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*Full Length Research Paper*

# Comparisons between two production–scale methods for the intensive culture of juveniles spotted babylon, *Babylonia areolata*, to marketable sizes

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**This study is the first attempt to compare the aquaculture potential on growth, production and economic analysis for growth of spotted babylon juveniles (*Babylonia areolata)* to marketable sizes using the large-scale operation of flow-through canvas ponds and earthen ponds. This study shows that the average growth rates in body weight were 0.91-1.07 g/month and 0.82 – 0.98 g/month for the canvass pond and earthen pond trials, respectively. At the end of the experiment, final body weights of snails ranged from 5.6 - 6.6 and 5.2 – 6.2 g for the canvas pond and earthen pond trials, respectively. Total yields per production cycle were 1,930 and 1,760 kg for the canvas pond and earthen pond trials, respectively. For economic analysis, investment requirements of the canvas pond trial ($US18,629.6) was higher than that of earthen pond trial ($US8,832.3) and total cost per production cycle were estimated to be $US13,143.3 and 10,162.4 for the canvas pond and earthen pond trials, respectively. Net return per production cycle of the canvas pond ($US5,075.9) was lower than that of earthen pond trial ($US6,452.0) and payback period were estimated to be 1.8 and 0.7 production cycle for the canvas pond and earthen pond trials, respectively. This study indicated that grow out of juvenile *B. areolata* in earthen ponds was highly profitable than those in flow-through canvas ponds.**

**Key words:** *Babylonia areolata,* grow out, flow-through system, canvas, earthen ponds, growth, production.

## INTRODUCTION

There has been considerable interest in the commercial culture of spotted babylon, Babylonia areolata, in Thailand resulting from a growing demand and an expanding domestic market of seafood, and a catastrophic decline in natural spotted babylon populations in the Gulf of Thailand. At present, the successful culture of spotted babylon juveniles to marketable sizes was operated in large-scale production using the flow-through seawater system in concrete/canvas ponds. However, this culture technique had many considerations in terms of disadvantages of investment of pond construction, buildings and facilities, the culture purposes. Basically, it needs the high, but the production and low economic returns is not high large area for pond construction, and operational costs for commercial operations Various scientists pay high attention to developing the land-based aquaculture system which were focused on the potential and feasibility for growing-out of the spotted babylon juveniles to marketable sizes in earthen ponds for reducing costs, shortened culture period and increasing yield per unit area. In addition, many marine shrimp (Penaeus monodon) ponds have been abandoned due to diseases, poor management, and environmental degradation for very long time in Thailand.

This study may provide an opportunity to develop a sustainable aquaculture system for grow out of spotted babylon juveniles to marketable sizes in earthen ponds resulting in the best utilization of many abandoned shrimp ponds in coastal areas of Thailand. Kritsanapuntu et al. (2006) reported the successful monoculture and

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**Abbreviations: FCR,** Feed conversion ratio; **PVC,** polyvinyl chloride; **SR,** survival rate; **SGR,** specific growth rate; **WG,** weight gain; **PE,** polyethylene.

polyculture of juvenile spotted babylon (B. areolata) to marketable sizes in large-scale operation of earthen ponds. However, a lack of economic data is an important constraint to the successful development of spotted babylon aquaculture operations. A financial investment analysis tied biological, production, cost, and market price variables; these had been used to make decisions about culture methods, and feasibility and potential for commercial operation of this enterprise. Thereafter, the land-based aquaculture operation for grow out of spotted babylon in earthen ponds was developed for commercial purposes in Thailand. The objective of this study is to determine the growth, production and economic considerations for commercial grow out of juveniles spotted babylon, B. areolata, to marketable sizes using large-scale operation of flow-through canvas ponds and earthen ponds.

## MATERIALS AND METHODS

### Experimental animals

Juvenile spotted babylon (B. areolata) with an average body weight of 0.30 g were obtained from a commercial private hatchery at Prachuabkirikhan province, southern part of Thailand and maintained in indoor hatchery at the research unit for complet commercial aquaculture of spotted Babylon at the Chulalongkorn University, Petchaburi province, prior the growing out experiment. Individuals from the same cohort were sorted by size to minimize differences in shell length (maximum anterior-posterior distance) and prevent possible growth retardation of small babylon when cultured with larger individuals. Initial stocking density was 250 snails m-2.

### Culture method

This study aimed to compare the growth, production and economic analysis for grow out of juveniles spotted babylon, B. areolata, to marketable sizes using large-scale operation of flow-through canvass ponds and earthen ponds as follows:

### Flow-through canvas ponds

Sixteen 6.0 x 12.0 x 0.4 m canvas ponds with bottom area of 72 $m^2$ were used for the culture trials. A total area of canvass ponds for grow out was 1,209 $m^2$. The rearing ponds were designated in pairs with 2 rows (Figure 1) and a total area of canvas ponds for grow out was 1,152 $m^2$. Pond bottom was covered with coarse sand of approximately 2-3 cm in thickness. Water level in the ponds was maintained at 30 cm. The grow-out ponds are supplied with flow-through of ambient unfiltered, natural seawater at a flow rate of 150 L/h daily for 16 – 20 h. The seawater system is powered by one 5.5-hp engine equipped with water pump of 12.5 cm in diameter of outlet pipe.

The seawater intake consists of a 12.5 cm in diameter polyvinyl chloride (PVC) pipe manifold horizontally into the sea. Seawater is delivered to one stocking earthen pond of 800 $m^2$ and 1.8 m in depth. One seawater pump of 2-hp was used to pump seawater from the stocking pond to each rearing pond in the form of water spray. The drainage pipe of 2.5 cm in diameter PVC pipe was used as outlet. Two air blowers (2 hp) were used to supply high volume of air for all grow-out ponds in the form of air bubbles. Each pond was provided with 24 large-size airstones. Aerator was operated daily for 16 – 20 h except during feeding and resting of blower. The snails were fed with fresh trash fish at satiation once daily in the morning (10:00 h). Food was offered to the animals until they stopped eating and the uneaten food was removed immediately. For growth estimation, 20% of snails were random sampled from each pond at 30 days interval for measurement of body weight individually and counting the number of snail per kg. No chemical or antibiotic agent was used throughout the entire experimental periods. Grading by size was not carried out in any pond throughout the growing-out period. The spotted babylon were cultured until they reached the marketable size of 150 snails/kg.

### Earthen ponds

Three 20.0 x 19.0 m earthen ponds and 1.2 m in depth were used for culture trials (Figure 2). A total area of earthen ponds for growing out was 1,200 $m^2$. Pond wall was 1.5 m in height, 3.0 m in width at the base and 2.5 m in width at the top and pond bottom was covered with coarse sand of approximately 10-15 cm in thickness. Each grow-out pond was fenced by plastic net of 15.0 mm mesh size and 1.2 m in width, supported with bamboo frame for strengthening. The plastic net must be buried under sand about 6 cm in depth to limit movement of snail along pond bottom and pond wall, and ease for harvesting. Prior to the start of the grow-out, all ponds were dried for 2 weeks, and filled with ambient, unfiltered natural seawater from a nearby canal to a depth of 70 cm. Water level in the ponds was maintained at 70 cm by adding seawater to replace water loss due to seepage and evaporation. The grow-out ponds are supplied with ambient unfiltered, natural seawater from seawater intake system.

The seawater system is powered by one 5.5-hp engine equipped with water pump of 12.5 cm in diameter of outlet pipe. The seawater intake consists of a 12.5 cm in diameter PVC pipe manifold horizontally into the sea. Seawater is delivered to each pond through main unlined canal of 80 cm width and 30 cm depth, and 15.0-cm diameter PVC distribution pipes (inlet). The drainage pipe of 12.5 cm in diameter PVC pipe was used as outlet. Fifty percent of seawater was exchanged at 15 days intervals. Two air blowers (2 Hp) were used to supply high volume of air for all grow-out ponds. PVC pipes of 2.54 cm in diameter were connected to the outlet of the air blower and extended to the pond dike of each pond. Four polyethylene (PE) pipes of 18 m long and 1.6 cm in diameter was connected to the PVC pipe and extended to the bottom of each pond. On the PE pipe, there were 10 holes of 1.5 mm in diameter, and the distance between adjacent holes was 2 m. The PE pipes were sustained at 10 cm off the pond bottom using bamboo sticks. Aerator was operated daily for 16 – 20 h except during feeding and resting of blower.

The snails were fed with fresh trash fish at satiation (the same proportions in amounts of food given daily in canvas pond experiment) once daily in morning (10:00 h). Feeding behaviour was monitored daily by means of baited traps. For growth estimation, 20% of snails were random sampled from each pond at 30 days interval for measurement of body weight individually and counting the number of snail per kg. No chemical or antibiotic agent was used throughout the entire experimental periods. Grading by size was not carried out in any pond throughout the growing–out period. The spotted babylon were cultured until they reached the marketable size of 150 snails/kg.

### Measured parameters

### Growth and survival

Growth measurement of weight (g) was undertaken at the

**Figure 1.** Grow out of *B. areolata* to marketable sizes using large-scale flow-through canvas ponds of 6.0x12.0x0.4 m.

**Figure 2.** Grow out of *B. areolata* to marketable sizes using large-scale earthen ponds of 20.0x19.0x1.2 m.

beginning of the growing out experiment, then again on day 30, 60, 90, 120, 150 and 180. Random samples of 3,000 snails from each replicate tank were done. Wet weight of all snails from each tank was measured individually to the nearest 0.01 g on electronic balance. Growth performance was determined and feed utilization was calculated as follows (Tan, Mai & Luifu 2001; Ye et al. 2006; Liu et al. 2006):

Weight gain (WG) = Final weight (g) – Initial weight (g)

Specific growth rate (SGR) = 100 (ln Wf – ln Wi) / T

Feed conversion ratio (FCR) = Feed intake (g) / weight gain (g)

Survival rate (SR) = 100 x (final snail number) / (initial snail number)

#### Cost analysis

The components of financial analysis were categorized according to initial investment, ownership costs, operating costs and total cost (Adams and Pomeroy, 1992; Rubino, 1992; Fuller et al., 1992).

Investment requirements for farm construction on culture of juvenile spotted babylon to marketable sizes were evaluated. The investment requirements included construction of grow-out ponds and housing, seawater reservoirs, seawater pumps and housing, air blowers and housing, accommodation for labor and office, and operating equipment and facilities.

Fixed costs per production cycle consisted of land lease, depreciation, and interests on investment. Annual depreciation was estimated by the straight-line method based on the expected useful life of each item of equipment. Assets are assumed to have no residual value for all items constituting facilities at the end of their useful life. The life expectancies of all grow out unit and equipments were assigned a useful life ranged from 2 to 5 years. Interest was charged at a rate of 3.0% per year for all depreciable items that compose the farm. Repair and maintenance was also charged at a rate of 5.0% per year for all depreciable items.

Operating costs per production cycle are incurred upon actual operation of the grow-out unit and include purchasing of juvenile, repairs and maintenance, labor, feed, electricity, fuel and interest on operating capital. Costs for purchasing of spotted babylon juveniles are $US0.016 per individuals. Spotted babylon is fed fresh meat of trash fish at a cost of $US0.27 per kg and feed conversion ratio was 1.68-2.0. The repairs and maintenance is estimated upon a percentage of the investment cost (5%) for housing, grow out unit, earthen ponds, reservoirs and operating equipment costs. Electricity is used for operating the various pumps and lighting units in the farm. The average charge was $0.03 per KWh. Labor requirements were based on the particular needs for production cycle of the proposed farm. Two labors (full-time) were assigned for operation of the farm and one labor cost was $US155.10 per month. Land of 4,800 $m^2$ is the actual lease from private sector at a rate of $US792 per year. Interest charges for operating capital are based on 2007 bank loan rates (3.0% per year) for this type of business.

#### Return analysis

Net return for grow-out production were computed at the current market price of spotted babylon at farm gate in 2007 ($US9.44 per kg). Gross return per production cycle was computed from total yield multiplied by selling price. Net return per production cycle was calculated from the gross return minus the total amount cost per production cycle (Rubino, 1992; Fuller et al., 1992). Payback period was calculated from the total investment divided by net return per production cycle.

## RESULTS

### Growth and production

Growth of B. areolata in body weight over a period of 6 months is shown in Figure 3. Results showed that average growth rates in body weight were 0.91-1.07 g /month and 0.82 – 0.98 g /month for the canvas pond and earthen pond trials, respectively. The snails for both canvas pond and earthen pond trials can reach the marketable sizes within 6 months. At the end of the experiment, final body weights of the snails ranged 5.6 – 6.6 g and 5.2 – 6.2 g for the canvas pond and earthen pond trials, respectively, equivalent to the sizes of 150 – 180 and 161 – 200 snails /kg, respectively. Feed conversion ratio (FCR) and final survival of snails in the canvas pond trial were 1.82 and 98.0%, respectively, and 2.39 and 81.0% for those of the earthen pond trial, respectively. Total yields per production cycle were 1,930 and 1,760 kg for the canvas pond and earthen pond trials, respectively. Actual data used for grow out of juvenile B. areolata to marketable sizes in large-scale flow-through canvas ponds and earthen ponds are presented in Table 1.

### Cost analysis

Farm data (total farm area, pond sizes, and total pond area), grow-out data (average initial weight, stocking density) and harvest data (duration of growing-out, average weight at harvest, final survival, feed conversion ratio and yield) were based on the actual data in Table 1 and parameters used for the cost analysis for grow out of the spotted babylon juveniles to marketable sizes in the canvas pond and earthen pond trials are presented in Tables 2 to 7.

Investment requirements were estimated to be $US18, 629.6 and US8, 832.3 for the canvas pond and earthen pond trials, respectively (Table 2). The top three total investments of the canvas pond trial were the construction of growing-out ponds and housing (71.19%), followed by accommodation and facilities (8.48%), seawater pump and housing (5.09%). For the earthen pond trial, the top three total investments were the construction of grow out ponds (35.65%), followed by accommodation and facilities (17.88%) and air blower and housing (14.29%). These three components of the farm represented 84.76 and 67.82% of total investment for the canvas pond and earthen pond trials, respectively. Fixed costs per production cycle for the canvas pond trial was estimated to be $US2,381.6 and the major groups of fixed costs in the canvas pond trial were depreciation (92.6%), repairs and maintenances (4.6), and interests

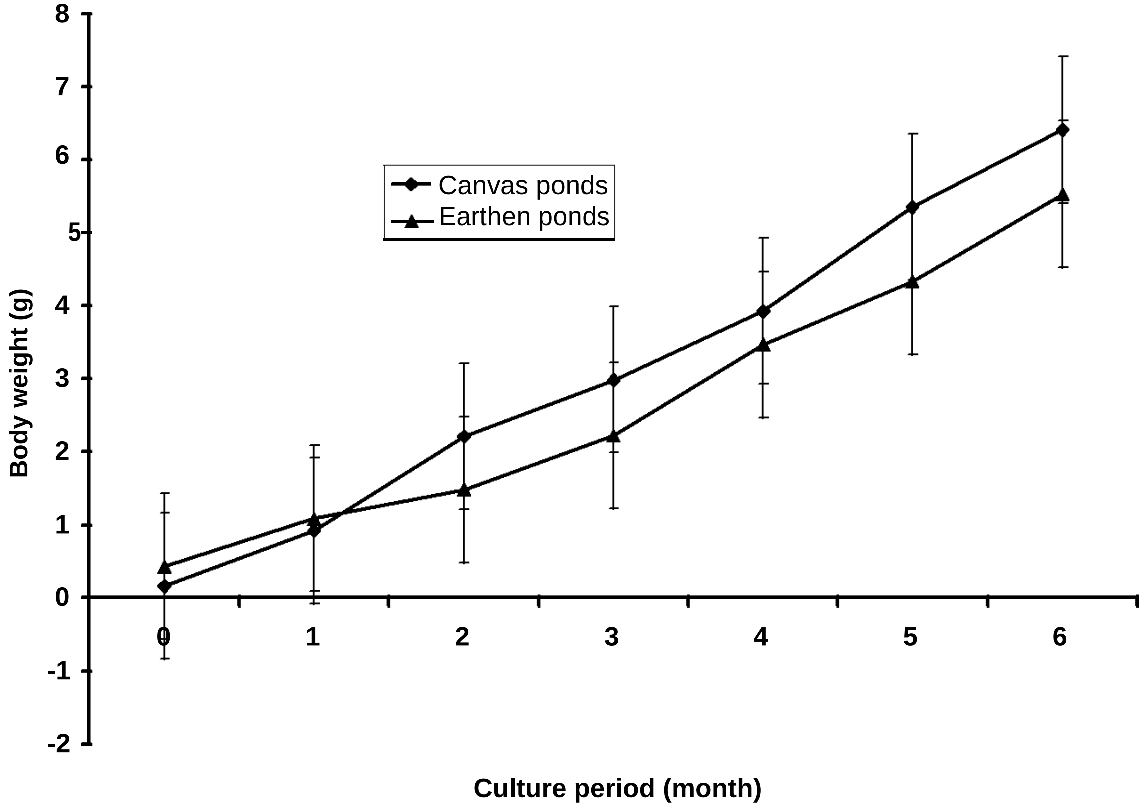


**Figure 3.** Growth in body weight of juvenile *B. areolata* cultured to marketable sizes in large-scale flow-through canvas ponds and earthen ponds.

on fixed cost (2.8%). For the earthen pond trial, the fixed costs per production cycle was $US1, 317.8 consisting of depreciation (92.6%), repairs and maintenances (4.6), and interests on fixed cost (2.8%) (Table 3 and 4). The fixed cost per kg of the canvas pond trial (US1.23) was higher than that of the earthen pond trial ($US0.75).

Operating costs per production cycle were estimated to be $US10,761.6 and US8,844.5 for the canvas pond and earthen pond trials, respectively (Table 5). The top three operating costs of the canvass pond trial were the purchasing of juveniles (37.74%), followed by labor (17.56%) and electricity (17.56%). For the earthen pond trial, the top three operating costs were the purchasing of juveniles (45.92%), followed by fuels for aeration (18.58%) and feed (13.37%). These three components of the farm represented 72.86 and 77.87% of total investment for the canvas pond and earthen pond trials, respectively. The operating cost per kg of the canvas pond trial ($US5.58) was higher than that of the earthen pond trial ($US5.03) as presented in Table 6

Total cost per production cycle of the canvass pond trial were estimated to be $US13,143.3 which consisted of the operating cost and ownership cost of 81.88 and 18.12% respectively, and those of the earthen pond trial were $US10,162.4 with the operating cost and ownership cost of 87.03 and 12.97%, respectively. The total cost per kg of the canvass pond trial ($US6.81) was higher than that of the earthen pond trial ($US5.77).

## Return analysis

Parameters used for the cost analysis for grow out of the spotted babylon juveniles to marketable sizes in the canvas pond and earthen pond trials are presented in Table 7. The economic analysis was based on the price of spotted babylon at farm gate in 2007 of $US9.44 per kg. Gross return per production cycle was estimated to be $US18, 219.2 and US16, 614.4 for the canvas pond and earthen pond trials, respectively, and $US5, 075.9 and US6, 452.0 for those of net return per production cycle, respectively. Break-even in amount were estimated to be 616.9 and 298.8 kg per production cycle for the canvas pond and earthen pond trials, respectively, and 1.8 and 0.7 for those of payback period per annum, respectively.

## DISCUSSION

This study provides good results in economic analysis that the investment requirements of the canvas pond trial

**Table 1.** Actual data used for economic analysis for grow out of juvenile *B. areolata* to marketable sizes in large-scale flow-through canvass ponds and earthen ponds

| Parameter | Canvas pond | Earthen pond |
|---|---|---|
| **Farm data** | | |
| - Total area of farm ($m^2$) | 3,200 | 3,200 |
| - Pond size (m) | 6.0x12.0x0.4 | 20.0x19.0x1.2 |
| - Pond bottom area ($m^2$) | 72 | 380 |
| - Number of ponds | 16 | 3 |
| - Total area of grow out ($m^2$) | 1,152 | 1,140 |
| - Total volume of seawater stocking pond ($m^3$) | 1,200 | 1,200 |
| - Total area of housing and facilities ($m^2$) | 400 | 400 |
| **Grow out data** | | |
| - Initial weight (g/snail) | 0.30 | 0.30 |
| - Initial sizes (snails/kg) | 3,000 | 3,000 |
| - Stocking density (no. $m^{-2}$) | 280 | 280 |
| - Number of snails per pond (individuals) | 20,160 | 106,400 |
| - Total snails per crop (individuals) | 322,500 | 319,200 |
| - Duration of grow-out (mo/crop) | 6 | 6 |
| - Feed cost ($US/kg) | 0.27 | 0.27 |
| - Total feed used (kg/production cycle) | 3,290 | 4,380 |
| **Harvest data** | | |
| - Final weight (g/snail) | 5.6 – 6.6 | 5.2 – 6.2 |
| - Final sizes (individual/kg) | 150 – 180 | 160 – 200 |
| - Growth rate (g/month) | 0.91 – 1.07 | 0.82 – 0.98 |
| - Final survival (%) | 98.0 | 81.0 |
| - Feed conversion ratio (FCR) | 1.82 | 2.39 |
| - Average yield per pond (kg) | 120 | 586 |
| - Total yield per production cycle (kg) | 1,930 | 1,760 |
| - Selling price at farm gate ($US/kg) | 9.44 | 9.44 |

**Table 2.** Estimated investment requirements for grow out of juvenile *B. areolata* to marketable sizes in large-scale flow-through canvass ponds and earthen ponds.

| Item | Canvas pond | | Earthen pond | |
|---|---|---|---|---|
| | $US | % | $US | % |
| Sixteen grow out canvass ponds (6.0x12.0x0.4 m) and housings | 13,261.8 | 71.19 | - | - |
| Three grow out earthen ponds (20.0x19.0x1.2 m) | | - | 3,148.6 | 35.65 |
| Accommodation and facilities | - | 8.48 | 1,578.8 | 17.88 |
| Digging of seawater stocking earthen pond | 1,578.9 | 3.39 | 631.5 | 7.15 |
| Seawater pumps and housing | 631.5 | 5.09 | 947.3 | 10.73 |
| Air blowers and housing | 947.3 | 3.39 | 1,263.0 | 14.29 |
| Seawater pumps for flow-through seawater | 631.5 | 1.69 | - | - |
| Operating equipments (salinometer, thermometer, ect) | 315.8 | 1.69 | 315.8 | 3.58 |
| Miscellaneous | 947.3 | 5.08 | 947.3 | 10.72 |
| Total investment | 18,629.6 | 100 | 8,832.3 | 100 |

**Table 3.** Estimated depreciation, interest charges, and repairs and maintenances for grow out of juvenile *B. areolata* to marketable sizes in large-scale flow-through canvas ponds and earthen ponds.

| Item | Canvas pond | | | | Earthen pond | | | |
|---|---|---|---|---|---|---|---|---|
| | Cost (US$) | Annual depreciation (US$) | Annual interest charges[1] (US$) | Annual repairs /maintenance[2] (US$) | Cost (US$) | Annual depreciation (US$) | Annual interest charges[1] (US$) | Annual repairs /maintenance[2] (US$) |
| Canvass ponds and housings (5)* | 13,261.8 | 2,652.4 | 79.6 | 132.6 | - | - | - | - |
| Grow out earthen ponds (5)* | - | - | - | - | 3,148.6 | 629.7 | 18.9 | 31.5 |
| Accommodation and facilities (3)* | 1,578.9 | 526.3 | 15.8 | 26.3 | 1,578.8 | 526.3 | 15.8 | 26.3 |
| Water stocking earthen pond (5)* | 631.5 | 126.3 | 3.8 | 6.3 | 631.5 | 126.3 | 3.8 | 6.3 |
| Seawater pumps and housing (3)* | 947.3 | 315.8 | 9.5 | 15.8 | 947.3 | 315.8 | 9.5 | 15.8 |
| Air blowers and housing (3)* | 631.5 | 210.5 | 6.3 | 10.5 | 1,263.0 | 421.0 | 12.6 | 21.1 |
| Water pumps for flow-through (2)* | 315.8 | 157.9 | 4.7 | 7.9 | - | - | - | - |
| Operating equipments (3)* | 315.8 | 105.3 | 3.2 | 5.3 | 315.8 | 105.3 | 3.2 | 5.3 |
| Miscellaneous (3)* | 947.3 | 315.8 | 9.5 | 15.8 | 947.3 | 315.8 | 9.5 | 15.8 |
| Total cost per year | | 4,410.3 | 132.4 | 220.5 | | 2,440.2 | 73.3 | 122.1 |

Numbers in parenthesis are economic life in years.[1]Annual interest charges for all items are estimated to be 3%; [2]annual repairs /maintenances for all items are estimated to be 5%.

($US18, 629.6) were higher than that of earthen pond trial ($US8, 832.3). The major advantage of the earthen pond trial was lower investment costs for construction of grow out ponds and housing (35.65%) than those of canvass pond trial

(71.19%). Total cost per production cycle of the earthen pond trial contained the lower fixed cost (12.97%) than that of canvas pond trial (18.12%). Finally, net return per production cycle of the canvass pond ($US5, 075.9) was lower than that of earthen pond trial ($US6,452.0) and the payback period were estimated to be 1.8 and 0.7 production cycle for the canvass pond and earthen pond trials, respectively. This study indicated that grow out of spotted babylon in earthen pond is more highly profitable than those in the canvass pond. Chaitanawisuti et al. (2002) reported that a pilot commercial production of spotted babylon in canvass ponds with a total culture area of 135 $m^2$ provided gross return of US$5747.2 and net return of US$1128.2 which was lower than this study. Kritsanapuntu et al. (2006) reported the feasibility of grow out B. areolata for monoculture and two polyculture trials with sea bass (*Lates calcarifer*) or milkfish (*Chanos chanos*) in large-scale earthen pond. This study provided good result in growth and survival of spotted babylon in earthen ponds. Mean body weight gain of snails held in the monoculture was 5.39 and 4.07 g and 4.25 g for those held in the polyculture with sea bass or milkfish, respectively. FCR was 2.69, 2.96 and 2.71 for snails held in the monoculture, polyculture with sea bass and milkfish, respectively, and final survival were 84.94, 74.30 and 81.20%, respectively. The most concerned major issues for slow growth and sizes distribution of spotted babylon in earthen pond is the soil sanitization caused by pond seepage, salinity increases due to water evaporation, salinity decrease due to heavy rain falls, fast deterioration of total alkalinity, appropriate feeding strategy and invasions of snails (*Cerithium* sp.). These may be due to the excessive food offered which caused the degradation of water quality and decay of pond bottom. Food competition from various predators naturally occur in earthen ponds such as tiger prawn (P. *monodon*), swimming crabs (*Portunus pelagicus*), mud crab (*Scylla* sp), carp(Orechormis mossambica); deterioration of water quality particularly total alkalinity caused slower feeding of spotted babylon, salinity decrease during raining season caused slower feeding and slow growth obviously, and mineral competition from large number of snail (Cerithium sp.) particularly calcium for shell formation caused shell abnormality and slow growth.

In the present study, production and economic analysis performed for growing out of juvenile B. areolata to marketable sizes using a pilot large-

**Table 4.** Estimated fixed costs for grow out of juvenile *B. areolata* to marketable sizes in large-scale flow-through canvas ponds and earthen ponds.

| Item | Canvas pond | | Earthen pond | |
|---|---|---|---|---|
| | $US | % | $US | % |
| Annual depreciations | 4,410.3 | 92.6 | 2,440.2 | 92.6 |
| Annual interest charges | 132.3 | 2.8 | 73.3 | 2.8 |
| Annual repairs /maintenances | 220.5 | 4.6 | 122.1 | 4.6 |
| Fixed cost per annum | 4,763.1 | 100 | 2,635.6 | 100 |
| Fixed cost per production cycle[1] | 2,381.6 | | 1,317.8 | |
| Fixed cost per kg[2] | 1.23 | | 0.75 | |

[1]One production cycle was 6 months; [2]yield per production cycle was 1,930 and 1,760 kg for canvass pond and earthen pond, respectively.

**Table 5.** Estimated operating costs per production cycle for grow out of juvenile *B. areolata* to marketable sizes in large-scale flow-through canvas ponds and earthen ponds.

| Item | Canvas pond | | Earthen pond | |
|---|---|---|---|---|
| | $US | % | $US | % |
| Purchasing for juveniles | 4,061.7 | 37.74 | 4,061.7 | 45.92 |
| Fuels and lubricants for seawater pumping | 821.8 | 7.64 | 328.7 | 3.72 |
| Fuels and lubricants for aeration | - | - | 1,643.6 | 18.58 |
| Electricity for aeration (air blowers) | 1,889.2 | 17.56 | - | - |
| Feed | 888.3 | 8.25 | 1,182.6 | 13.37 |
| Labor (full time) | 1,889.2 | 17.56 | 944.6 | 10.68 |
| Repairs and maintenance | 931.5 | 8.66 | 441.6 | 4.99 |
| Interests on operating cost | 279.9 | 2.59 | 241.7 | 2.74 |
| Operating cost per production cycle[1] | 10,761.6 | 100 | 8,844.5 | 100 |
| Operating cost per annum | 21,523.2 | | 17,689.0 | |
| Operating cost per kg[2] | 5.58 | | 5.03 | |

[1]One production cycle was 6 months; [2]Yield per production cycle was 1,930 and 1,760 kg for canvas pond and earthen pond, respectively.

scale production of earthen ponds showed that juvenile spotted babylon could be successfully grown to marketable size in earthen ponds. The present study has basically demonstrated that it had advantage to culture the spotted babylon in earthen ponds such as the abandoned shrimp ponds by stocking acclimated spotted babylon juveniles to marketable sizes. Thus, monoculture of spotted babylon is environmentally friendly because of no chemical substances and antibiotic throughout the culture period, and economically attractive with appropriate abandoned shrimp farms, resulting in effective reuse of abandoned shrimp ponds, better economic returns and less environmental pollution.

The results of this study provide evidence for the biological feasibility of culturing the spotted babylon in earthen ponds. The feasibility of producing spotted babylon marketable sizes in pilot grow-out earthen pond operation should be continued to be examined, although return are small, production with 80% survival and selling price of $US9.44/kg is economically feasible under the assumptions employed. Profitability also can be improved by targeting production, and market prices and areas. In general, snails are rendered unmarketable by stunting and deformities characteristics which are presumably related to lowered growth rates (i.e. final average weights) and survival. Decreasing the culture period to 5 month and decreasing the juvenile prices to $0.01 per juvenile considerably improve the economic feasibility, higher profitability and more production cycle per year.

This economic analysis is intended as a guide and must be modified to reflect individual situations. However, application of these results to commercial levels of production should be preceded by careful examination of other parameters that might be important such as deterioration of water quality at high stocking densities. Further study should be concentrated for pond design, management of seawater and pond bottom, feeding strategy, and competition for food and habitat due to

**Table 6.** Estimated total cost per production cycle for grow out of juvenile *B. areolata* to marketable sizes in large-scale flow-through canvas ponds and earthen ponds.

| Item | Canvas pond | | Earthen pond | |
|---|---|---|---|---|
| | $US | % | $US | % |
| Fixed costs | 2,381.7 | 18.12 | 1,317.9 | 12.97 |
| Depreciations | 2,205.2 | 16.78 | 1,220.1 | 12.01 |
| Interests | 66.2 | 0.51 | 36.7 | 0.36 |
| Repairs and maintenances | 110.3 | 0.84 | 61.1 | 0.60 |
| Operating costs | 10,761.6 | 81.88 | 8,844.5 | 87.03 |
| Purchasing for juveniles | 4,061.7 | 30.90 | 4,061.7 | 39.97 |
| Fuels and lubricants for seawater pumping | 821.8 | 6.25 | 328.7 | 3.23 |
| Fuels and lubricants for aeration | - | - | 1,643.6 | 16.17 |
| Electricity for aeration (air blowers) | 1,889.2 | 14.37 | - | - |
| Feed | 888.3 | 6.76 | 1,182.6 | 11.64 |
| Labor (full time) | 1,889.2 | 14.37 | 944.6 | 9.29 |
| Repairs and maintenance | 931.5 | 7.09 | 441.6 | 4.35 |
| Interests on operating cost | 279.9 | 2.13 | 241.7 | 2.38 |
| Total cost per production cycle[1] | 13,143.3 | 100 | 10,162.4 | 100 |
| Total cost per annum | 26,286.6 | | 20,324.8 | |
| Total cost per kg[2] | 6.81 | | 5.77 | |

[1]One production cycle was 6 months; [2]yield per production cycle was 1,930 and 1,760 kg for canvas pond and earthen pond, respectively.

**Table 7.** Economic analysis for grow out of juvenile *B. areolata* to marketable sizes in large-scale flow-through canvas ponds and earthen ponds. One production cycle was 6 months.

| Parameter | Canvas pond | Earthen pond |
|---|---|---|
| Yield | | |
| Yield per production cycle (kg) | 1,930 | 1,760 |
| **Costs** | | |
| Investment requirements[1] ($US) | 18,629.6 | 8,832.3 |
| Fixed costs ($US per production cycle) | 2,381.6 | 1,317.8 |
| Operating costs ($US per production cycle) | 10,761.6 | 8,844.5 |
| Total cost ($US per production cycle) | 13,143.3 | 10,162.4 |
| **Returns** | | |
| Gross return[2] ($US per production cycle) | 18,219.2 | 16,614.4 |
| Net returns ($US per production cycle) | 5,075.9 | 6,452.0 |
| Net returns ($US per annum) | 10,151.8 | 12,904.0 |
| Net returns ($US per kg) | 2.63 | 3.67 |
| Break-even in amounts (kg per production cycle) | 616.99 | 298.82 |
| Break-even in cash ($US per production cycle) | 5,808.7 | 2,803.8 |
| Payback period per annum | 1.8 | 0.7 |

[1]For whole operations of 16 canvas ponds (6x12x0.4 m) and 3 earthen ponds (20x19.0x1.2 m); [2c]urrent market price at farm gate for spotted babylon of $US 9.44 per kg in 2007

naturally occurring organisms, harvesting techniques, etc for the success of commercial grow-out operation of spotted babylon in earthen ponds.


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