Journal of Natural and Allied Sciences
Vol. IV No. 1, pp. 1-13, January – December 2020

Soft Shell Crab *Scylla olivacea* (Herbst, 1796) Production Using Different Types of Feed

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Abstract - *A 105-day feeding experiment was conducted at the brackishwater pond of a private operator in Sitio Iringan Brgy. Palsabangon, Pagbilao, Quezon from November 2017 to April 2018 to demonstrate soft-shell production of crab using three different types of feed. Three hundred (60-100 g) Scylla olivacea were used in the study. During the experiment, treatments used were trash fish (Treatment I), coconut meat (Treatment II), and shellfish (Treatment III). At the end of the study, S. olivacea fed with shellfish (Treatment III) obtained the highest number of molted crabs with mean value of 47.6 or 95% while trash fish (Treatment I) obtained the least number with mean value of 45 or 90%. Highest mortality was observed in trash fish (Treatment I) with mean value of 4.5 or 9% while least mortality was noted in coconut meat (Treatment II) with mean value of 2 or 4%. On the other hand, few numbers of escaped crab were noticed in the study. The highest weight gain was observed most in trash fish (Treatment I) among the three treatments with mean weight gain of 27.52 g while the least was coconut meat (Treatment II) with mean weight gain of 22.86 g. Likewise, highest carapace length gain was observed in trash fish (Treatment I) and shellfish (Treatment III) with mean length gain of 0.69 cm while least length gain was noticed in coconut meat (Treatment II) with mean length gain of 0.675 cm. Also, highest carapace width gain was seen in trash fish (Treatment I). Feeding with trash fish also had the shortest average number of days to molting (<30 d) as compared with other treatments. However, ANOVA revealed no differences regarding number of moltings, weight gain, carapace length and width gain, and survivorship among the different treatments. Meanwhile, water parameters changed as salinity and turbidity decreased from November 2017 to January 2018 and increased from February to April 2018 which was not during the typhoon season. Weather condition affect the experiment process as it caused a lot of mortality during rainy days specifically within the typhoon period. In terms of profitability, coconut is 40% cheaper than trash fish and shell fish. In line with this, Treatment 2 had the highest net income which was Php 1,806.00 and rate of return which was 51%. On the other hand, Treatment 1 had the lowest net income of Php 1,243.00 and with a 27.26% rate of return.*

Key words*:* *carapace; molting; trash fish; shellfish; coconut meat*

INTRODUCTION

The production of soft-shell crab is a new technology in the Philippines. In Myanmar and Thailand where commercial soft shell crab farming has long been practiced, the juveniles for stocking are sourced from the wild. Soft shell crabs are sold to local restaurants and exported to Hongkong, Singapore, South Korea, Japan, Australia, Taiwan, Europe and USA [1].

The culture of soft-shell crab is done in tanks or in ponds where the crabs are individually placed in plastic containers or trays. The chelipeds are removed to avoid cannibalism when the crab molts. Removal of chelipeds may also induced molting of crabs. The newly-molted crab are retrieved immediately after molting when they are still soft shelled. Molting is the periodically shedding of exoskeleton in crabs in order to grow [1].

The present study focused on *Scylla olivacea* or red crab, which is one of the 4 species of mudcrabs found in the Philippines and the most abundant species caught locally in Pagbilao, Quezon. Most fishermen in the locality arrive early morning from fishing with marketable sized and juvenile red crab. To uplift its market value, there is a need to introduce the technology of softshell production. This is done by allowing the crabs to be held individually in perforated plastic boxes [2] or sometimes in groups in big cages set in ponds or tanks to molt and grow. However, in communal rearing, the claws are removed to prevent cannibalism [1], as *S. olivacea* and other *Scylla* spp, are highly cannibalistic as early as the megalopa and crablet stages [3]. The advantage of producing softshell crab is that the whole crab including the appendages can be eaten without removing the shell. The size for stocking may range from 60-100 grams with carapace width of 2-3 inches. The upper claw is also cut to prevent damaging the trays. Crabs grow through repeated molting. The hard outer shell cannot stretch during growth so the crab must molt or shed its old exoskeleton in order to grow. Before molting, a new exoskeleton is formed below the old and hard exoskeleton. The new shell gradually develops and hardens in 4-8 hours [4] or harden in less 5 than hours [1]. Furthermore, majority of the crab molts during the night and early morning. The peak of molting for 60-100 g in the intermolt stage is normally within 2nd to 3rd week after stocking. The newly molted crabs must be retrieved immediately after molting. The time to next molt will be longer since crabs have grown bigger [1]. Duration of culture is from 30-60 days thereby assuring for fast recovery of investment. By means of this technology, the smaller low-valued species may increase its market value [2].

The present study was conducted (1) to determine the best type of feed (trash fish, coconut meat, and shellfish meat) that will enhance and shorten the molting time of red crab (*Scylla olivacea*) in terms of number of molted crabs and duration time of molting; (2) determine growth in terms of weight gain, carapace length gain, and carapace width gain; (3) monitor the water quality parameters (salinity, turbidity, and water depth) during the culture period; and (4) to determine the cost and return analysis.

MATERIALS AND METHODS

Research Design and Experimental Treatments

The study is a feeding experiment using different type of feeds (trash fish, coconut meat and shellfish) that will trigger *Scylla olivacea* to molt for shortest period of time. Initial weight, carapace length and carapace width were measured individually before stocking in each tray. The feeds were given to the crabs at 8% of their body weight. Physico-chemical parameters of the water and weather condition were monitored.

The three different types of feeds which were used as feed for molt induction of red crab (***Scylla olivacea***) were designated as the three treatments of the study (Table 1) and each treatment was replicated two times. The experimental units were arranged in a Randomized Complete Block Design (RCBD). The three treatments were as follows:

Table 1. Treatments used in the study.

TREATMENTS	TEST FEED	STOCKING DENSITY
I	Trash fish, Sapsap *(Leiognathus equulus)*	50 pieces per replicate
II	Coconut Meat	50 pieces per replicate
III	Shellfish 1. Tabahong (*Modiolus modulaides*) 2. Tapalang (*Geloina expansa*)	50 pieces per replicate

Location of the Study

The study was conducted at a brackishwater fishpond located at Sitio Iringan, Brgy. Palsabangon, Pagbilao, Quezon from November 2017 to April 2018 for a 6-months culture period. The pond area for soft shell crab production was 0.5 ha with water inlet/outlet gate and net enclosure (Figure 1).

Figure 1. Location of the study.

Experimental Lay-Out

Six units of bamboo pontoons with a dimension of 1.32 meters x 2 meters were installed in a 0.50-hectare brackishwater pond (Figures 2-4). The pontoons were protected by a shade (Figure 3) made of bamboo and coconut leaf to prevent exposure from direct sunlight. Each pontoon consisted of 50 pieces plastic trays with covers (Figure 5). The cover was tied with nylon to prevent the escape of the crab. The top of the cover had bigger holes for feeding and inspection of moulted crab without opening the tray. The trays were numbered from 1 to 50. Thus, a total of 300 trays were used in this study.

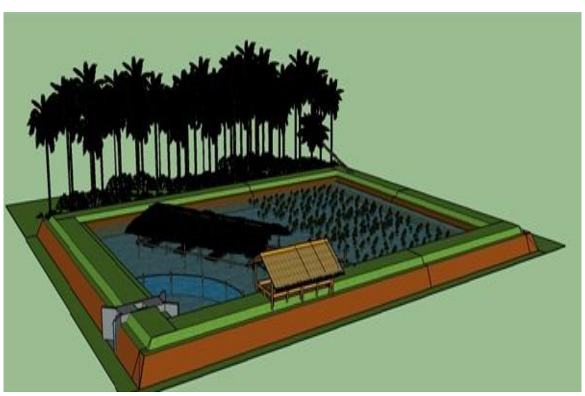

Figure 2: Layout of the experiment in a brackishwater pond.

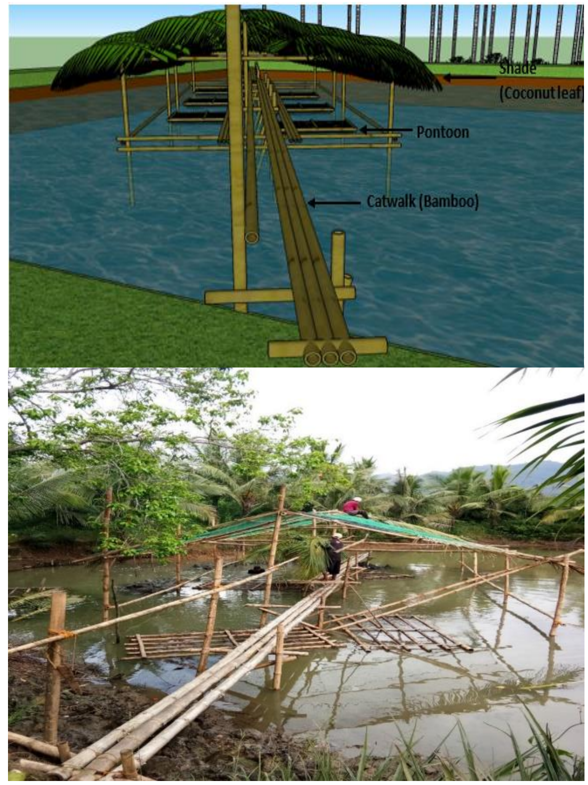

Figure 3. Layout design of soft-shell crab shade.

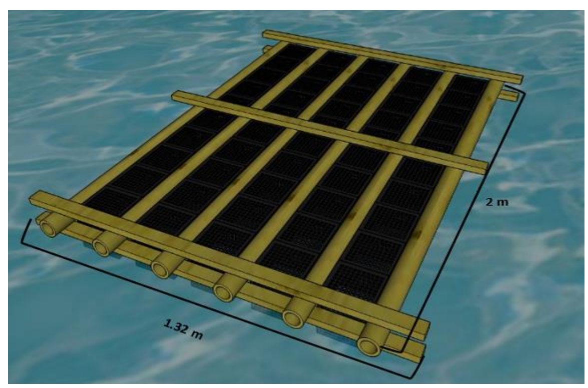

Figure 4. Pontoon or floating platform.

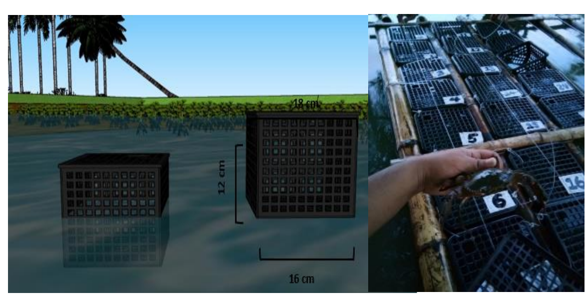

Figure 5. Individual crab trays.

A Randomized Complete Block Design (RCBD) was used in the experimental design. The treatments for soft shell crab were Treatment 1 - Trash fish, Treatment 2 - Coconut meat and Treatment 3 – Shellfish with 2 replicates per treatment (Figure 6).

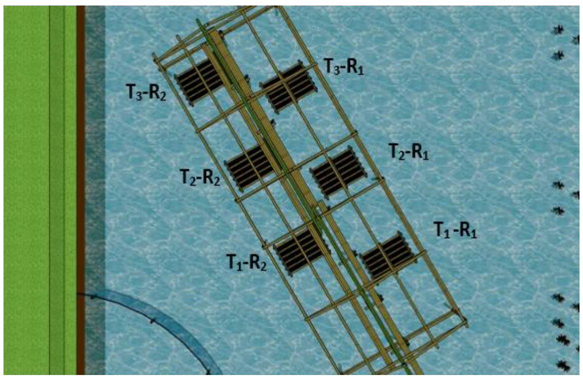

Figure 6. Layout design of pontoons.

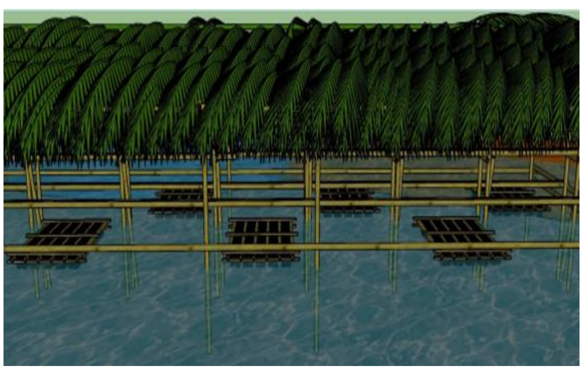

Figure 7. Sideview layout design of pontoons.

Experimental Animal

A total of 300 pieces of red crab (*Scylla olivacea*) with weights ranging from 60 – 100 grams each were used in the study. These were stocked randomly in 6 pontoons at the stocking rate of 50 pieces red crabs per pontoon. The red crabs used in the study were purchased from the local gatherers.

Acclimation and Stocking of Crabs

Before stocking, the initial weight, carapace length and carapace width of the red crabs were measured. During stocking, the red crabs were acclimated first by sprinkling water coming from the pond where they were stocked. This procedure enabled them to acclimatize to the quality of the water where they were cultured throughout the duration of the study. The tie or string around the crab was then cut by means of scissors. One of the upper claws of the pincher was also cut. This was done so that the crab may not destroy the tray. Stocking was done individually in each tray.

Monitoring of Stocks

Inspection and monitoring of the crab were done every four (4) hours to reduce the risk of hardening of the shell. This was done by pulling the pontoon slowly and inspecting through the holes for moulted or dead crab. The presence of an empty shell inside the tray showed that the crab had moulted. Checking the condition of the crab, if alive or dead, was also done. Live crab has moving antennae even though the body is immobile. Uneaten food was removed while dead crabs were discarded.

Date and time of moulting were recorded. The final body weight, carapace length and carapace width of the crabs after moulting were measured and recorded.

Handling and Storing of Softshell Crab

Harvested moulted crabs were placed in a basin with aerated freshwater to remove salt in the body. The weight, carapace length and carapace width of each crab were measured. After taking the measurements, the crab was individually packed on a plastic bag and stored in a freezer. Every crab has the chance to moult many times, however due to the experimental process in this study, moulting of experimental crabs was allowed once.

Monitoring of Water Quality Parameters

The water salinity, temperature and turbidity were monitored in the morning. The salinity was measured using a refractometer while the temperature and turbidity were measured using laboratory thermometer and Secchi disc, respectively.

Computation of Survivorship and Growth Parameters

The percentages of moulted, escaped and dead crabs were computed using the following formula:

$$\text{Percent of moulted crab} = \frac{\text{Total crab molted}}{\text{Total crab stocked}} \times 100$$

$$\text{Percent of escaped crab} = \frac{\text{Total crab escaped}}{\text{Total crab stocked}} \times 100$$

$$\text{Percent of dead crab} = \frac{\text{Total crab dead}}{\text{Total crab stocked}} \times 100$$

Weight gain, carapace length gain and carapace width gain were also determined using the following formula:

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

Carapace length gain (cm) = Final Carapace length – Initial Carapace length

Carapace width gain (cm)= Final Carapace width – Initial Carapace width

Data Treatment and Analysis

Data on weight gain, carapace length increment, carapace width increment, and survival of red crab were analyzed using descriptive statistics. Data were subjected to one-way analysis of variance to compare statistical differences among the treatments.

RESULTS AND DISCUSSION

Number of Moulted and Escaped Crabs

The number of moulted, escaped and dead red crabs (*Scylla olivacea*) fed with different feed types is presented in Table 2.

Table 2. Number of moulted, escaped and dead red crabs (*Scylla olivacea*) fed different types of feeds for moulting induction from November 2017 to April 2018.

TREATMENT (FEED TYPE)	REPLICATION	Total Crabs Stocked	Molted Crab		Escaped Crab		Dead Crab		Total	%
			No.	%	No.	%	No.	%		
I TRASH FISH	1	50	45	90	1	2	4	8	50	100
	2	50	45	90	-	-	5	10	50	100
	Mean	**50**	**45**	**90**	**0.5**	**1**	4.5	**9**	**50**	**100**
II COCONUT MEAT	1	50	45	90	1	2	4	8	50	100
	2	50	48	96	2	4	-	-	50	100
	Mean	**50**	**46.5**	**93**	**1.5**	**3**	**2**	**4**	**50**	**100**
III SHELLFISH	1	50	48	96	-	-	2	4	50	100
	2	50	47	94	-	-	3	6	50	100
	Mean	**50**	**47.5**	**95**	**-**	**-**	**2.5**	**5**	**50**	**100**

Result showed that red crabs (*Scylla olivacea*) fed with shellfish feed (Treatment III) obtained the highest number of moulted crabs with mean value of 47.5 or 95%, followed by those crabs fed with coconut meat feed (Treatment II) with mean value of 46.5 or 93%. Red crabs in Treatment I fed with trash fish got the lowest number of moulted crabs with mean value of 45 or 90%. However, analysis of variance (ANOVA) on the number moulted crabs failed to show any significant difference (P>0.05) among treatment means.

It can be observed that the highest number of mortality (dead crabs) was noted in Treatment I with mean value of 4.5 or 9%, followed by Treatment III and Treatment II with mean values of 2.5 (5%) and 2 (4%), respectively. For the number of escaped crabs, only very few was observed in Treatment II and Treatment I with mean valued of 1.5 (3%) and 0.5 (1%), respectively.

In a study in Indonesia, it was discovered that soft shell crabs need to be fed 5% food of their body weight, but due to incorrect amount of food, wastes are accumulated [5]. On the other hand, the lesser amount of food would cause slow growth of soft-shelled crabs. Furthermore, in the study of Misieng (2007) on *Scylla olivacea*, food and unilateral eyestalk ablation had significant effects on the growth and maturation of *S. olivacea* [6].

Duration Time of Moulting

The number of moulted red crabs (*Scylla olivacea*) and the duration time of moulting when fed with different types of feeds is presented in Table 3 and graphically shown in Figure 8.

Table 3. Number of moulted red crabs (*Scylla olivacea*) and the duration time of moulting when fed with different types of feeds for moulting induction**.**

TREATMENT (FEED TYPE)	REP	NO. OF MOLTED CRABS/ MOLTING TIME (Days)							TOTAL
		1-15 Days	16-30 Days	31-45 Days	46-60 Days	61-75 Days	76-90 Days	91-105 Days	
I TRASH FISH	1	5 (10%)	7 (14%)	12 (24%)	8 (16%)	10 (20%)	2 (4%)	1 (2%)	45 (90%)
	2	7 (14%)	6 (12%)	7 (14%)	19 (38%)	3 (6%)	3 (6%)	- (-)	45 (90%)
	Mean	**6 (12%)**	**6.5 (13%)**	**9.5 (19%)**	**13.5 (27%)**	**6.5 (13%)**	**2.5 (5%)**	**0.5 (1%)**	**45 (90%)**
II COCONUT MEAT	1	2 (4%)	1 (2%)	1 (2%)	12 (24%)	13 (26%)	9 (18%)	7 (14%)	45 (90%)
	2	2 (4%)	1 (2%)	8 (16%)	20 (40%)	5 (10%)	5 (10%)	7 (14%)	48 (96%)
	Mean	**2.5 (5%)**	**1 (2%)**	**4.5 (9%)**	**16 (32%)**	**9 (18%)**	**7 (14%)**	**7 (14%)**	**46.5 (93%)**
III SHELLFISH	1	1 (2%)	- (-)	9 (18%)	17 (34%)	12 (24%)	6 (12%)	3 (6%)	48 (96%)
	2	1 (2%)	2 (4%)	7 (14%)	12 (24%)	11 (22%)	1 (2%)	13 (26%)	47 (94%)
	Mean	**1 (2%)**	**1 (2%)**	**8 (16%)**	**14.5 (29%)**	**11.5 (23%)**	**3.5 (7%)**	**8 (16%)**	**47.5 (95%)**

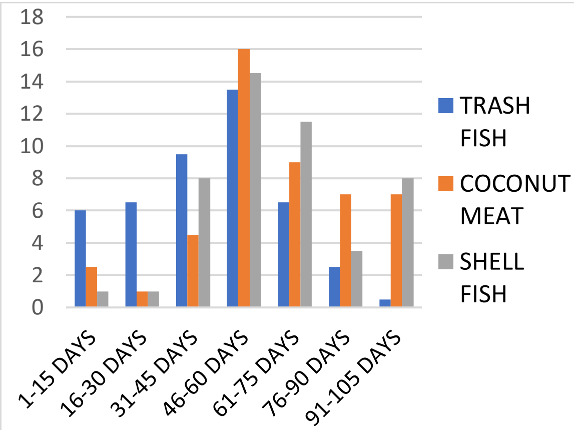

Figure 8. Graphical presentations on the number of moulted crabs for 105 days of feeding different types of feeds for moulting induction.

Result showed that red crabs fed with trash fish (Treatment I) had the highest number of moulted crabs for the first 15 days, from 16-30 days and from 31-45 days with mean values of 6 (12%), 6.5 (13%) and 9.5 (19%) compared to Treatment II (coconut meat) with mean values of 2.5 (5%), 1 (2%) and 4.5 (9%), respectively and Treatment III (shellfish) with mean values of 1 (2%), 1 (2%) and 8 (16%), respectively.

For the period 46-60 days, Treatment II (coconut meat) obtained the highest number of moulted crabs with mean value of 16 or 32%, followed by Treatment III (shellfish) with mean value of 14.5 or 29%, and Treatment I (trash fish) with mean value of 13.5 or 27%.

For the period 61-75 days, Treatment III (shellfish) had the highest number of moulted crabs with mean value of 11.5 (23%), followed by Treatment II (coconut meat) with mean value of 9 (18%), and Treatment I (trash fish) with mean value of 6.5 (13%).

For the period 76-90 days and 91-105 days, red crabs in Treatment II (coconut meat) got the highest number of moulted crabs with both mean values of 7 (14%), followed by Treatment III (shellfish) with mean values of 3.5 (7%) and 8 (16%), respectively, and Treatment I (trash fish) with mean values of 2.5 (5%) and 0.5 (1%).

Figure 9 shows the cumulative number of moulted red crabs (*Scylla olivacea*) fed with different types of feeds for moulting induction. Result showed an increasing number of moulted red crabs from day 1 to 105 days of feeding different types of feeds for moulting induction. Treatment I (trash fish) gave the highest increase on the number of moulted crabs, followed by Treatment II (coconut meat) and Treatment III (shellfish).

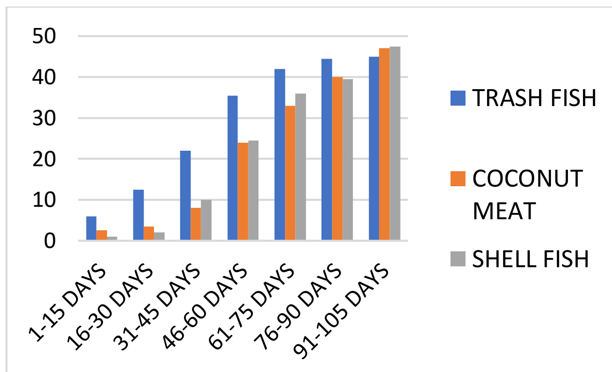

Figure 9. Cumulative number of moulted crabs from the first day to 105th of feeding different types of feeds for moulting induction.

Figure 9 shows the cumulative number of moulted crabs from the first day to 105th day of feeding different types of feed for moulting induction. Trash fish fed crabs had the shortest average number of days to moulting (<45 d); however, there are numbers of mortality. On the other hand, shellfish-fed crabs have the most number of moulted crabs, but moulting was not that fast. In 45 days, there were lots of moulting observed especially in trash fish fed crabs, because it is the best time for moulting due to their physical growth which are usually observed in 2 weeks after stocking [2].

According to Rabia (2015), moulting incidence of similar-sized *S. serrata* in a 15-day fattening was promoted by feeding with trash fish mixed with golden apple snail as compared to trash fish alone [2]. High calcium content of the diet (from the shells of the snail) could possibly induced moulting of stocks [2].

Weight Gain of Red Crabs

The initial, final and gain in weight of red crabs (*Scylla olivacea*) after feeding with different types of feeds which were used for moulting induction for a period of 105 days are presented in Table 4.

Result showed that Treatment I (trash fish) gave the highest mean weight gain of 27.52 grams after moulting, followed by Treatment III and Treatment II with mean weight gain of 26.47 g and 22.86 g, respectively. Analysis of variance on mean weight gain showed no significant differences (P>0.05) among treatment means. This result means that the weight gained by the red crabs after moulting are comparable among treatment means.

The weight gain observed in this study was similar to that observed by Rabia (2015) where she observed average weight gain of 21.93 g for similarly-sized *S. serrata* after 15 days of feeding with golden apple snail and trash fish [2]. According to the study of Karim et al. (2017), the daily growth rate (%/d) obtained from *Scylla olivacea* ranged from 0.67% to 1.20% per day [7]. Their group used trash fish, mujair fish, oyster and rice field snails in feeding the *Scylla olivacea*. Least growth rate was seen in trash fish at 0.67±0.04% while greatest was in oyster at 1.20±1.37%. For Mirera and Mtile (2009), growth of mangrove crabs is 1.29% per day [8]. The increase of size in past studies was measured in terms of specific growth rates during the entire culture period whereas in the present study, it was obtained once immediately after moulting.

S. olivacea is a carnivore based on their study on food and feeding, which was confirmed by the high occurrence of fragments of crustacean appendages, pieces of shells, spats of molluscs and scales of fishes in the gut [9]. Being highly carnivorous, this explains the higher weight gain of *S. olivacea* fed trash fish and shellfish in this study over coconut meat.

Table 4. Weight gain of red crabs (*Scylla olivacea*) fed with different types of feeds.

TREATMENT (FEED TYPE)	REPLICATION	WEIGHT OF CRABS (g)		
		Initial Weight	Final Weight	Weight Gain
I TRASH FISH	1	76.13	100.62	24.49
	2	79.71	110.2	30.56
	Mean	**77.92**	**105.44**	**27.52**
II COCONUT MEAT	1	73.37	93.89	20.52
	2	74.64	99.83	25.19
	Mean	**74.00**	**96.86**	**22.86**
III SHELLFISH	1	72.46	98.19	25.73
	2	76.45	103.66	27.21
	Mean	**72.45**	**100.92**	**26.47**

Carapace Length Gain

Table 5 presents the initial, final and gain in carapace length of red crabs (*Scylla olivacea*) fed the different types of feeds before and after moulting for the culture period of 105 days.

Result showed that the highest mean carapace length gain of 0.69 cm was observed in both Treatments I (Trash fish) and Treatment III (Shellfish) and this followed by Treatment II (Coconut meat) with mean carapace length gain of 0.675 cm. Analysis of variance, however, showed no significant difference (P>0.05) among treatment means. This result showed that red crabs (*Scylla olivacea*) fed different types of feeds have similar gain in carapace length after moulting.

Carapace Width Gain

Table 6 presents the initial, final and gain in carapace width of red crabs (*Scylla olivacea*) fed different types of feeds before and after moulting for the culture period of 105 days.

Result showed that red crabs in Treatment I (trash fish) got the highest mean carapace width gain of 1.04 cm after moulting, followed by Treatment II and Treatment III with both mean carapace width gain of 0.90 cm. Analysis of variance, however, showed no significant difference ($P>0.05$) among treatment means. This result means that red crabs fed with three different types of feeds have similar gain in carapace width after moulting.

Table 5. Carapace length increment of red crabs (*Scylla olivacea*) fed with different types of feeds.

TREATMENT (FEED TYPE)	REPLICATION	CARAPACE LENGTH OF CRABS (cm)		
		Initial Carapace Length	Final Carapace Length	Carapace Length Gain
I TRASH FISH	1	4.90	5.64	0.74
	2	5.11	5.75	0.64
	Mean	**5.00**	**5.69**	**0.69**
II COCONUT MEAT	1	4.85	5.54	0.69
	2	5.04	5.70	0.66
	Mean	**4.94**	**5.62**	**0.675**
III SHELLFISH	1	4.82	5.67	0.85
	2	5.06	5.59	0.53
	Mean	**4.94**	**5.63**	**0.69**

Table 6. Carapace width gain of red crabs (*Scylla olivacea*) fed with different types of feeds.

TREATMENT (FEED TYPE)	REPLICATION	CARAPACE WIDTH OF CRABS (cm)		
		Initial Carapace Width	Final Carapace Width	Carapace Width Increment
I TRASH FISH	1	6.94	7.93	0.99
	2	7.09	8.18	1.09
	Mean	**7.01**	**8.05**	**1.04**
II COCONUT MEAT	1	6.87	7.87	1.00
	2	7.00	7.87	0.80
	Mean	**6.97**	**7.87**	**0.90**
III SHELLFISH	1	6.97	7.95	0.92
	2	7.14	7.99	0.85
	Mean	**7.05**	**7.95**	**0.90**

In the study of Moser et al. (2002), they reported mean moult increment of 1.67±0.48 cm [10]. They used data from 664 male and 463 female recaptures and that moult increment in the investigated size range (5-13 cm external carapace width) was independent of size and sex. Meanwhile, in the study of Viswanathan et al. (2015), the carapace width of *Scylla olivacea* has been studied by gender [9]. They discovered that males increase at 3.035 mm whereas female at 2.925 mm. Also, Waiho et al. (2016) found that the size of *Sylla olivacea* ranged from 47 to 134 mm carapace width depending on its gender, with males being significantly smaller in size but heavier than females [11]. Moreover, in the study of Ismail et al. (2017), the total carapace width of orange crab ranged from 6.6 to 12.8 cm [12]. Likewise, they were able to show that growth bands deposited in hard structure of gastric mill in the cardiac stomach are found retained after moulting process and that it can be used as age indicator and growth estimation because increase in CW were highly correlated with increases in GBC. However, in the present study, the ranges of carapace width increase depended on the treatment given and ranged from 1.04 cm for trash fish and 0.90 cm for both shellfish and coconut meat. The sex identification of *Scylla olivacea* was not included in this study.

Water Quality Parameters

Result showed that the salinity levels in the study area ranged from 17-25 ppt in November 2017, 0 to 17 ppt in December 2017, 0 to 20 ppt in January 2018, 8 to 24 ppt in February 2018, 24 to 30 ppt in March 2018 and from 27 to 37 ppt in April 2018. It can be observed that salinity levels decreased from November to January 2018 and increased from February to April 2018. The mean levels of salinity ranged from 6.16 ppt to 37.89 ppt.

For the turbidity, it was observed that there was a decreasing water clarity reading from November 2017 to January 2018 with mean values of 27.75 cm to 12.19 cm, and there was an increasing water clarity reading from February 2018 to April 2018 with mean values of 24.39 cm to 36.96 cm. This result showed that water from November 2017 to January 2018 was more turbid compared to the water from February 2018 to April 2018.

The water depth in the study area did not fluctuate much throughout the culture period. The mean water depth ranged from 69.07 cm to 90.46 cm.

In support, in the study of Baylon [3, 13] with regards to the influence of temperature and salinity on survival and moulting in early stages of *S. serrata and S. olivacea* crabs, she showed that temperature and salinity affected the survival of zoea larvae, megalopa, and juveniles. Generally, as the larvae grew, there was tolerance to wider salinity and low temperature. Likewise, in the study of Jantrarotai et al (2002), the survival rates of *Scylla olivacea* from zoea to megalopa and from megalopa to crab stage are significant [14]. As they discovered that zoea stage (7.08% to 13.16%) survival rate in percentage at 28, 30, 32 and 34 ppt is lower than megalopa (76.19 to 80%) at 12, 16, 20, 32, 36 and 40 ppt. Thus, water parameters matter in the survival of crabs in present study.

Cost and Return Analysis

Table 7 shows the cost and return analysis of Treatment 1 - crab (*Scylla olivacea*) fed with trash fish after 60 days culture period with a net income of P1,567.00 and Rate of Return of 38.14%.

Table 8 shows the cost and return analysis of Treatment 2 - crab (*Scylla olivacea*) fed with coconut meat. Results showed that the net income in this treatment is Php 1,806.00 with a Rate of Return (RR) of 51%, the highest RR among the three treatments

Table 9 shows the cost and return analysis of Treatment 3 – crab fed with shellfish. Results showed that the net income in treatment 3 was Php 1,243.00 with a Rate of Return (RR) of 27.26%, the lowest net income and RR among the three treatments.

The treatment that got the highest net income and rate of return (Php 1,806.00 and 51% respectively) was Treatment 2, while Treatment 1 had the lowest net income (Php 1,243.00) and Rate of Return 27.26%. The result was affected by the cost of feed given, coconut meat is 40% cheaper than trash fish and shellfish. However, the use of trash fish as feed for producing soft shell crab results to shorter average number of days to moulting, which is important factor in profitability of operations, i.e., lesser labor cost and to accommodate and produce more soft shell crabs that are held individually in enclosures.

Table 7. Cost and return analysis of *Scylla olivacea* in Treatment 1-Trash fish.

Particulars	**Treatment 1 Trash fish**		**Total Quantity**	**Amount**
	T1R1	T1R2		
Total no. of Soft shell Harvested (kg)	4.5	4.96	9.46	
Sales @P600/kg	2,700	2,976		5,676.00
Construction Cost: Shade, catwalk, Coconut fronds etc.				1,607.00
Pontoon @P250/unit	1	1	2	500.00
Tools: (Total expenses divide into 3)				284.00
Perforated tray @P35/piece	50	50	100	3,500.00
Operating Cost Crablets 60-100 grams @P10/piece	50 500	50 500	100	1,000.00
Trash fish @P20/kg	25	26	51	1,020.00
Depreciation Cost				589.00
Labor Cost				1,500.00
Total Cost				4,109.00
Net Income				1,567.00
Rate of return				38.14%

Table 8. Cost and return analysis of *Scylla olivacea* in Treatment 2-Coconut.

Particulars	**Treatment 2 Coconut meat**		**Total Quantity**	**Amount**
	T2R1	T2R2		
Total no. of Soft shell Harvested (kg)	4.2	4.47	8.9	
Sales @P600/kg	2,520	2,820		5,340.00
Construction Cost: Shade, catwalk, Coconut fronds etc.				1,607.00
Pontoon @P250/unit	1	1	2	500.00
Tools: (Total expenses divide into 3)				284.00
Perforated tray @P35/piece	50	50	100	3,500.00
Operating Cost Crablets 60-100 grams @P10/piece	50 500	50 500	100	1,000.00
Coconut meat@P10/kg	21	23.5	44.5	445.00
Depreciation Cost				589.00
Labor Cost				1,500.00
Total Cost				3,534.00
Net Income				1,806.00
Rate of return				51%

Table 9. Cost and return analysis of *Scylla olivacea* in Treatment 3 – Shellfish.

Particulars	Treatment 3 Shellfish		Total Quantity	Amount
	T3R1	T3R2		
Total no. of Soft shell Harvested (kg)	4.97	4.7	9.67	
Sales @P600/kg	2,982	2,820		5,802.00
Construction Cost: Shade, catwalk, Coconut fronds etc.				1,607.00
Pontoon @P250/unit	1	1	2	500.00
Tools: (Total expenses divide into 3)				284.00
Perforated tray @P35/piece	50	50	100	3,500.00
Operating Cost Crablets 60-100 grams @P10/piece	50 500	50 500	100	1,000.00
Shellfish @P30/kg	25	24	49	1,470.00
Depreciation Cost				589.00
Labor Cost				1,500.00
Total Cost				4,559.00
Net Income				1,243.00
Rate of return				27.26%

CONCLUSIONS

The three diets (trash fish, coconut meat and shellfish) can promote moulting of red crabs (*Scylla olivacea*) but with the shortest average number of days to moulting using trash fish followed by shellfish and coconut meat. The feeding of trash fish, coconut meat and shellfish have similar effect on the weight gain, carapace length gain and carapace width gain of red crabs after moulting. However, trash fish promoted the fastest moulting time among the different treatments. *Scylla olivacea* is a good species for the production of soft-shell crab using trash fish, coconut meat and shellfish as feed for moulting induction.

Acknowledgement

The senior author wishes to thank the following: Mr. Ambhet D. Guevarra, for allowing his pond to be used for this study; Mr. Roberto R. Guinto, for wholeheartedly sharing his crab trays; and Mr. Mharlon C. Pornobi, for supplying the crabs and helping the researcher in making the pontoon and shade.

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