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EFFECT OF GOLDEN APPLE SNAIL (*Pomacea canaliculata)* MEAT AS FEEDS ON THE GROWTH AND SURVIVAL RATES AND BIOCHEMICAL COMPOSITION OF MUD CRAB (*Scylla serrata)*

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Abstract

Mud crab is considered a new species in aquaculture, widespread interest in its culture is increasing due to rising market valueof mud crabs. At present shrimp feeds and trash fish are currently used as feed stuff for mud crabs, however, their prices are continually r Finding low cost feed supplies has been identified as one of the key challenges facing the rapid growth of the mud crab farming sector in Asian countries. The study aimed to compare the effect of five different feed types - GAS meat, trash fish, shrimp feed, GAS meat + trash fish, GAS meat + shrimp feed, to the growth and survival rate, % biochemical compositions and economic viability of 75 pieces lean mud crabs (*Scylla serrata*) fattened for 20 days. Mud crabs were stocked individually in plastic cases fitted in bamboo frames and installed in brackish water pond. Results showed that mean final weight, carapace length and width of mud crabs fed with GAS meat do not differ significantly (P>0.05) among other treatments. 100% survival rates were recorded on mud crabs fed with GAS meat, TrF and GAS meat + TrF. Protein content is highest in GAS+TrF – fed mud crabs. Cost-benefit analysis showed that GAS meat + TrF diet resulted to highest gain. In conclusion, golden apple snail (*Pomacea canaliculata*) meat is a potential feed source for the mud crab diet as an alternative to trash fish and shrimp feed.

I. INTRODUCTION

Mud crabs (S. *serrata*) are high value resources that are abundant in the Philippines and is considered a new species in aquaculture and are valued due to their economic viability (Nirmale et al. 2012). Aquafarmers ventured into mud crab fattening of these undersized (< 300g female; < 350 g male) crabs for 15 to 20 days to attain the highly priced meat of the pincers of males and the bright red roe of gravid females much sought after by consumers (Patterson and Samuel 2005). Zafar and Ahsan (2006) and Noorbaiduri et al., (2014) mentioned that the widespread interest in its culture is increasing with high expectation to continue to grow in the future due to rising market value and its high demand.

According to Sathiadhas and Najmudeen (2004), feed cost constitutes major cost in aquaculture and this is also the case for mud crab farming. Current feeds and feeding practice used in large-scale mud crab culture are largely derived from shrimp culture. Large-scale mud crab culturists deemed that shrimp feeds are good but is expensive because the ingredients are imported hence, the probable returns for aquacultured crabs may not warrant this expense (Vega-Villasante et al. 2007). Small-scale mud crab farmers depend on low valued fish. Mud crab will eat any trash fish and has shown to be suitable for mud crab. However, the cost of this natural diet continues to increase and in time its use may no longer profitable (Manivannan et al. 2010). Despite an interest from coastal communities for adopting mud crab aquaculture, the availability of sustainable feed is still unpredictable (Moksnes et al. 2012). Finding low cost feed supplies has been identified as one of the key challenges facing the rapid growth of the mud crab farming sector in Asian countries (Le Vay et al., 2007), hence, this study seek to use golden apple snail as an alternative local feed resources to complement or replace the current type of feeds that may be necessary for achieving sustainable large-scale and small-scale crab farming. The price of the golden apple snail meal may be the most promising protein source for partial or total replacement of trash fish and shrimp feed in mud crab diets. Feeding trials indicate that golden apple snail meat can be a promising animal feed (Kaensombath 2003; Jintasataporn et al. 2004; Diomandé et al. 2008; Phonekhampenget et al. 2009; Chimsung et al. 2013; Rabia 2015).

The main focus of the study was to compare the effect of golden apple snail meat as feeds on the growth and survival rates, biochemical compositions (protein, carbohydrate, fat, ash, and moisture) and economic viability of mud crabs with trash fish diet, and shrimp feeds. The cost-benefit analysis of mud crabs was used to project the potential benefits of investing and operational changes in mud crab farming.

II. METHODOLOGY

A. Research Design

This mud crab culturing was an experimental study that focused on the fattening of lean crabs. A total of 75 mixed sexed crabs divided into five groups with five crabs each were fed with golden apple snail (GAS) meat, trash fish, shrimp feeds, combination of GAS meat and trash fish, and combination of GAS meat and shrimp feeds for 20 days. Each feed type have three replicates. The economic viability of the feed types in terms of market value, pre- operational and operational cost was also evaluated. The total pre-operational cost was divided into ten since it was assumed that the set-up can be used for ten croppings.

B. Procurement of Stock

Lean mud crabs were purchased from crab collectors in Sta. Ana, Cagayan. Mud crabs, *Scylla serrata*, were identified and selected by Local Government Unit (LGU) officer from Bureau of fisheries and Aquatic Resources (BFAR)-Sta. Ana. Mud crabs were checked for complete appendages, which indicates high quality.

C. Cage Design and Preparation

Crab case (plastic tray made of virgin plastic) measuring 25.4cm x 25.4cm x 20.3cm with cover was used. Crab case was fitted and arranged in floating bamboo frames or pontoons. The pontoons were installed in existing brackish water pond with a water depth of at least 1 meter. Catwalk and shade were installed for ease of monitoring and for crab protection.

D. Stocking and Stocking Density

The mud crabs were stocked at a density of 1 crab per cage. Five mud crabs were stocked per feed diet with 3 replicates each. A total of 75 mud crabs were stocked for this study.

E. Feeding and Rearing

Feeding was done twice a day in the morning (7 am) and evening (5pm), 50% of the feeding ration was given in the morning and the remaining 50% in the evening (Rodriguez 2009). Feeding ration was based on the 10% body weight of each mud crab. Termination of feeding was done after 20 days, the expected number of days when they reach the maximum size of ≥450 grams.

F. Harvesting and Post-harvest Handling

Fattened crabs were taken out of the cage, washed with clean pond water, taking care not to lose any appendages, especially the claw. Each crab were measured and weighed individually.

G. Biochemical Analysis of the Experimental Mud Crabs

The proximate biochemical composition of the fattened crabs was determined using standard methods: protein, carbohydrate, fat, ash and moisture (Soundarapandian and Ananthan, 2008).

H. Assessment of the Cost- Benefit

The cost- benefit of live crabs at harvest was based on the expenses incurred from the pre- operation and operation costs against the profit.The pre-operating cost includes the cost of materials and labor for the construction and installation of floating bamboo cages in the pond. Operating cost includes mud crabs, feeds, and labor. The unit cost of crabs produced was based on the prevailing price in Sta. Ana, Cagayan town market during the harvest.

I. Data Gathering and Analysis

Throughout the experiment, crabs' was assessed every 5 days by recording individual increase in body weight. Increase in carapace length and width were measured as the crabs reached their maximum size. Specific growth rate (SGR) measurement of the increase in body weight (g), increase in carapace length (cm) and width (cm), and total weight gain of crabs on different feed types were calculated based on Tacon (1990) and De Silva and Anderson (1995). . Profitability of crab fattening using five feed types was determined by cost-return and partial budgeting analysis based on Jahan and Islam (2016), Shang (1990), Tiño and Rodriguez (2000) and Zannatul and Xiang (2010).

III. RESULTS AND DISCUSSION

Growth

The total weight gain (g) (Table I) of mud cabs after 20-day fattening period ranged from 84.47 g – 119.33 g. Mud crabs fed with combination of GAS + trash fish recorded the highest weight gain while those fed with GAS meat has the lowest weight gain. However, mean weights showed no significant difference among treatments (P>0.05).

Table I: Mean weight gain (g) of mud crab (*S. serrata*) fed with different diets

Treatments	Mean Initial Weight (g)	Mean Final Weight (g)	Weight Gain (g)	% Weight Gain
GAS	219.53	304	84.47[a]	38.48
TrF	218.87	329.6	110.73[a]	50.59
ShF	216.07	307	90.93[a]	42.09
GAS+TrF	208.67	328	119.33[a]	57.19
GAS+ShF	199.13	296.75	97.62[a]	49.02
±SD		53.61		

** GAS (fed with golden apple snail meat); TrF (fed with trash fish); ShF (fed with shrimp feed); GAS + TrF (fed with golden apple snail meat and trash fish); GAS + ShF (fed wih golden apple snail meat and shrimp feed)*

*** letters that are similar means no significant difference at P> 0.05 using ANOVA*

Triño et al. (2001) reported that mud crabs fed with trash fish diet has significantly higher mean body weight, while Begum et al. (2009) reported that trash fish-fed mud crabs recorded a lower weight gain. On the study of Rabia (2015), the combination of GAS meat and trash fish recorded higher mean body weight which was also observed in this study.

No increase in carapace width and length was observed in TrF, ShF and GAS+ShF- fed mud crabs (Table II). Mud crabs fed with GAS meat and combination of GAS meat + trash fish recorded an increase in carapace width and length. However, mean carapace width and length showed no significant difference among treatments.

Table II. Mean initial and final carapace width (cm) and length (cm), increase in carapace width (cm) and length (cm)

Treatments*	Carapace Width (cm)			Carapace Length (cm)		
	Initial	Final	Total** Increase	Initial	Final	Total** Increase
GAS	10.67	10.74	0.07[a]	7.23	7.19	0.04[a]
TrF	10.54	10.54	0[a]	7.17	7.17	0[a]
ShF	10.64	10.64	0[a]	7.21	7.21	0[a]
GAS + TrF	10.39	10.72	0.33[a]	7.39	7.01	0.38[a]
GAS + ShF	9.73	9.73	0[a]	7.28	7.28	0[a]
±SD		1.25			0.84	

*GAS (fed with golden apple snail meat; TrF (fed with trash fish); ShF (fed with shrimp fee); GAS + TrF (fed with golden apple snail meat and trash fish); GAS + ShF (fed wih golden apple snail meat and shrimp feed)

** letters that are similar means no significant difference at P> 0.05 using ANOVA

Growth is a combination of the increase in size at a moult and the number of times moulting occurs (Severo et al. 2016). The body of a mud crab is entirely enclosed in a calcified outer shell and for increase of carapace length and width to occur the shell has to be casted out through the process of moulting. Within the 20-day fattening period of mud crabs in this study, it was observed that the occurrence of moulting was very low. According to Heasman (1980), the duration of moult cycle stages in *S. serrata* (and all decapod crustaceans) are the net result of complex interactions between many endogenous (genetic) and exogenous factors including nutrition.

In the present study, it was observed that two of the crabs fed with the combination of GAS meat + TrF moulted during the experiment, one moulted with those fed with GAS meat, hence this could be contributory to the slight increase of the carapace length and width. None of the mud crabs moulted in groups fed only with TrF, ShF and GAS meat+ShF. This may be the reason why no increase in carapace was observed. On the experimental fattening of mud crabs by Rabia (2015), 20% of the crabs fed with GAS meat and GAS meat+ TrF moulted during the experiment. Rabia mentioned that the use of GAS meat could have accelerated moulting incidences. Mirera and Mtile (2009) reported that *S. serrata* fed with gastropod meat has 93% moulting incidence, hence, there is recorded high increase in carapace length and width.

Survival

The survival rate of mud crabs was high in all feed types (Table III). However, it is worth noting that ShF and GAS meat + ShF- fed mud crabs did not attain 100% survival rate.

Table III. Survival rate (%) of mud crabs fed with different diets

Treatments*	Survival Rate (%)
GAS	100
TrF	100
ShF	97.78
GAS + TrF	100
GAS + ShF	95.53

**GAS (fed with golden apple snail meat);TrF (fed with trash fish); ShF (fed with shrimp feed);GAS + TrF (fed with golden apple snail meat and trash fish); GAS + ShF (fed wih golden apple snail meat and shrimp feed)*

Survival rate of mud crabs is the key indicator of success or failure in grow-out or fattening system (Allan and Fielder 2004; Rodriguez et al. 2007, Mirera 2009, Shelley and Lovatelli 2011). High survival rate was observed in this study since crabs were held individually as they were provided with optimal environment for growth. In this study, survival rate of 100% was observed in GAS meat, TrF, GAS+TrF-fed mud crabs which was also the reported result in the feeding experiment conducted by Marasigan (1999), Soundarapandian et al. (2010) and Rabia (2015), while Severo et al. (2016) reported that the use of trash fish and combination of trash fish and GAS meat achieved a low survival rate of 45.67% only.

Biochemical Composition Analysis

Highest moisture content was observed on the meat of mud crabs fed with GAS + TrF, followed by those fed with TrF, ShF, GAS + ShF respectively. However, the difference in the % moisture is not significant. In terms of % ash content, the slight differences observed across different diets is not significant.

Table IV. Mean proximate analyses of the biochemical composition of mud crab (*Scylla serrata*) fed with different diets

Treatments*	Biochemical Composition (%)				
	Moisture**	Ash**	Protein**	Fat**	Carbohydrate**
GAS	78.08[a]	1.77[a]	19.37[b]	0.06[a]	0.72[a]
TrF	79.21[a]	1.91[a]	17.69[a]	0.11[a]	1.09[a]
ShF	79.01[a]	1.65[a]	16.96[a]	0.22[a]	2.16[a]
GAS+TrF	80.41[a]	1.74[a]	16.99[a]	0.05[a]	0.81[a]
GAS+ShF	76.03[a]	1.93[a]	21.41[b]	0.03[a]	0.60[a]
±SD	2.61	0.27	2.96	0.18	1.27

**GAS (fed with golden apple snail meat; TrF (fed with trash fish); ShF (fed with shrimp fee); GAS + TrF (fed with golden apple snail meat and trash fish); GAS + ShF (fed wih golden apple snail meat and shrimp feed)*

*** letters that are similar within biochemical composition means no significant difference at P> 0.05 using ANOVA*

The protein contents of mud crab fed with GAS+ShF has the highest percentage of protein. This is followed by those fed with GAS alone. Statistically, their difference is not significant. However, protein content of mud crabs fed with all other diets have significantly lower ($P<0.05$) protein contents compared to GAS and GAS + ShF. Highest fat and carbohydrate contents were observed in mud crabs fed with ShF, however, this % content was not significantly different from other mud crabs fed with other diets.

The protein of crab has a high biological value with its growth promoting capacity. This study observed that GAS meat diet resulted to high % protein and value is higher when GAS meat is used in combination with shrimp feed. Severo et al. (2016) reported that a higher protein content was observed in mud crabs fed with trash fish compared with apple snail-fed mud crabs. Manivannan et al. (2010) noticed that S. tranquebarica fed with clam meat have a higher protein value compared to mud crabs fed with Acetes sp., whereas on the study of Trino et. al (2001) a higher protein value is determined on mud crabs fed with trash fish.

Serra (1997) reported that the analysis on the biochemical composition of golden apple snail meat revealed that it has protein content of 62.48%. This may be the reason why mud crabs receiving GAS meat diet has higher protein content compared to other feed types.

Cost- Benefit Analysis

Majority of the harvested mud crabs were on the large (250- 499g) group classifications. Market values based on weight at harvest of mud crabs fed with different diets ranged from Php 973.00 – Php 1770.10.

Feeding mud crabs with the trash fish resulted in highest market value and lowest in the use of combination of GAS meat and shrimp feed. Among the meal feed, weight was highest with those fed with TrF, thereby, it has the highest market value. This was closely followed by mud crab fed with GAS + TrF, and GAS alone respectively. The lower market values was observed in mud crab fed with ShF and GAS + ShF because both did not attain 100% survival rate, resulting to less number of crabs.

Table V. Cost- benefit Analysis for 20-day Culture Period with Live Mud Crabs

Treatments	No. of Live Crabs	Crab Final Weight (g)	Market Value Based on Weight (Php)	POC + OC	Profit (Php)	%Profit Gain
GAS	15	4560	1584.00	1150.80	433.20	37.64
TrF	15	4944	1770.10	1374.30	395.80	28.80
ShF	14	4270	1461.00	1493.99	-32.99	-2.21
GAS+TrF	15	4920	1722.00	1225.83	496.17	40.48
GAS+ShF	13	3855	973.00	1220.19	-247.19	-20.26

In terms of expenses, those ShF- fed mud crab has the highest expense, followed by TrF fed crabs. Those fed with GAS had lower expenses. Over-all, the highest % profit was attained from mud crabs fed with GAS + TrF (40.48%) and GAS (37.64%).

Severo et al. (2016) reported that higher profitability was derived using apple snail and the combination of apple snail and trash fish because of lower production cost in terms of feed cost while a negative profitability was derived using trash fish alone due to its higher price. On the experimental fattening of mud crabs by Rabia (2015), results showed that mud crabs fed with GAS constitute the higher return of investment due to lower expenses incurred since GAS is readily available.

According to Say and Ikhwanuddin (1999), the most important parameters affecting the profitability of mud crab culture were sale price, finishing weight, survival rate, feed cost, feed conversion ratio and capital cost. Agbayani et al. (1990) budgeted labour as higher than mud crab cost while Triño et al. (1999) budgeted labour as being well below the cost of crabs and in the study of Say and Ikhwanuddin (1999), the highest cost by a considerable margin was feed, followed by labour and stocks. Agbayani and Samonte (1992) reported that feed and labor were the major costs for crab monoculture. Assessing the quality of the meat of the mud crab and profit gain, it can be deduced that GAS is the best diet with high protein content and higher profit. The reduction of feed cost with the use of GAS would render crab fattening operations a viable proposition and provide a reliable source of income to both large and small-scale mud crab culturist. The use of GAS has resulted in higher returns which indicates that this practice is economically viable.

IV. CONCLUSION

V. CONCLUSION

This study concludes that GAS meat, trash fish, shrimp feed, GAS meat + trash fish, and GAS meat + shrimp feed do not show significant effect on the growth of mud crabs in terms of weight and carapace length and width. Survival is at 100% except for mud crabs receiving diet with ShF. Percent biochemical compositions of crab meat did not show significant difference on ash, moisture, protein, carbohydrate and fat. However, protein content of mud crabs is higher in GAS diet and GAS + ShF. Cost- benefit analysis revealed that the combination of GAS meat and trash fish resulted in highest net return due to its low production cost. Utilization of GAS meat can reduce cost of production in aquaculture since it is cheaper as compared to trash fish and shrimp feed. Over-all, GAS meat is the best feeds since it has low cost and higher profit and protein content of the meat is higher as compared to other diets.

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