



The effect of stocking density on the growth of apple snails native *Pomacea bridgesii* and exotic *Pomacea lineata* (Mollusca, Gastropoda)

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ABSTRACT

The demand for alternative food sources is currently in evidence in the world and, therefore, the culture of animal species considered not conventional makes this theme relevant and appropriate. In the present study, the species *Pomacea lineata* and *Pomacea bridgesii*, each with three stowage densities (0.5 [T1], 1 [T2], and 1.5 [T3] animal/L), were tested. They were analyzed regarding growth rate, weight gain, final biomass, feed conversion and percentage of survival. There was not any statistically significant difference between the different densities for both species. The final average weight in the three waterworks did not differ significantly in *P. bridgesii*. In *P. lineata*, T1 ($22.3 \pm 1.80\text{g}$) was significantly higher than T2 and T3. On the other hand, the absolute gain of weight in *P. lineata* and *P. bridgesii* was significantly higher in T1 ($21.9 \pm 1.80\text{g}$ and $37.2 \pm 6.34\text{g}$) than in T2 and T3 respectively. In contrast, the gain of biomass of *P. lineata* and *P. bridgesii* was significantly higher in T3 ($276.3 \pm 33.16\text{g}$ and $431.4 \pm 37.20\text{g}$) than in T1 and T2, respectively. Based on the results obtained, all species studied presented potential for aquaculture, mainly *P. bridgesii*, distinguished for showing a better development even in waterworks with higher densities.

Key words: mollusk, aquaculture, alternative food source, feed conversion, grow rate, weight gain.

INTRODUCTION

Currently, world aquaculture has been prominent for the growth and successive rise of productivity. Its share on world fish production attains values over 55.1 million tons/year (FAO 2010), conferring to this type of production a prominent position in the sector of international meat production.

Having the fish gathering practically reaching its maximum limit of sustainable exploitation, with a growth rate inferior to 1% per year, aquaculture has been showing an average growth of 6.6% per year (FAO 2005).

Towards the continuous rise in population rate and, consequently, food demand, it is noticeable a protein-caloric malnutrition, mainly in underdeveloped countries (Freitas and Barroso

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2006). Mainly with the reduction on the availability of fishing food products, the demand for different food sources has been growing. With that in mind, it has been even more noticeable the exploitation and the culture of animal species considered not conventional and not traditionally commercialized.

Among the animals with high potential as food source there can be found mollusks of the genre *Pomacea*, which are rich in proteins, carbohydrates, fat, glycogen and essential amino acids. The species *Pomacea lineata* (Spix

1827), and *Pomacea bridgesii* (Reeve 1856) are gastropods from the Ampullariidae family and inhabit low marginal zones of rivers, brooks, lakes and calm water swamps (Figure 1). The species *P. lineata* can be widely found in the South American continent, but they are currently spread in the Northeast area of Brazil (Guimarães 1981). The species *P. bridgesii* is native from Florida, USA, and it can be found in lakes and swamps of North America, making of this an exotic species in the South American continent.

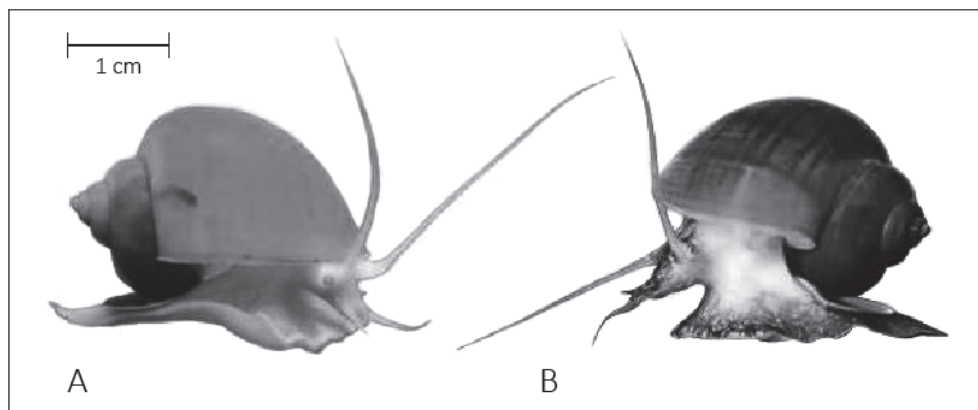


Figure 1 - Side view of: **A)** *Pomacea bridgesii* **B)** *Pomacea lineata* (Chesquiere, s/d).

Pomaceas are fed of plants and seaweed leftovers, their own aerial and bronchial breathing, and internal fertilization and they are oviparous (Guimarães 1981).

The snails can be used to other finalities. Bombeo-Tuburan et al. (1995) studied the application of the golden apple snail *Pomacea monodon*, a native snail from South America, how food supply in shrimp culture. They concluded that it increases shrimp production and improves the size-frequency distribution of the harvest. Currently, the snails have been used in ecotoxicology bioassays (Das and Khangarot 2010) and are helpful for advancing water quality guidelines for protecting aquatic biota (Das and Khangarot 2011).

In this study, the species were used for presenting high reproduction rates, growth and precocious sexual maturity, as well as for being

rustic animals already used as food for the population of Trinidad, The Guianas and North and Northeast of Brazil. The aim of this study was to evaluate the performance of *Pomacea lineata* and *Pomacea bridgesii* species cultivated in different stowage densities with the purpose of showing the viability of water production of these species and a possible emerge of a new food source.

MATERIALS AND METHODS

The experiment was developed in the installations of the Malacology Museum, in the Department of Fishing and Aquaculture, Universidade Federal Rural de Pernambuco, in the city of Recife, PE, Brazil, UFRPE (08°03'14 S – 34°52'52 W).

The animals were collected in the Fish Culture Koike station (UFRPE – Recife-PE). These samples

were kept in two masonry tanks of 1,000 liters each, species were separated and it was awaited for 30 days for pomaceas to spawn.

At the moment of spawn, two spawns from *P. lineata* and *P. bridgesii* were selected and they were transferred to emergence tanks of 40 x 40 x 40 cm, filled with 5L of water, put under floating screens, and kept there until spawn, which occurred after 15 days approximately. After hatch, more 10L of water were added to these tanks. The recently hatched animals were kept in this tank until they were 30 days old.

The experiment was conducted through an entirely casualized delineation, with a 2 x 3 factorial

scheme, in which two species of *P. bridgesii* and *P. lineata* were tested in three different stowage (0.5; 1.0 and 1.5 animal/L) with three repetitions, amounting to a total of 6 waterworks. In the experiment, 18 tanks tanks were used, disposed in a water recirculation closed system (Figure 2). The tanks had an area of 0.165 m², a total volume of 15L, filled with 10L of water. Each tank had a place for water provision and another for drainage. The drained water from the tanks descended to the pipes by gravity up to the filter. After passing through the filter, the water was reinserted in the system by a submersible pump (1,400 L/h), pumping in a speed of 605 L/h and with a renew volume of approximately 18 minutes.

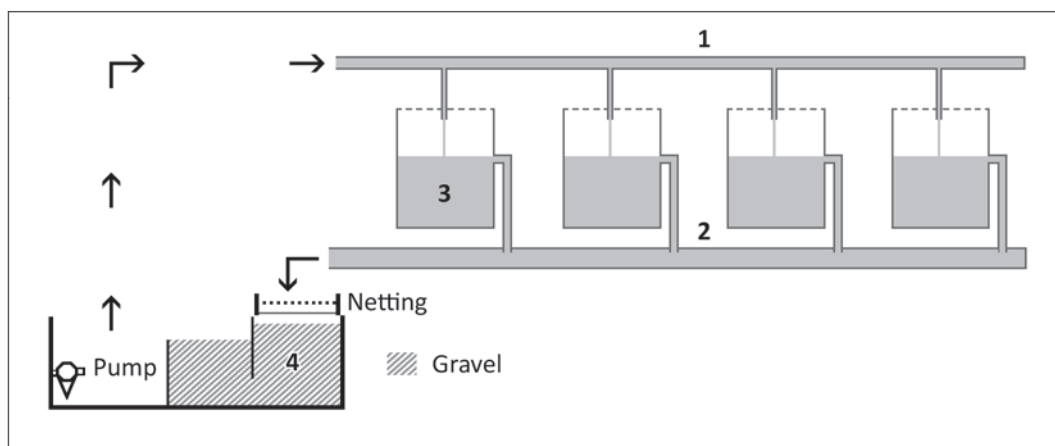


Figure 2 - Scheme of the water recirculation closed system (1: Water Supply Piping Provision – 2: Water Drainage Pipe – 3: Tank – 4: Biological Filter).

The filter used was adapted, according to Valenti (1998), for sweet water prawns larviculture. It was divided in two parts: the first with a mechanical seep and the second part consisted of a biological filter.

The tanks were constantly cleaned by siphons, in order to collect the excess of animal excrement, and the filter was backwashed every 30 days. The animals were daily fed with commercial pellet food for prawns (35% protein levels). The food was heavy and offered in trays that were collected on the following day by the morning, when leftovers were also collected. The leftovers were put to dry

on the greenhouse until acquiring constant weight, only then being weighted. Initially, it was used a food rate of 15% of biomass and every 15 days this rate was readjusted, considering the consumption and the biometry of the animals.

The following growth variables were calculated, in which: Fw = Final weight; Iw = Initial weight and T = time passed in days. **Gain of Biomass** (GB = (Fw x number of animals taken from the tank) - (Iw x number of animals kept) ; **Feed Conversion** (FC = Food consumption (dry material) / Gain of Biomass); **Specific Growth Rate** (SGR = (Log Fw - Log Iw) x 100 / T);

Absolute Weight Gain (increment of the animal weight during culture. $AWH = Fw - Iw$); **Relative Weight Gain** (expressed in growth percentage during culture. $RWG = Fw - Iw \times 100 / Iw$) and finally **Final biomass** ($Fb = Fw \times \text{number of animals taken from the tank} / \text{Total tank volume}$).

After the culture period, the animals were taken from the tank and slaughtered by thermal shock. In order to profit from their carcasses and to obtain dry weight, the soft parts of the operculum and the shell were removed. After that, the soft parts were weighted in an analytical balance and then subtracted from the total weight, obtained previously in biometry. The soft parts that were weighted were wrapped in aluminum foil. They were then identified and taken to the greenhouse, in a temperature of 70°C until obtaining constant weight. After the process of drying, the soft parts were weighted again to obtain of dry weight.

Variables of the culture water system were analyzed weekly, in order to check the efficiency of the biological filter, to check the water quality and to maintain the levels above 100 mg/L, by adding Calcium Magnesium Carbonate (dolomite, $\text{CaMg}[(\text{CO}_3)_2]$). The variables analyzed were: temperature (°C) and dissolved oxygen (mg/L) measured with a digital oximeter, pH measured with a digital pH meter, hardness (mh/L of CaCO_3), alkalinity (mg/L of CaCO_3) and ammonia ($\mu\text{g/L}$) measured by samples analyzed in the Limnology Laboratory from the Fishing Engineering Department of UFRPE.

The statistical analysis used was from Program SAEG 9.0, through Analysis of Variance, and the comparison of means made through Tukey's test at the 5% level.

RESULTS AND DISCUSSION

At the end of 16 weeks of culture, the average weight obtained by *P. lineata*, stocked up with 30 days in a density of 0.5 animal/L, was of 22.3g, weight superior of that obtained by (Rezende 1998),

which was of 3.05g for animals isolated reared, and of 1.48g for grouped animals in a density of 0.5 animal/L for 4 months. This difference was probably given by the difference of the culture water average temperature, being 21°C against 28°C in this experiment. There was not any significantly difference between the gains of biomass reached in the higher density treatment, considering that there was no difference in weight gain.

Considering the development of *P. bridgesii*, the treatment with higher density differed from the others by a less gain of weight, what may have been caused by social factors. There was not any statistical difference between the treatments considering feed conversion, but when compared between the species, the samples of *P. bridgesii* had a better conversion.

Even though the animals were not fed with a balanced diet for their species, a higher conversion rate in animal protein was noted, which was already reported by Santos (1995), Padilla et al. (2000), Sharfstein and Steinman (2001) and Mendoza et al. (2002).

The average survival rate obtained for the species was 100% for the animals stocked up in densities of 0.5 animal/L, not showing any significantly difference when compared to the other treatments. Therefore, on treatments with higher density it was noted higher mortality rates, because of male dispute for female and for food. In addition, cannibalism was also directly related to the density of stowage (Rezende 1998) (Table I).

There were not found any defects on shells, certainly due to corrections made with addition of dolomite calcareous to the control of water hardness on the system.

In some *P. bridgesii* samples that were once submitted to higher densities (T-2 and T-3), some wounds were found in the mantles that prevented the shell formation. They were certainly a result of the dispute between the snails, causing a lower performance in these treatments.

TABLE I
Growth data* of: A) *Pomacea lineata* and B) *P. bridgesii*.

Growth variable	A)			B)		
	<i>P. lineata</i>			<i>P. bridgesii</i>		
	D1	D2	D3	D1	D2	D3
Initial Average Weight (g)	0.315	0.259	0.273	0.386	0.403	0.357
Stowage Density (ind./L)	0.5	1	1.5	0.5	1	1.5
Cultivation Time (weeks)	16	16	16	16	16	16
Final Average Weight (g)	22.3 a	18.0 b	19.5 ab	37.6	37.2	30.4
Growth Rate (%/day)	1.65	1.65	1.66	1.77	1.76	1.72
Absolute Weight Gain (g)	21.9 a	17.8 b	19.2 ab	37.2 a	36.8 a	30.1 b
Relative Weight Gain (%)	6.984	6.920	7.062	9.725	9.267	8.434
Survival Rate (%)	100	100	95.6	100	96.7	95.6
Final Biomass (g/L)	111.3	180.1	280.2	187.9	359.6	436.5
Gain of Biomass (g)	109.7a	177.5 b	276.3 c	186.0 a	355.7 b	431.4 c
Feed Conversion	0.84	0.86	0.84	0.70	0.71	0.76

*To the each species, different letters on the same line imply statistically different averages < 0.05 (the species aren't being compared). D1=density of 0.5 animal/L; D2= density of 1.0 animal/L; D3= density of 1.5 animal/L.

Regarding the water quality, samples of *P. bridgesii* were stocked up in the system approximately two months after the *P. lineata* samples were stocked up, due to problems occurred in the beginning of the initial culture of *P. bridgesii* species. Because of that, it was necessary to expose two phases in the water quality follow up.

Under this experiment the average water temperature was kept in excellent levels for a good development of these species, according to Guimarães (1981) and Estebenet and Cazzaniga (1992). The pH was kept between the considered normal limits (Guimarães 1981), certainly due to the correction of water hardness with the addition of dolomite calcareous.

Regarding the output of carcass and dry weight, mollusks shells, in general, consist basically of calcium carbonate and are plenty used as calcium supplement, just like oyster flour. The average output of the species carcass in the culture was of 50% in *P. lineata* and 48.6% in *P. bridgesii*. There was not any statistical difference in the carcass output when compared to the results obtained in the treatments.

The percentage of proteins, carbohydrates and other nutrients are considered higher in the dry bases of the animals. The protein proportion, for instance, exceeds from 13.01% to 44.26% in the analysis made from Rezende (1992), so it is of great importance the output of the dry bases of these animals. The dry weight of the sift parts represented 13.3% and 14.4% for *P. lineata* and *P. bridgesii* respectively. There was not any statistical difference when the three treatments are compared.

When it comes to the weight and length of both species in the three stowage densities, after the analysis of variance, the Tukey's test was made for weight and length variables in the eight periods during the experiment. In Table II, it can be found the result of Turkey's test for weight in the periods analyzed, except for period 4, which showed interaction between species and density (Table III). It can even be seen that the species *P. bridgesii* showed values significantly higher than *P. lineata* (Table II). But the best density was of 5 animals/tank.

TABLE II
Tukey's test for weight variable in different rating periods*.

Period	Species		Density (animals/tank)		
	<i>P. bridgesii</i>	<i>P. lineata</i>	5	10	15
1	0.3692 a	0.2823 b	0.3508 a	0.3117 b	0.3148 b
2	2.6138 a	1.2910 b	2.0277 a	1.9443 a	1.8852 a
3	8.3325 a	2.5000 b	5.7403 a	5.5673 ab	5.0912 b
5	20.3872 a	8.3746 b	15.5787 a	14.3182ab	13.1458 b
6	26.3786 a	13.7053 b	22.2550 a	19.9980ab	17.8728 b
7	31.3157 a	16.1823 b	26.1797 a	23.8203ab	21.2470 b
8	34.3094 a	18.5343 b	29.1137 a	26.4185ab	23.8835 b

*Means followed by different lowercase letters on the same line are different, by the Tukey test at the 5% level.

To period 4 (Table III), it can be seen that *P. bridgesii* showed higher weight in densities of 5 and 10 animals/tank, while *P. lineata* did not show any significant change to stowage density. This interaction showed in period 4 for the weight, can be explained through intrinsic biological relations of the species in the experiment.

TABLE III
Unrolling of interaction between species and density for the variable weight in period 4*, through Tukey's test.

Species	Density		
	5	10	15
<i>P. bridgesii</i>	15.0153 a A	14.0133 a A	12.3727 b A
<i>P. lineata</i>	3.9500 a B	3.8167 a B	3.6980 a B

*Means followed by different lowercase letters on the same line are different, by the Tukey test at the 5% level.

Table IV presents the result of the test of length average in the eight periods rated, except for periods 4 and 8 (Table V) that showed a significant interaction between species and density. The behavior was equal to the weight, in which the species *P. bridgesii* and the density of 5 animals/tank were superior.

It can be seen in Table V that in both periods *P. bridgesii* was superior to the two initial stowage densities (5 and 10 animals/tank) and that this species was superior than *P. lineata* in all stowage densities. The species *P. lineata* did not show any difference in any of the stowage densities. The interaction factor in periods 4 and 8 for the weight is explained in the same way mentioned above in relation to growth.

TABLE IV
Tukey's test for growth variable in different rating time.*

Period	Species		Density (animals/tank)		
	<i>P. brigdesi</i>	<i>P. lineata</i>	5	10	15
1	1.2388 a	1.0637 b	1.1468 a	1.1717 a	1.1352 a
2	2.3983 a	1.7491 b	2.0980 a	2.0736 a	2.0498 a
3	3.6204 a	2.2214 b	2.9837 a	2.9247 a	2.8545 a
5	4.6814 a	3.2953 b	4.1243 a	.9952ab	3.8457 b
6	5.5309 a	3.7607 b	4.5665 a	4.4565 a	4.9143 a
7	5.3187 a	4.0374 b	4.8862 a	4.6878ab	4.4602 b

*Means followed by different lowercase letters on the same line are different, by the Tukey test at the 5% level.

TABLE V
Unrolling of interaction between species and density and for the variable weight in periods 4 and 8 * through Tukey's test.

Time	Species	Density		
		5	10	15
4	<i>P. bridgesii</i>	4.5213 a A	4.2590 ab A	3.9537 b A
	<i>P. lineata</i>	2.5687 a B	2.4140 a B	2.5420 a B
8	<i>P. bridgesii</i>	5.3290 ab A	5.5887 a A	5.1943 b A
	<i>P. lineata</i>	4.3587 a B	4.0210 a B	4.0957 a B

*Means followed by different lowercase letters on the same line are different, by the Tukey test at the 5% level.

FINAL CONSIDERATIONS

In culture conditions of laboratory, samples of native *P. bridgesii* showed growth and gain of weight superior than exotic *P. lineata*. Regarding the density of species, *P. bridgesii* showed to be more sensitive to density, whereas *P. lineata*'s density is directly linked to the good water conditions of the culture.

Both species showed a high output of carcass and a moderate output of dry weight.

The species studied can present potential for being cultured in large scale as possible alternative food source and other applications, but it is necessary additional studies in the interdisciplinary areas to check the viability. The test of different kinds of food would clarify the best way of production, cheapen the productive process and become possible the culture in small farms. The test of culture in a bigger scale also is necessary to investigate the potentiality of these productions.

RESUMO

A demanda por fontes alternativas de alimento está em evidência atualmente no mundo e assim, o cultivo de espécies de animais considerados não convencionais, torna o tema relevante e apropriado. No presente estudo, cada espécie *Pomacea lineata* e *Pomacea bridgesii*, foram testadas com três densidades de estocagem (0,5 [T1], 1 [T2], and 1,5 [T3] animal/L). Avaliou-se, taxa de

crescimento, ganho do peso, biomassa final, conversão alimentar e porcentagem de sobrevivência, não havendo nenhuma diferença estatisticamente significativa entre as diferentes densidades para ambas as espécies. O peso final médio nos três tratamentos não diferiu significativamente para a *P. bridgesii*. Para *P. lineata*, o T1 (22,3 ± 1,80g) foi significativamente mais elevado do que o T2 e T3. Por outro lado, o ganho absoluto do peso na *P. lineata* e *P. bridgesii* foi significativamente mais elevado em T1 (21,9 ± 1,80 g e 37,2 ± 6,34 g) do que no T2 e T3, respectivamente. Em contraste, o ganho de biomassa da *P. lineata* e *P. bridgesii* foi significativamente mais elevado no tratamento T3 (276,3 ± 33,16 g e 431,4 ± 37,20 g) do que o T1 e o T2, respectivamente. Baseado nos resultados obtidos, todas as espécies estudadas apresentaram potencial para aquicultura, principalmente a *P. bridgesii* que se destacou por mostrar um desenvolvimento melhor, mesmo nos tratamentos com densidades mais elevadas.

Palavras-chave: molusco, aquicultura, fonte alternativa de alimento, conversão alimentar, taxa de crescimento, ganho de peso.

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