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Effects of Stocking Biomass on Growth, Survival and Production of the Two Sizes of Clam *Meretrix lyrata* Cultured in the Intertidal Areas And Notes on Hatchery Production of Clam Spat.

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Abstract

This paper mainly focused on providing the impact of stocking biomass on the production of clam. It also provides a brief on hatchery production of clam spat, one of the key achievements which contributed towards better aquaculture practice.

The triplicate experiment had been conducted in 50m² plots randomly placed in the intertidal areas to evaluate the effects of stocking biomass on survival, growth performance and quality of clam *Meretrix lyrata* Sowerby, 1851. The two stocking sizes (Mean±SD, cm) at shell length of 1.0±0.2 and 1.7±0.1 were scattered at different biomass: 0.05, 0.1, 0.2, 0.3 kg.m⁻² and 0.34, 0.68, 1.36, 2.03 kg.m⁻² and named as T1, T2, T3, T4 and T5, T6, T7, T8 respectively. Results shown that meat ratio of the clam were similar regardless of different stocking biomass. The fatty acids were rich in highly unsaturated fatty acids especially docosahexaenoic acid but were variable. In contrast, growth and survival of the clam were strongly affected by the stocking biomass in which, the lower stocking biomass resulted in higher specific growth rate (SGR) and survival rate. The biomass gained therefore was reduced accordingly with increasing of stocking biomass although the increase of final production was evident. However, SGR and survival of the treatments T1, T2 and T3 were not significantly different explained for the highest net profit and investment return of the treatment T3. The stocking biomass of 0.2 kg.m² therefore, was recommended to maximize profit of the clam cultivation.

Establishment of commercial hatcheries through the development of hatchery technology is the most important and tangible outcomes the project VIE 027/05. The production of clams in ponds is another key outcome. The artificial production of clam spats will assist in reducing the pressure of declining wild population of clams. That is one of the important contributions of the project towards Better Aquaculture Practices.

Effects of stocking biomass on growth, survival and production of the two sizes of clam *Meretrix lyrata* cultured in the intertidal areas.

Introduction

The mollusk production has been increasing steady during the last two decades (Gibbs, 2004) and reaching the total production of 13.25 mmt account for 23.3% of total world aquaculture production in 2004 (Tacon and Halwart, 2006). Among mollusk species, the bivalve shellfish appeared not only the favourable seafood but also were regarded as the most ecologically efficient forms of aquaculture due to those are low trophic level animals. Besides, bivalve shellfish are filter feeders which can also be used as bio-filter for water quality improvement (Mazzola and Sara, 2001; Shpigel and Blaylock, 1991; Shpigel et al., 1997; Shpigel et al., 1993) and thus contribute to the sustainable aquaculture development.

Clams belong to bivalve shellfish but they are different from the others by dwelling on the bottom. Researches have been conducted for various clam species on production (Cigarria and Fernandez, 2000; Shpigel and Spencer, 1996; Zhang and Yan, 2006) and the use of clam as water quality improvement (Jara-Jara et al., 1997; Shpigel and Fridman, 1990). In Vietnam, the endogenous brackish water clam *Meretrix lyrata* is an emerging cultured species for coastal aquaculture because this is favorable seafood in the national and international markets. *M. lyrata* distributes naturally in the intertidal of southern coast and known as "Ngheu Ben Tre" because the exploited production mostly comes from Ben Tre province, south of Vietnam. Recently, due to high consumption demand, *M. lyrata* has being cultivated and expanded to the northern coastal provinces such as in Nam Dinh, Thanh Hoa, Nghe An, Ha Tinh. However, the clam production still was very unstable and unpredictable due to poor management. The technical information on clam culture still has been very limited. It was therefore, necessary for research to establish a standard protocol to enhance the production and profit of clam culture.

Among the factors that affect growth and production, feed and feeding of clam have been regarded as the most important factors. Researches recently have revealed that feed clearance rate have positive relationship with body size and within a range of food concentration, their feeding can be strongly affected by substrata (Zhuang and Wang, 2004), by salinity or diurnal rhythm (Zhuang, 2006). For maximizing production and profit, Zhang and Yan (2006) described a new three-phase culture method for Manila clam farming in China. In this method, the seed production was artificial produced indoor for over winter and the grow-out phase was conducted in the intertidal with appropriate stocking size, stocking density and substrate. In the intertidal areas where the feed are naturally dependent, uncontrollable and variable, stocking biomass becomes an important factor to increase the growth and production. The objective of this research was to

evaluate the effect of stocking biomass of the two sizes of *M. lyrata* on growth performance and survival to enhance the production and profit of cultivation. The other parameters within the culture system can not be altered as it is a natural ecosystem highly connected to capture fisheries which is one of the key industry for the fishery community.

Materials and Methods

The experiment had been conducted in the intertidal areas belongs to Hau Loc District, Thanh Hoa Province. There were 24 plots of 50 m² each, separated by plastic mesh and randomly allocated for 8 treatments (3 replicates each). The small clam seed at shell length of 1.0±0.2 cm were scattered at 4 different biomass: 0.05, 0.10, 0.20 and 0.30 kg.m⁻² and named as T1, T2, T3 and T4 respectively. The bigger size of clam seed at shell length of 1.7±0.1 cm were stocked at 4 different stocking biomass: 0.34, 0.68, 1.36 and 2.03 kg.m² and named as T5, T6, T7 and T8 respectively. This experiment was terminated after 165 days rearing.

Environment factors such as temperature (thermal meter), DO, pH (Oxyguard) and turbidity (Sechi disk), salinity (Refractometer) of water in the experiment site were daily monitored at 3 designated points within the experimental area.

Growth of clam, expressed in mean of shell length (cm) and mean of live weight (g), was determined by random sampling (n=30) and measure every fortnight. The daily specific growth rate (SGR) was calculated using the following formula (Jara-Jara et al., 1997):

$$\text{SGR}(\% \cdot \text{day}^{-1}) = 100 * (\text{Ln}W_f - \text{Ln}W_i) / t$$

Where: W_i and W_f are mean of initial weight and final weight, respectively and t is number of experiment days.

Size variation of the clam was evaluated according to Wang et al. (1998) in which the mean of three replicates of the coefficient of variation (CV) was used to examine the inter-individual variation among the clam in each treatment: $\text{CV}(\%) = 100 * \text{SD} / M$ where M is mean of live weight and SD is standard deviation of the clam in each treatment.

The meat ratio (% of meat weight. total live weight) of clam was conducted by separating the meat content of random samples (n = 20). The excess water was removed by putting the sample on tissue paper.

At the end of experiment, clam was randomly sampled, preserved in Liquid Nitrogen Biological Container (YDS-3, -196°C) for fatty acids analysis. The fatty acids content expressed in mg.g⁻¹ dry weight was first extracted by put in a 35 mL glass tube with a teflon lined screw caps, added 5 mL methanol/toluene mixture (3:2 v/v) and added exactly 0.1 mL internal standard solution containing 4.78 mg.mL⁻¹ 20:2(n-6) fatty acid dissolved in iso-octane. The freshly prepared acetylchloride/metanol mixture (1:20 v/v) then was added as the esterification reagent. The tube was flushed with nitrogen gas and closed tightly before carefully shaking and was put in a boiling water bath (100°C). After

one hour, the tube was cooled down, added 5 mL distilled water and 5mL hexane, and separated the upper layer by centrifuging. The combined hexane phase was dried by filtered in a flask over the anhydrous sodiumsulphate filter and the FAME's were finally dissolved in 0.5 mL iso-octane and transferred in a 2 mL glass vial for injection in Finnigan Trace GC untra with capillary column BP-70 (50m x 0.32mm x 0.25 μ m).

All data of the treatments were tested for significant differences ($p < 0.05$) using One-way ANOVA followed by Turkey test for multiple comparisons of means. The data are expressed as Average \pm SD and statistical analyzed was performed using GraphPad Prism version 4.0 and Microsoft Office EXCEL for Window.

Results and Discussion

The environment conditions of the experiments

The experiment site situated the intertidal areas near the estuary where the clams have been already cultivated for recent years. The environment factors such as DO, water temperature, pH and salinity (table 1) were regarded as the best conditions for clam development. The high levels salinity fluctuation is typical for estuary ecological conditions. The average water temperature was $23.59 \pm 2.40^{\circ}\text{C}$, relatively low compared to the normal water temperature in the south of Vietnam, where *M. lyrata* naturally distributes. This mean clam are not be affected by the marked variation and good growth and survival rate noticed. However, low water temperature might affect growth performance and the growth and survival of *M. lyrata* might be not as high as the ones cultivated in the south of Vietnam. As Soudanta et al. (2004) has described, the Manila clam conducted in four rearing sites selected for their varied ecological characteristics, the environmental conditions were found having effect to the physiological and immunological parameters.

Growth performance

The growth performance of the two stocking sizes of *M. lyrata* at different stocking biomass expressed in specific growth rate, final shell length and final live weight as well as size variation are shown in the table 2 and table 3.

For the small size group, there was no significant difference in specific growth rate and final weight among T1, T2 and T3 treatments (table 2) indicating that growth of the clams were not be affected by the stocking biomass below 0.2 kg.m^{-2} . The final size of *M. lyrata* was more variable at low (T1) and high (T4) stocking density compared to the medium (T2 and T3) ones. The meat yield expressed in percentage of meat per total weight, which regarded as the most valuable part of the clams was not significant different ($p > 0.05$) in all treatments

The growth of *M. lyrata* at stocking size of 1.7 cm was significantly reduced as increasing of stocking biomass (table 3). At high stocking biomass (T7 and T8), the

SGRs were relatively low and were not significantly different. The final length and final weight of the treatment T8 were significantly smaller than the others. The size variation however, was not be affected by different stocking biomass.

Generally, at younger stage, animal has better grow rate. In the case of clam, at the same stocking biomass, the small size (1.0 cm) grown much better than the bigger size (1.7 cm). In the intertidal areas, the natural feed and environmental factors are uncontrollable and are dependent of nature. Dynamic of tide, wave and current create the availability of algae, organic matter that regarded as feed for clam. However, due to clam is filter feeder and passively dwells on the bottom, increase biomass beyond certain level, the natural feed might not be enough for growing. More over, in the same size treatments, increasing biomass lead to increasing the competition of other environmental condition such as habitat, DO and increasing metabolic wastes accumulated such as feces, which regarded as a detriment to the clam growing (Yan et al., 2006). It was also investigated that at the same temperature, the clearance rate and ingestion rate of clam were increased exponentially with increasing in size (Zhuang and Wang, 2004). Results of growing performance (table 3) indicated that at high stocking biomass (more than 0.3 kg.m^{-2}), the growing could be inhibited and the grow rate was significantly reduced as increasing of the biomass. It also is noted that the culture period was winter time of the year when water temperature normally is low and was not appropriate for growing of *M. lyrata*, the tropical species.

Survival

The stocking biomass impacted the survival rate in both sizes of clam stocked. Survival was very high in the low stocking biomass treatment (T1) and was almost similar in the treatment T2 and T3. The treatment T1 was significantly different ($p < 0.05$) to treatment T4 (Fig 1). In the bigger stocking groups, survival of the treatment T5 was highest followed by the treatment T6. Survival of the treatment T7 and treatment T8 were very low and were not significantly different (Fig 2). On the other hand, the results present in the fig 1 and fig 2 also indicated that the clam survival not only affected by stocking biomass but also by the stocking density. The environmental condition and food availability could be explained as the main reasons for the impact of the stocking biomass on survival rate.

Stocking size had been detected effecting survival of the Manila clam, in which, the small size showing higher mortality, not only because of substrata or predators (Cigarria and Fernandez, 2000) and the normal stocking size of this species for intertidal cultivation was 1.0 cm (Zhang and Yan, 2006). In our trial, at same stocking biomass (0.30 and 0.34 kg.m^{-2}), survival rate of treatment T4 (1.0 cm) were very low (55%) compared to survival rate of 90% of the treatment T5 (1.7 cm). Within the same size 1.7 cm, the treatment T7 and T8 had relatively low survival compared to the treatment T5 and T6 meaning those stocking biomass were too high for the clam development.

Production and quality

The production of clam derived from both growth and survival. There was a positive relationship of the clam production and stocking biomass although the growth and survival were negatively affected. Among the small stocking size group, the final production increasing accordingly with the biomass gained and no significant difference ($p>0.05$) was detected between T1 and T2 nor T3 and T4 (table 4). The percentage of biomass gained, in contrast, was showing reduction trend when increasing the stocking biomass. There was no significant difference between T1 and T4 was detected. This is due the fact that the increase in biomass negatively affected the growth and survival of the clams.

In the bigger stocking size (1.7 cm), the final production of the clam was significant increased as increasing of stocking biomass ($p<0.05$). The percentage of biomass gained, in contrast, was reduced as increasing of stocking biomass in T5, T6 and T7 (table 5). However, no significant difference ($p>0.05$) in the biomass gained in the treatment T5 and T6 nor percentage of biomass gained in the treatments T7 and T8. In both size groups, the increase in biomass certainly impacted net production negatively.

The high value of percentage of biomass gained confirmed the stocking biomass was barrier of clam development. However, the increasing of the biomass gained as well as final production indicated the benefit can be obtained if the appropriate stocking biomass was determined. The economic calculation therefore is vital to optimize investment benefit.

Fatty acid profile

There was variable in the fatty acid profile between treatments regardless of different stocking biomass. The total FAME varies from 134.4 to 193.7 mg.g^{-1} dry weight (table 6). However, the present of high content of HUFA especially DHA content (29.00 to 62.77 mg.g^{-1} dry weight indicated the value of clam as seafood product. The variation of fatty acids of clam may relate to the ovary and. or growing development stage when the fatty acids normally accumulated. Our result confirmed the variation of fatty acid of clam *Ruditapes decussatus* reared in sea water and effluent from a fish farm in Galicia (Jara-Jara et al., 1997). The fatty acid variation and the factors affecting to this variation need a further research.

Economic evaluation

The estimation of the economic benefit of clam cultured in the intertidal areas is showed in the table 7. The net profit calculated base on the output cost and input cost and price of the clam.

The main cost in *M. lyrata* cultivation was the expense in seed purchase. Cost of seed ranged between 46% to 81% in small size seed (1.0 cm) for the four treatments (T1, T2,

T3 & T4). As all other costs are fixed, the increase in stocking biomass increased the total cost invested. Although total production increased with the increase in stocking biomass, the economic analysis clearly indicated that the net profit decreased beyond the level of 2 ton.ha⁻¹ stocking biomass (T3). The treatment T4 with the stocking density of 3 ton.ha⁻¹ was yielded lesser net profit compared to the treatment T3. This can be explained by the higher proportion of seed cost while the biomass gained was lower due to less growth and survival. Therefore, the stocking biomass of 2 ton.ha⁻¹ is recommended for *M. lyrata* at stocking size of 1.0 cm.

For the treatment T5, T6, T7 and T8, cost of seed increased from 73.8% to 92.9%.

Due to the price of seed was higher than price of harvested clam, while the biomass gained reduced accordingly with increasing of stocking biomass, the net profit was reduced and relatively lower compared to the 1 cm seed stocking treatments. We suggested that the clam size more than 1.7 cm should not be culture at stocking biomass more than 6.8 ton.ha⁻¹.

Conclusions

The result of this experiment indicated that *M. lyrata* grown very well in the intertidal areas in north coast of Vietnam during winter at water temperature of 23.59±2.40°C. The stocking biomass had strong effect on growth performance and survival of clam. For the stocking seed at shell length of 1.7 cm, among 4 different stocking biomass 0.34, 0.68, 1.36 and 2.04 kg.m⁻², the higher biomass, the lower growth performance as well as the lower survival, which eventually resulted in reduction in the net profit even the final biomass were increasing. For the small seed at shell length of 1.0 cm, among stocking biomass of 0.05, 0.1, 0.2 and 0.3 kg.m⁻², the lower stocking biomass resulted in better grow performance. The survival rate of the stocking biomass of 0.3 kg.m⁻² however, was significant lower than the others and the highest net profit as well as investment return therefore, was obtained at the stocking biomass of 0.2 kg.m⁻². We recommend using this stocking biomass to maximize profit of the cultivation.

Quality of the clam expressed as the meat ratio of clam was similar regardless of different stocking size or stocking biomass. In addition, the fatty acids of clam were rich in HUFAs especially DHA and EPA but also were very variable in the treatments. This might related to the natural feed availability or the different development stages of maturation and research on this issue need to be addressed.

Notes on the hatchery production of clam spats.

Hatchery Technology Development

Before the implementation of clam project (2005), the *Meretrix lyrata* culture is restricted only in the intertidal areas south central Vietnam. The intertidal culture practice was mainly relying on the calm seed from wild; because of there are no clam hatchery in Vietnam before the implementation of this project. Clam hatchery technology (commercial production of clam spat) is not available in Vietnam. The lack of seed is a major constraint in the development of clam industry in Vietnam. The main cost in clam culture is seed. One of the objectives of this project is to develop clam hatchery technology and prepare the hatchery manual for commercial clam seed production.

Successful research was under taken at the marine hatchery (ARSINC) in Cua lo town, Nghe an province to determine optimum conditions in particular temperature and water quality in particular salinity condition, optimum feed requirements; optimum larval density and resettlement density. Also the infrastructure facilities required for a successful hatchery and nursery facilities were determined.

Among the parameters tested, salinity is one of important factors affecting growth and survival of clam larvae. The results indicated that clam larvae can tolerate a salinity range from 10ppt to 30ppt. At a salinity of 35ppt, all larvae had died on day 6 post hatching. Growth and survival rate of the larvae reared in the 20ppt and 25ppt treatments were significant higher ($p < 0.05$) and they reached metamorphosis faster (at 8 day post hatching) compared to that of the other treatments. At the other salinities of 10ppt, 15ppt and 30ppt, no significant difference in growth and survival was detected. Our results indicated that salinity of 20 and 25ppt should be optimum for clam larvae development.

Establishment of new calm hatchery has been the focus of our work during the last six months. In accordance with the project objective to establish at least two hatcheries in addition to ARSINC and producing more than 6.5 mills of spats as indicated in the project output for the year 2007 was achieved. Project VIE 027/05 has developed following key aspects of hatchery technology.

- Hatchery design and construction
- Brooder selection and conditioning
- Feed requirements including production of live feed
- Breeding and spawning technologies
- Larval rearing and settlement
- Hatchery management

Establishment of Commercial Hatchery

After two years operation, the success of research experiments on clam hatchery production opened the possibilities for mass production of spats. The main criteria considered for the selection and establishment of a clam hatchery include: suitability of the hatchery site and operational resource requirements. The following important factors were considered for the selection of the site and establishment of the local hatcheries.

- Water supply and water quality control

- Infrastructure facilities for mass production of at least 3 marine algae species
- Adequate area and facilities for brood stock conditioning and breeding induction
- Hatchery facilities for larval rearing and settlement
- Suitable area and facilities for nursery for spat production

A work shop was held at Nghe An, 23rd - 24th Sep, 2007 to introduce the results on clam culture. The participants from six provinces in the North Central Region expressed their interest in clam hatchery technology as there was a high demand of clam seed for cultivation.

A modern hatchery for clam (*M. lyrata*) spat production has been established at Aquaculture Research Sub-Institution for North Central (ARSINC) with all necessary infrastructure facilities. Several successful batches of clam spats were produced using these facilities. This hatchery could be utilised for both commercial production of spat and research and development.

One calm hatchery at Thanh Hoa (one of the province selected for the project) has been established by upgrading the infrastructure to suit mass production of *M. lyrata* spat. Spat production in this hatchery also started.

As a part of the project activities, ARSINC collaborated with some private hatcheries in Thanh Hoa, Ho Chi Minh and Ninh Binh Provinces to produce clam spat for demonstration. The collaboration is not only produced the spat but also transferring the hatchery technology developed by ARSINC/SARDI to the provinces. These private hatcheries and ARSINC will provide clam spat for on farm trials. With the increased capacity, the demand for clam spat will be met partially.

In addition, at the request of local provincial authorities for clam hatchery technology due to high demand from local farming community, the National Fisheries Extension Centre made a commitment in supporting the spat production at Hue and Thanh Hoa Province.

Conclusion

Hatchery technology development and establishment of commercial hatcheries are the most important and tangible outcomes the project VIE 027/05 achieved. The production of clams in ponds is another key outcome. The artificial production of clam spats will assist in reducing the pressure of declining wild population of clams. That is one of the key contributions of the project towards Better Aquaculture Practices.

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Tables

Table 1. Environment conditions in the experiment site

Parameters	DO (ppm)	Water temperature (°C)	pH	Salinity (ppt)	Turbidity (cm)
Average±SD	6.25±0.42	23.59±2.40		25.65±2.84	9.05±3.13
Maximum	7.66	31.00	8.99	31.00	20.00
Minimum	5.50	19.50	7.21	20.00	5.00

Table 2. Growth performance of clam at stocking size of 1.0 cm

Treatments	T1	T2	T3	T4
SGR	1.25±0.05 ^a	1.13±0.05 ^a	1.08±0.10 ^{ab}	0.94±0.37 ^b
Final length (cm)	2.04±0.13 ^a	2.01±0.09 ^{ab}	1.95±0.10 ^b	1.95±0.11 ^b
Final weight (g)	5.92±1.08 ^a	5.76±0.81 ^{ab}	5.46±0.76 ^{ab}	5.30±0.85 ^b
% of meat.total weight	15.87±1.00 ^a	15.48±2.72 ^a	15.53±1.02 ^a	15.15±5.47 ^a
CV% (weight)	28.72±2.55 ^a	23.07±0.24 ^b	23.73±1.55 ^b	27.78±2.11 ^{ab}

Value (Mean±SD) followed by different superscript letters within a row are significantly different ($P<0.05$). T1, T2, T3, T4 are treatments of clam cultured at 0.05, 0.1, 0.2 and 0.3 kg.m⁻² respectively. SGR = daily specific growth rate; CV = coefficient of variation

Table 3. Growth performance of clam at stocking size of 1.7 cm

Treatments	T5	T6	T7	T8
SGR	0.62±0.04 ^a	0.46±0.03 ^b	0.33±0.02 ^c	0.32±0.02 ^{cd}
Final length (mm)	2.36±0.17 ^{ab}	2.40±0.10	2.32±0.11 ^{bc}	2.27±0.10 ^c
Final weight (g)	9.24±1.20 ^a	9.33±0.95 ^a	8.90±1.12 ^a	8.21±1.01 ^b
% of meat.total weight	14.53±1.89 ^a	15.78±2.35 ^a	16.53±0.62 ^a	15.48±1.31 ^a
CV% (weight)	22.3±0.45 ^a	19.05±5.16 ^a	18.69±3.36 ^a	22.73±4.16 ^a

Value (Mean±SD) followed by different superscript letters within a row are significantly different ($p<0.05$). T5, T6, T7 and T8 are treatments of clam cultured at 0.34, 0.68, 1.36 and 2.06 kg.m⁻² respectively. SGR = daily specific growth rate; CV = coefficient of variation

Table 4. Biomass production of clam at stocking size of 1.0cm

Treatments	T1	T2	T3	T4
Final production (ton.ha ⁻¹)	4.14±0.57 ^a	6.82±0.56 ^a	12.62±2.16 ^b	14.84±0.91 ^b
Biomass gained (ton.ha ⁻¹)	3.62±0.57 ^a	5.78±0.56 ^a	10.54±2.16 ^b	11.72±0.91 ^b
% of biomass gained	697.1±109.4 ^a	555.8±53.6 ^{ab}	506.9±104.0 ^{ab}	375.8±29.3 ^b

Value (Mean±SD) followed by different superscript letters within a row are significantly different ($p<0.05$). T1, T2, T3 and T4 are treatments of clam cultured at 0.05, 0.1, 0.2 and 0.3 kg.m⁻² respectively

Table 5. Biomass production of clam at stocking size of 1.7cm

Treatments	T5	T6	T7	T8
Final production (ton.ha ⁻¹)	9.49±0.68 ^a	14.46±0.69 ^b	23.58±0.68 ^c	34.80±1.00 ^d
Biomass gained (ton.ha ⁻¹)	6.10±0.68 ^a	7.68±0.69 ^a	10.02±0.69 ^b	14.46±0.99 ^c
% of biomass gained	180.0±20.0 ^a	113.3±10.1 ^b	73.9±5.1 ^c	71.1±4.8 ^c

Value (Mean±SD) followed by different superscript letters within a row are significantly different ($p<0.05$). T5, T6, T7 and T8 are treatments of clam cultured at 0.34, 0.68, 1.36 and 2.06 kg.m⁻² respectively.

Table 6. Fatty acids of clam cultured at different stocking sizes and different stocking biomass

Fatty Acids	T1	T2	T3	T4	T5	T6	T7	T8
14:00	0.58	-	-	1.07	-	0.59	2.52	6.35
16:00	44.26	42.67	78.27	21.63	47.07	84.63	33.54	33.94
16:1(n-7)	9.85	-	3.53	7.88	-	0.75	10.94	11.71
17:00	0.19	-	-	0.89	-	-	1.94	1.22
17:1(n-7)	-	-	-	-	-	-	3.39	7.71
18:00	4.63	15.63	22	23.98	16.82	7.84	10.08	10.72
18:1(n-9)	63.02	39.79	26.83	29.68	49.38	33.41	27.18	31.94
18:1(n-7)	-	-	-	5.31	6.33	-	-	-
18:2(n-6)t	0.41	8.19	-	1.06	-	-	2.35	13.74
18:3(n-3)	-	-	-	0.54	-	-	1.1	5.16
20:1(n-9)	-	7.83	-	0.52	8.18	-	-	-
20:4(n-6)	1.11	-	7.72	2.98	5.06	2.72	3.54	8.9
20:4(n-3)	-	-	-	0.31	-	-	-	-
20:5(n-3)	4.45	3.11	-	5.95	6.2	0.97	7.96	3.29
24:00:00	-	-	-	1.17	-	-	-	-
22:5(n-6)	-	-	-	-	-	-	1.56	-
22:5(n-3)	-	3	4.96	1.85	-	-	2.46	-
22:6(n-3)	45.78	29	33.62	29.65	27.58	62.77	30.4	30.0
Sum (n-3)	50.23	35.11	38.58	37.76	33.78	63.74	40.82	30.29
Sum (n-6)	0.11	0	7.72	2.98	5.06	2.72	5.1	8.9
Sum HUFA	50.34	35.11	46.3	40.74	38.84	66.46	45.92	42.19
Total FAME	174.3	149.2	176.9	134.4	166.6	193.7	139	166.1

Value = mg.g⁻¹ dry weight; T1, T2, T3 and T4 are treatments of clam cultured at 0.05, 0.1, 0.2 and 0.3 kg.m⁻² respectively; T5, T6, T7 and T8 are treatments of clam size 1.7cm cultured at 0.34, 0.68, 1.36 and 2.06 kg.m⁻² respectively.

Table 7. Economical evaluation of the two stocking size of clam rearing at different stocking biomass

Stocking size	Shell length 1.0 cm				Shell length 1.7 cm			
	T1	T2	T3	T4	T5	T6	T7	T8
Treatments								
Stocking biomass (ton.ha ⁻¹)	0.50	1.00	2.00	3.00	3.40	6.80	13.60	20.40
Final production (ton.ha ⁻¹)	4.14	6.82	12.62	14.84	9.49	14.46	23.58	34.80
<i>Input (* mill VND.ha⁻¹)</i>								
Cost for seed (1)	17.50	35.00	70.00	105.00	61.20	122.40	244.80	367.20
Mesh and fencing	3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30
Labour cost	7.20	7.20	7.20	7.20	7.20	7.20	7.20	7.20
Hut for daily monitoring	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Land lease	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Harvesting cost (B*2%)	0.99	1.64	3.03	3.56	2.28	3.47	5.66	8.35
Total input (A)	37.99	56.14	92.53	128.06	82.98	145.37	269.96	395.05
<i>Output (* mill VND.ha⁻¹ with assumption price of 12 mill VND.ton⁻¹ for all harvested clam)</i>								
Total output (B)	49.72	81.82	151.44	178.08	113.90	173.52	282.96	417.60
Net profit (A - B)	11.72	25.68	58.91	50.02	30.93	28.15	13.00	22.55
Rate of investment return (%)	30.85	45.75	63.67	39.06	37.27	19.36	4.82	5.71

(1) The seed cost were 0.035 mill VND.kg⁻¹ size 1.0 cm and 0.018 mill VND.kg⁻¹ size 1.7 cm

Figure captions

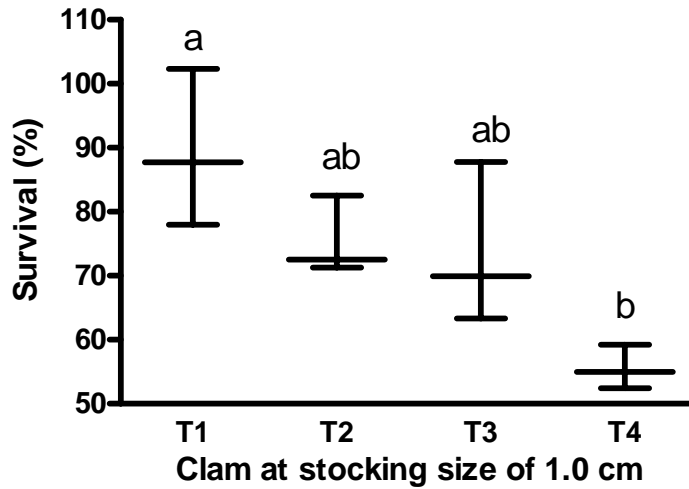


Figure 1. Survival of clam size 1.0 cm rearing at different stocking biomass.

Value (Average \pm SD) followed by different superscript letters are significantly different ($p < 0.05$). T1, T2, T3 and T4 are treatments of clam cultured at 0.05, 0.1, 0.2 and 0.3 kg.m^{-2} respectively.

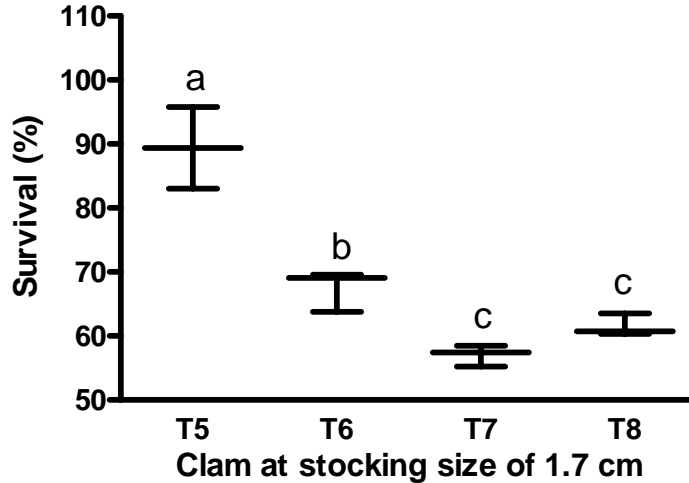


Figure 2. Survival of clam size 1.7 cm rearing at different stocking biomass.

Value (Average \pm SD) followed by different superscript letters are significantly different ($P < 0.05$). T5, T6, T7 and T8 are treatments of clam size 1.7cm cultured at 0.34, 0.68, 1.36 and 2.06 kg.m^{-2} respectively.



Figure shows spats from the Novel Nursery System at 45 days.