/m². Not likewise, Sandifer *et al.* (1987) working with *L. vannamei* in ponds stocked at densities of 10, 20 and 40 shrimp/m² found survivals of 66.3, 68.0 and 63.3%, respectively. Once most authors found great variability in the results for different cultured species, survival may not be affected by the variable density, once either in ponds as in pens shrimp can use the substrate as shelter, burying themselves to get protection against adverse environmental conditions, like it is cannibalism.

On the other hand, when rearing structures that lack in substrate are used, such as tanks and cages, the stocking density seems to exert a more significant effect on the survival rate of cultivated shrimp. For example, when working with nursery cages for *P. monodon* at densities of 72, 144, 288, and 423 juveniles/m², Rodriguez *et al.* (1993) registered survivals of 91.7, 90.8, 82.1 and 69.1%, respectively. Similar results were found by Scardua (1998) when rearing *F. paulensis* in cages at densities of 50, 100 and 150 shrimp/m². In this case, respective survival percentage were 94.3, 62.5 and 57.7. In the present research, even at the highest stocking density (120/m²) a high survival rate was obtained (85.8%).

Contrary to survival, penaeid shrimp growth rate is a parameter highly affected by the stocking density. There is almost an agreement among researchers: the higher the density, the lower the growth rate. In fact, in the present study it was observed that growth of *F. paulensis* juveniles was negatively affected by the stocking density. Apud *et al.* (1980) also verified a negative correlation between *P. monodon* growth rate in function of a higher stocking density. Similar results were found by Aravindakshan *et al.* (1980) when rearing *Fenneropenaeus indicus* (Milne Edwards, 1837) in cages, where a growth rate reduction of 60% took place, at the density of 40 shrimp/m^2, in comparison to lower densities (5 and 10/m^2).

With regard to the potential of *F. paulensis* grow-out in alternative structures (pens and cages) at Patos Lagoon estuary, this study data demonstrates feasibility and good performance in comparison to other species.

Another fundamental parameter to be considered by a shrimp farmer is the final biomass, once it refers to the total production at harvest. It is determined in function of shrimp survival and mean final weight. Most papers on cage aquaculture suggest the use of higher stocking densities (from 30 to 150 shrimp/m^2) if compared to conventional ponds.

As an example of this fact, when Martinez-Cordova (1988) stocked *Litopenaeus stylirostris* (Stimpson, 1874) in floating cages at a density of 100 shrimp/m^2 for 105 days, a net productivity of 411g/m^2 was obtained. An even better productivity with floating cages was achieved by Walford and Lam (1987) working with *F. indicus* at 80 shrimp/m^2, when 112 days after nursery resulted of 600 g/m^2. Although the present study lasted only 90 days, the pen densities of 90 and 120 shrimp/m^2 resulted in a net of 460 and 517 g/m^2, respectively. The density of 60 shrimp/m^2 resulted in mean final biomass of 374.5 g/m^2, however Jorgensen (1998) with the same experimental conditions and species obtained only 116.4 g/m^2. In spite of the good performance of *F. paulensis* in this work, other penaeid may present even better results in terms of productivity at high densities. Wyban *et al.* (1989) can here be cited for rearing *L. vannamei* at stocking densities of 45, 75, 100 and 150 shrimp/m^2, where net productivity of 710, 1710, 1600 and 1910 g/m^2 were obtained, confirming not only the excellent zootechnical performance of the species but also the penaeid potential to be stocked at high densities.

Taking into account the little number of published works regarding commercial scale pens, the biomass produced within this system point to a promising use in carcinoculture. As an example, there are the works of Samaranayake (1990), in which *P. monodon* averaging 2 g was stocked at 4 shrimp/m^2, in a 0.18 ha pen, and resulted in survival of 70.8% and a total production of 719.4 Kg/ha in 120 days of culture; the work of Lumare (1982) with *Marsupenaeus japonicus* (Bate, 1888) initially averaging 0.2 g, in two 0.1 ha pens, which resulted in 364.3 and 373.5 Kg/ha in 113 and 141 days of culture, respectively; and the work of Wasielesky (2000), in which *F. paulensis* averaging 0.18 g was stocked at 7.5 shrimp/m^2 and resulted in mean final weight of 9.05 g and survival of 82.5%, reaching a net production of 560.3 kg/ha in 100 days of culture. These data also support that *F. paulensis* presents good performance in commercial scale structures.

Conclusion drew from results described in this paper made clear the inverse effect of stocking density upon pen reared *F. paulensis* growth rates. However, the species grow-out at high densities, for relatively long periods, can produce a similar, or even higher, cultured biomass than those registered for other penaeids. Being so, *F. paulensis* may be cultured in pens stocked at high densities by Patos Lagoon artisanal fishermen, as a means of supplementing their precarious income.

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References

Allan, G. L. and Maguire, G. B. 1992. Effects of stocking density in production of *Penaeus monodon* Fabricius in model farming ponds. Aquaculture, 107(1): 49-66.

Apud, F. D.; Gonzales, K. and Deatras, N. 1980. Survival, growth and production of *Penaeus monodon* at different stocking densities in earthen ponds with flow through system and supplementary feeding. Res. Rep. Aquac.Dep. Southeast. Asian Fish. Dev. Cent. 1980, 4(4): 15-18.

Aravindakshan, P. N.; Paulinose, V. T.; Balasubramanian, T.; Menon, P. G. and Krishnankutty, M. 1980. On the growth of Penaeus indicus experimented in cages at different densities in a selected nursery ground. Proceedings of the Symposium on Coastal Aquaculture, Cochin, India, 1980. Part-1: Prawn-Culture. 398-402 pp.

Cavalli, R. O.; Scardua, M. and Wasielesky, W. J. 1997. Reproductive performance of different-sized wild and pond-reared *Penaeus paulensis* females. Journal of the World Aquaculture Society, 28(3): 260-267.

Genodepa, J. G. 1999. Pen culture of experiments of the mud crab *Scylla serrata* in mangrove areas. Proceedings of an international forum in Darwin, Australia, 216pp.

Jorgensen, P. 1998. The pen experimental culture of *Penaeus paulensis* in a Patos Lagoon estuary bay - Brazil: Association responses to benthic macroinvertebrates. Biolagical Oceanography Master dissertation, Fundação Universidade do Rio Grande, RS, Brazil. 227 pp.

Lumare, F. 1982. Studio Sull'allevantamento di *Penaeus japonicus* Bate in Moduli di Rete ella Laguna di Lesina. Relazione ativvitá. Ministero Agricoltura e Foreste. Italy, 38 pp.

Lutz, C. G. and Wolters, W. R. 1986. The effect of five stocking densities on Growth and yield of red swamp crawfish *Procambarus clarkii*. Journal of the World Aquaculture Society, 17(1-4): 33-36.

Marchiori, M. A. 1996. Guia ilustrado de maturação e larvicultura do camarão-rosa *Penaeus paulensis* Pérez-Farafante, 1967. Ed. FURG, 79 pp. Rio Grande, RS, Brazil.

Martinez-Cordova, L. R. 1988. Culture of Blue Shrimp (*Penaeus stylirostris*) in floating cages. Univesidad de Sonora Hermosillo, Sonora 83000. México. Progress Fish-Culturist, 50:39-41.

Ravichandran, P.; Verghese, P. U.; Karmakar, H. C. and Rajyalakshmi, T. 1980. Effect of stocking density and size on *Penaeus monodon* (Fabricius) postlarvae in nursery rearing experiments. Proceedings of the Symposium on Coastal Aquaculture, january-12-18/1980. PART-1. Cochin, India , 412-413 pp.

Rodriguez, E. M.; Bombeo-Tuburan, I.; Fukumoto, S. and Ticar, R. B. 1993. Nursery rearing of *Penaeus monodon* (Fabricius) using suspended (hapa) net enclosures installed in a pond. Aquaulture, 112: 107-111.

Samaranayake, R. A. D. B. 1990. Pen culture trials with the tiger prawn *Penaeus monodon* in Chilaw lagoon, Sri Lanka. In: Hirano e Hanyu (eds.). Proceedings of the second Asian Fisheries Forum. Tokyo, Japan, april/1989. The Asian Fisheries Society, Manila, Philippines, 107-108 pp.

Sandifer, P. A.; Hopkins, J. S. and Stokes, A. D. 1987. Intensive culture potencial of *Penaeus vannamei*. Journal of the World Aquaculture Society, 18(2): 94-100.

Scardua, M. P. 1998. Utilização de alimentadores do tipo bandeja no cultivo do camarão rosa *Penaeus paulensis* (Pérez-Farfante, 1967) em tanques redes. Master thesis, Universidade Federal de Santa Catarina, Brazil, 78 pp.

Walford, J. and Lam, T. J. 1987. Floating hatchery and net cage culture of *Penaeus indicus* in the straits of shore, Singapore. Aquaculture, 62:11-32.

Wasielesky, W. J. 1999. Oceanos: Fontes de Alimentos. "Production of Marine Shrimp *Penaeus paulensis* in Southern Brazil: Culture in Alternative Structures", Book Chapter. Publication of Roberto Marinho Foundation, Gerdau, and CNPq, XV Jovem Cientista Award, p. 53-106

Wasielesky, W. J. 2000. Culture of pink shimp *Farfantepenaeus paulensis* (Decapoda:Penaeidae) in Patos Lagoon estuary: effects of environmental paramenters and management. Biological Oceanography PhD thesis, Fundação Universidade do Rio Grande, RS, Brazil. 199 pp.

Wyban, J. A and Sweeney, J. N. 1991. Intensive shrimp production technology. Oceanic Institute shrimp manual. Honolulu, Hawaii, USA. The Oceanic Institute, 1991, 158 pp.

Wyban, J. A.; Sweeney, J. N.; Kanna, R. A.; Kalagayan, G.; Godin, D.; Henandez, D. and Hagino, G. 1989. Intensive shrimp culture management in round ponds. In: Simpósio Brasileiro sobre Cultivo de camarão, João Pessoa, PB. Anais. vol. 1, 189-202 pp.

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