Effect of Apple Snail *(Pomacea canaliculata)* and By-Catch Fish Feeding on the Growth, Production and Nutrient Composition of Mudcrub *(Scylla serrata)* in Ponds

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Abstract: The culture of mud crab (*Scylla serrata*) was carried out at the Brackishwater Fishpond of Samar State University Mercedes Campus, Catbalogan City. Nine net enclosures, each with 50 m^2 area were stocked with crablets (25 g. average body weight) at 1 crablet/m^2 and raised for 120 days. The study consisted of three treatments, as follows: Treatment I (fed with apple snail), Treatment II (fed with apple snail + by-catch fish combination), and Treatment III (fed with by-catch fish). Results showed that after 120 days, the highest final mean weight of 471.59 g was obtained in Treatment II, followed by 442.04 g in Treatment III and 424.27 g in Treatment I. Mean daily weight increments (g/crab/day) for Treatments I, II and III were 3.33 g; 3.72 g and 3.47 g, respectively. Survival rates were 45.67% (Treatment II and III) and 45.33% (Treatment I). Mean yield of 2,185.60 (Treatment II), 2,027.67 (Treatment III), and 1,887.27 kg/ha (Treatment I) do not differ significantly (P 0.05). However, final mean weights, mean daily weight increments, and percentage survival do not differ significantly (P 0.05) among treatments. Apple snail (*Pomacea canaliculata*) is a potential feed source for mud crabs or it could be administered in combination with by-catch fish. In order to improve production mortality rates should be reduced.

Keywords: aquaculture, mariculture, alternative feeds, crab, brackish water

1. Introduction

Mud crab of the Genus ***Scylla***, also known as green crab, mangrove crab or king crab and locally known as “alimango” constitute an important secondary crop in traditional shrimp or milkfish ponds in the Philippines and in the Asian countries. This aquaculture commodity has come into prominence with the commencement of live crab export to the Southeast Asian countries which have created a renewed interest in the exploitation as well as in the production of mud crabs through aquaculture. The importance of live mud crabs as an export commodity has opened up great opportunities for crab farming, most especially in areas with vast mangrove resources and unproductive and less fishponds devoted for milkfish and giant tiger shrimps.

Mudcrabs are luxury items and are well-appreciated for their taste and texture. These are acknowledged to be low in fat, high in protein, and are excellent sources of vitamins and minerals (SEAFDEC Aqua Farm News, 1977). It has high demand and price in the domestic and export market such as Japan, China, Hong Kong, and Taiwan (Department of Agriculture Website).

Mud crabs are voracious eaters and requires high energy content feed (Hill, 1979). In the Philippines, under culture conditions they are given trash fish and mussel meat as the primary feedstuffs. However, because of their inadequacy in some areas and increasing prices, mud crab production activities become limited. Hence, alternative feedstuffs need to be tried and studied.

Freshwater apple snail (*Pomacea canaliculata*) locally known as "kuhol" is envisioned to be a potential feed material. The introduction of this organism to the Philippines has caused dramatic problems among rice farmers, causing havoc and destruction to newly-planted rice in many parts of the country. Their high fertility, fast growth, and being voracious feeders on vegetation become a major problem in agriculture from the past to the present times. Therefore, their utilization as feed for mud crab in ponds is an alternative solution to the persistent problem on this freshwater organism as an agricultural pest. The apple snail in terms of its nutritive value per 100 grams flesh contains: food energy (83 calories); protein (12.2 g); fat (0.4 g); carbohydrates (6.6 g); ash (3.2 g); phosphorous (61 mg); niacin (1.8 mg) and other food values such as Vitamin C, zinc, copper, manganese, and iodine (the apple snail *website:http://www.applesnail.net*) making it a potential feedstuff for aquaculture production.

2. Objectives

This study aims at evaluating the growth, percentage survival, yield and cost analysis of mudcrab culture in ponds fed with apple snail, by-catch fish, and apple snail + by-catch fish combination including the proximate analysis of the feeds given as well as the mudcrabs produced.

3. Methodology

3.1. Experimental Site. This study was conducted at the Samar State University Brackishwater Fishpond in Pupua, Catbalogan City (Western) Samar, Philippines. Nine experimental net enclosures were constructed, each with an area of 50 m^2. Knotted nylon netting No. 14 were buried into the muddy bottom at 0.75 m deep and fastened to bamboo posts. The upper end of the net extends 1.0 m above the waterline.

3.2. Experimental Treatments. The study consisted of three (3) treatments, namely: Treatment I (mud crabs fed with apple snail), Treatment II (mud crabs fed with apple snail and by-catch fish combination at 1:1 ratio), and Treatment III (mud crabs fed with by-catch fish as Control). Each treatment consisted of three replicates.

*3.3 Experimental Design***.** A completely randomized design was adopted.

*Production Activities***.**

*3.3.1 Pond Preparation***.** The pond was completely drained**,** levelled and cleared of unnecessary dirt and debris. This was exposed to direct sunlight for 7 days until the bottom cracked. After

drying, the pond was flushed with new tidal water.

3.3.2 Stocking. Crablets 25 g mean weight was stocked at one (1) crablet/m^2. Stocking was done late in the afternoon.

3.3.3 Feeding. The stocks were fed 20% body weight for the first 2 months of culture then reduced to 10% for the rest of the growing period. Feeding was done late in the afternoon (1700 HRS). Chopped by-catch fish and crushed apple snails were broadcast over the compartments.

3.3.4 Culture period. The culture period runs for 120 days.

3.3.5 Water management. Water inside the compartment was maintained at 0.75 to 1 meter depth. Regular water renewal was done twice a week to ensure good water quality and removal of metabolites. Thirty (30) percent of the water was removed every water freshening and replaced with the same amount during high water marks.

3.3.6 Sampling. Monthly sampling of stocks was undertaken to monitor growth and as basis for feeding adjustments. Twenty percent (20%) of the stocks were sampled using collapsible traps.

3.3.7 Monitoring of water parameters. Temperature and salinity were monitored daily at 0800HRS and 1500HRS.

3.3.8 Pond maintenance. Regular inspection of enclosures and water control structures were done regularly in order to prevent loss of stock. Leakages were immediately checked. Damage in net enclosures was immediately repaired.

3.3.9 Harvest. After 4 months of culture, the pond was totally drained and stocks were harvested manually. The carapace length and width was measured using a calliper while individual weights were taken using a top loading balance.

3.4 Proximate Analyses. Steamed by-catch fish, meat of harvested crabs, and apple snails were submitted to DOST Regional Standard and Testing Laboratory, Regional Office VIII for nutrient analyses. Ash content was determined using gravimetric method; moisture content by oven drying; total fat through Soxtec System. Crude protein was analyzed through block digestion/steam distillation while carbohydrate content was determined by difference and energy by computation.

4. Results and Discussion

4.1 Growth.

The body of mud crab is entirely enclosed in a calcified outer shell and for growth to occur the shell has to be casted through the process of molting. Growth is a combination of the increase in size at a molt (molt increment) and the number of times molting occurs (molt frequency) (Edwards, 1979). For the entire culture period of 120 days, three monthly samplings were made in order to monitor growth of the cultured stock. Mean weights taken served as basis for computation of feeding rate adjustments.

The average final weights after 120 days culture (Table 1) were: 471.59 g. (Treatment II); 442.04 g (Treatment III); and 424.27 g (Treatment I). Mean weights

Table 1. Final weight in grams (g) of mud crab (*Scylla serrata*) cultured in pond fed with apple snail (*Pomacea canaliculata*), by-catch fish, and apple snail+ by-catch fish combination.

Treatments*	Replicates			Treatment Total	Treatment Mean
	R1	R2	R3		
I	523.44	369.73	379.65	1272.82	424.27
II	561.96	535.00	317.81	1414.77	471.59
III	512.50	514.82	298.79	1326.11	442.04
Total				4013.70	445.97

**Treatment I (fed with apple snail)*
Treatment II (fed with combined apple snail + by-catch fish)
Treatment III (fed with by-catch fish)

Table 2. Mean daily increment in grams per day of mud crab cultured in pond fed with apple snail, by-catch fish, and apple snail+ by-catch fish combination.

TREATMENTS*	Replicates			Treatment Total	Treatment Mean
	R1	R2	R3		
I	4.15	2.87	2.96	9.98	3.33
II	4.48	4.25	2.44	11.17	3.72
III	4.06	4.08	2.28	10.42	3.47
Total				10.52	3.51

**Treatment I (fed with apple snail)*
Treatment II (fed with combined apple snail + by-catch)
Treatment III (fed with by-catch fish)

showed no significant differences among treatments (P >0.05).

4.2 Weight Increment

In terms of daily weight increment for 120 days culture period (Table 2), Treatment II obtained the highest value of 3.72 g/ crab/day. Treatment III and I obtained a daily weights increment of 3.47 and 3.33 g/crab/day, respectively. However, daily weight increment among treatments do not differ significantly (P>0.05).

4.3 Carapace length and width

After 120 days culture period, the mean carapace measured 12.32 cm (length) and 9.41 cm (width) in Treatment II; 11.80 cm (length) and 7.95 cm (width) in Treatment III; and 11.38 cm (length) and 7.73 cm (width) in Treatment I. **Survival.** The survival rates of mud crab were unexpectedly low in all treatments. Treatments II and III achieved the highest mean survival of 45.67% while in Treatment I obtained a mean of 45.33% (Table 3). However, the accounted mortalities were 54.67%, 54.33%, and 54.33% in Treatments I, II, and III, respectively.

Low survival rates could be attributed to low water depth in the experimental enclosures because the pond could not maintain a depth higher than 75 cm since its perimeter dikes are not strong enough to hold greater water volume which resulted to abrupt changes in water conditions such as temperature and salinity. Moreover, mud crabs are scavengers and highly cannibalistic in nature which reduced the population of the cultured stock. They even feed on other crabs under cultivation especially those that have just molted and are weak (Triño, 1997). Hill (1978) reported that major prey groups of mud

Table 3. Mean carapace length and width in centimeters at harvest of mud crab cultured in pond

Treatments*	Replicate 1		Replicate 2		Replicate 3		Treatment Mean	
	CL	CW	CL	CW	CL	CW	CL	CW
I	12.45	8.42	10.88	7.31	10.81	7.46	11.38	7.73
II	13.33	9.00	12.97	11.90	10.66	7.13	12.32	9.41
III	12.90	9.02	12.00	8.17	10.51	6.67	11.80	7.95
Mean							11.83	8.36

**Treatment I (fed with apple snail)*
Treatment II (fed with combined apple snail + by-catch)
Treatment III (fed with by-catch fish)
Note: CL – carapace length CW – carapace width

Table 4. Survival rate (percent per compartment) of mud crab in pond

Treatments*	Replicates			Treatment Total	Treatment Mean
	R1	R2	R3		
I	38.00	48.00	50.00	136.00	45.33
II	48.00	45.30	43.67	137.00	45.67
III	48.00	46.33	42.67	137.00	45.67
Total				410.00	45.56

**Treatment I (fed with apple snail)*
Treatment II (fed with combined apple snail + by-catch fish)
Treatment III (fed with by-catch fish)

Table 5. Monthly averages and ranges of salinity and temperature measured at different measured at different time periods.

Month	Salinity (ppt)				Temperature °C			
	0800 hours	Range	1500 hours	Range	0800 hours	Range	1500 hours	Range
Nov.	30.33	30.0-31.0	30.66	30.5-31.0	27.33	26.5-28.5	27.83	27.0-29.0
Dec.	29.71	25.0-34.0	29.72	25.0-34.0	28.19	26.0-30.0	28.24	26.0-31.0
Jan.	24.29	22.0-25.5	24.50	22.0-26.0	28.50	27.5-30.0	29.01	28.0-31.0
Feb.	32.41	28.0-37.0	32.62	28.0-35.5	28.59	25.0-32.0	31.57	25.0-34.0
Mar.	21.98	5.0-32.0	22.00	5.0-32.0	28.80	25.7-31.0	30.23	26.0-35.0

crabs are burrowing bivalves, attached bivalves, and small crabs. They showed preference for small crabs as prey because of their larger mass and higher energy content compared with other prey organisms.

4.4 Ranges of salinity and temperature

The salinity and temperature readings are presented in Table 5. Monthly average readings of salinity at 0800HRS ranged from 5.00 to 37.00 parts per thousand and 5.00 to 35.5 parts per thousand at 1500HRS. The mean salinity for the 120-day culture period is 27.42 ppt (0800HRS) and 27.33 ppt (1500HRS). These salinity values are within the favorable levels for *Scylla serrata* as reported by Bhuiyan (1981) in a salinity tolerance experiment which stressed that most favorable regime of salinity is 10 to 50 ppt with lower and upper lethal salinity level is 10 ppt and 50 ppt, respectively. However, according to Triño

(1997) mud crabs are able to survive in a salinity range of 2 – 43 parts per thousand but their optimum salinity requirement is 15 – 30 parts per thousand.

Average monthly temperature readings at 0800HRS for the entire study period ranged from 25 to 32oC while afternoon readings (1500HRS) ranged from 25 to 35oC. Mean daily temperature for the entire culture period is at 27.8oC and 28.67oC. And this is within the range of favorable conditions as mentioned by Triño (1997) that mud crabs are eurythermal. They can withstand water temperature ranging from 12 – 35oC but their activity and feeding fall rapidly at temperature below 20oC. The optimum temperature requirement for fast growth is 23 - 32oC (Triño, 1997).

Variations in salinity and temperature in the culture site could be attributed to heavy downpour of rain, prolonged sunny days, and water freshening.

4.5 Production and Feed Conversion Ratio (FCR)

The mean yield per hectare per cropping at 1 crab/50 m2 stocking density varied among the three treatments (Table 6). Treatment II obtained the highest mean yield of 10.928 kg, followed by Treatment III with 10.138 kg., and finally by Treatment I with 9.436 kg. Yield in Treatment II was significantly higher (P>0.05) than in Treatment I. However, no significant difference existed between Treatment I and III and Treatments II and III.

In terms of production income in different treatments (Table 7), the highest is noted in Treatment II with lowest in

Table 6. Yield of mud crab in the different treatments in pond for 120 culture period

Treatments*	Replicates			Treatment Total	Treatment Mean	FCR
	R1	R2	R3			
I	9.945	8.873	9.491	28.309	9.436[a]	12.12
II	13.487	12.305	6.992	32.784	10.928[b]	9.23
III	12.30	11.84	6.275	30.415	10.138[ab]	12.32
Total				91.508	10.167	

**Treatment I (fed with apple snail)*
Treatment II (fed with combined apple snail + by-catch fish)
Treatment III (fed with by-catch fish)
Means in a column with the same superscripts are not significantly different (P>0.05)

Table 7. Production income (PhP) in the three treatments

Treatments	Replicates (income in pesos)			Treatment Total	Treatment Mean
	R1	R2	R3		
I	3505.61	2395.71	2562.57	8463.89	PhP 2,821.30
II	4754.17	4337.51	1887.84	10979.52	PhP 3,659.84
III	4335.75	4067.85	900.46	9304.06	PhP 3,101.35
Total				28747.47	PhP 3,194.06

Note: Average selling price at Calbayog City for the least 2 years
500 – 599 g – PhP 352.50/kg.
300 - 399 g - PhP 270.00/kg
200 – 299 g - PhP 143.50/kg

Table 8. Comparative Projected Cost of Production of Mudcrab at Different Treatments per hectare per year (2 croppings). First Cropping (120 days culture period)

Items	Treatment I	Treatment II	Treatment III
Pre-operating cost:			
-Pond repair	20,000	20,000	20,000
-pond levelling	5,000	5,000	5,000
-installation of posts and netting materials	20,000	20,000	20,000
-Bamboo post (150 pcs @ 200/pc)	30,000	30,000	30,000
-Bamboo braces (25 pcs @ P200/pc)	5,000	5,000	5,000
-Nails	300	300	300
-Netting twine	200	200	200
-Monofilament Nylon (20 kgs @ P180.00/kg)	3,600	3,600	3,600
-Wooden banca	5,000	5,000	5,000
-Misc. Expenses	10,000	10,000	10,000
Sub-total	99,100	99,100	99,100
Operating Cost:			
-crablets	230,000	230,000	230,000
-Feeds:			
-Apple snail (22,873.71 @ P4.00/kg)	91,494.84		
-Apple snail + by-catch fish combination		141,211.70	
-By-catch fish (P24,980.89 kg @ P 10/kg)			249,808.90
-Wages (2 persons) for 5 months culture period and harvest	45,000.00	45,000.00	45,000.00
-Misc. Expenses	2,000.00	2,000.00	2,000.00
Sub-total	368,494.84	418,211.70	526,808.90
TOTAL	467,594.84	517,311.70	625,908.90

**Treatment I (fed with apple snail)*
Treatment II (fed with combined apple snail + by-catch fish)
Treatment III (fed with by-catch fish)

Treatment I. Sales of products vary with size at harvest, sex of mud crabs, and the prevailing buying price at the locality. Higher prices of mud crabs was observed during the holiday seasons , i.e. Christmas, New Year, and the Chinese New Year (December – February of each year).

It can be noted that lower FCR value was obtained in treatment with apple snail and by-catch fish combination. However, feeding mud crab with by-catch fish requires more feed quantity as compared to using apple snail as feeds. Thus, the more feed is required at higher cost, the greater is the production expense.

Comparing the three treatments, in terms of production cost per hectare, greater amount is required during the first cropping period due to its pre-operating costs. Feeding mud crabs with apple snail (Treatment I) and apple snail + by-catch fish combination resulted to a return of investment during the first cropping of 20.67% and 41.49%, respectively. A negative ROI is noted in Treatment III (using by-catch fish) due to the higher cost of feeds. However, during the second cropping and onwards, higher profitability will be derived, most particularly in Treatments I and II.

4.6 Body Composition Analysis

Presented in Table 7 is the result of analyses on the body composition of both feedstuffs and experimental species.

Table 9. Comparative Projected Cost of Production of Mudcrab at Different Treatments per hectare per year (2 croppings). Second Cropping (120 days culture period)

Items	Treatment I	Treatment II	Treatment III
-crablets	230,000	230,000	230,000
-Feeds:			
-Apple snail (22,873.71 @ P 4.00/kg)	91,494.84		
-Apple snail + by-catch fish combination		141,211.70	
-By-catch fish (24,980.89 kg @ P 10.00/kg)			249,808.90
-Wages (2 persons for 5 months culture period and harvest)	45,000.00	45,000.00	45,000.00
-Misc. Expenses	2,000.00	2,000.00	2,000.00
TOTAL	368,494.84	418,211.70	526,808.90

**Treatment I (fed with apple snail)*
Treatment II (fed with combined apple snail + by-catch fish)
Treatment III (fed with by-catch fish)

Table 10. Cost and Return analysis per hectare per year for two (2) stocking periods.

Items	Treatments		
	I	II	III
First Cropping			
Total net production (kg/ha)	1,887.27	2,185.60	2,027.67
Production cost (pesos/ha.)	467,594.84	517,311.70	625,908.90
Total Sales	564,260.00	731,968.00	620,270.00
Net Income	96,665.16	214,656.30	(-5,638.90)
ROI (Return of Investment)	20.67%	41.49%	(-0.90%)
Second Cropping			
Total net production (kg/ha)	1,887.27	2,185.60	2,027.67
Production cost (pesos/ha.)	368,494.84	418,211.70	526,808.90
Total Sales	564,260.00	731,968.00	620,270.00
Net Income	195,765.16	313,756.30	93,461.10
ROI (Return of Investment)	53.13%	75.02%	17.74%

**Treatment I (fed with apple snail)*
Treatment II (fed with combined apple snail + by-catch fish)
Treatment III (fed with by-catch fish)

By-catch fish (consisting of slipmouth, cardinal fish, puffer fish, and other low-value fish species)(Appendix Table A) contain higher level of crude protein, total fat, energy, and ash with 19.00%, 1.88%, 95.6 kcal, and 5.38%, respectively as compared to apple snail with 15.40% crude protein, 0.96% total fat, 90.0 kcal energy, and 5.18% ash. In terms of moisture, apple snail recorded at 73.50% and by-catch fish with 73.10%.

The body compositions of mud crabs harvested after 120 days showed that high crude protein levels of 18.40% was obtained in Treatments II and III the highest value is noted in Treatment II (0.94%), followed by Treatment I (0.86%) and Treatment III (0.85%). On the energy levels Treatment II with 90.8 kcal, followed by Treatment III with 88.10 kcal, and Treatment I with 86.8 kcal. The carbohydrate content is highest in Treatment II with 2.21%, followed by Treatment I with 1.78%, and Treatment III with 1.69%. The ash contents are 1.89%,

Table 11. Body composition of feedstuffs (apple snail and by-catch) and mud crab produced in pond.

Parameter*	Apple Snail (feed)	By-catch Fish (Feed)	Experimental Treatments**		
			Treatment I	Treatment II	Treatment III
Ash	5.18	5.38	1.89	1.84	1.88
Moisture	73.50	73.10	77.50	76.60	77.10
Total Fat	0.96	1.88	0.86	0.94	0.85
Crude Protein	15.40	19.00	18.00	18.40	18.40
Carbohydrate	4.96	0.66	1.78	2.21	1.69
Energy	90.0 kcal.	95.6 kcal	86.8 kcal	90.8 kcal	88.10 kcal

*(*Analyses conducted by DOST Regional Standards and Testing Lab.,* Regional Office No. VIII, *Palo, Leyte)*
***Treatment I (fed with apple snail)*
Treatment II (fed with combined apple snail + by-catch fish)
Treatment III (fed with by-catch fish)

1.88%, and 1.84% for treatments I, II, and III, respectively. Treatment I recorded the highest moisture content at 77.50%, followed by Treatment III with 77.10%, and treatment II with 76.60%.

5. Conclusion and Recommendation

The apple snail is a potential feedstuff for mud crab culture in ponds. They can be fed singly or in combination with by-catch fish. In order to obtain higher survival, depth of water of one meter or more should be maintained to provide the organism a more favorable environment.

Utilization of apple snail in aquaculture can be a good protein source for the culture of high-value aquatic products such as mud crab; reduced cost of production in aquaculture since it is cheaper as compared to by catch-fish; reduce destruction of agricultural crops thereby increasing the yield and income of rice farmers; source of income among farmers, children and school youths; and maximum utilization of mangrove areas and less productive fishponds for environment-friendly aquaculture venture.

Further investigation on varied proportions of apple snail to by-catch fish should be undertaken also to determine desirable level of combination for a more profitable aquaculture venture, as well as developing a formulated diet for mud crabs.

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