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Effects of Various Natural Feeds on Growth Performance and Protein Content of Mud Crabs (Scylla serrata)

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Abstract

The increasing demand for mud crab as a seafood delicacy entails crab growers providing a nutrient-rich diet for them. This study aimed to determine the effect on growth performance and protein content of mud crab using various natural feeds. It also aimed to determine the survival rate, low and high FCR of crabs, and assess the cost of producing crabs fed with different natural feeds. This study employed a completely randomized design that included three feed treatments: trash fish, horn snail, and copra. The cages had five compartments, with one mud crab in each of the compartments. The crab feeding system was based on the water level at which natural feeds were given to the crabs once or twice a day, with an amount adjusted to 5% of the crab's body weight. The results revealed that the highest growth performance in weight increment and protein content was seen in trash fish feed, with a feed conversion ratio of 6.90, indicating an efficient and high-quality feed. In addition, it also showed an impressive ROI of 33.26%, indicating it as a viable feed for fattening. Mud crabs fed with horn snail and trash fish exhibited an identical low mortality rate. In terms of sensory attributes of mud crab meat characteristics, mud crabs fed with copra had the highest mean in all categories; they produced very juicy, flavorful, soft, and acceptable crab meat.

Keywords: Feed conversion ratio, Growth performance, Meat characteristics, Protein content.

1. Introduction

Crab farming is widely practiced to meet the export demand globally. Philippines remains one of the top producers of mud crab aside from Thailand and Vietnam. The demand for high quality mud crabs presents a profitable opportunity for Filipinos. With the proper growing or fatttening of mud crab, crab farming can be profitable and successful.

Scylla serrata locally known as "alimango" is considered as faster-growing breed and most prominent in aquaculture industry. Crab growers prefer this breed due to its peculiar taste and larger size. It is traditionally fed by trash fish by many ponds owner which is considered as natural food and top option in protein source.

The increasing demand for mud crab as a seafood delicacy entails crab growers to provide nutrient-rich diet for it. Aquatic animals require adequate protein diet to support growth, health, and reproduction (Huo et al.,2014). One potential solution to assess this concern is to formulate a balanced diet rich in protein and essential nutrients (Garcia et al., 2018).

It is necessary to explore alternative feeds, as mud crab growers experienced conflict on the high price of trash fish and its availability. Mud crab growers also seeks for another type of feeds, as they aimed to exceed the quality of mud crabs they produced. However, not a lot of research has been conducted to improve the food composition of mud crab. This study identified which among the trash fish, horn snail, and copra can improve the growth performance and protein content of mud crab.

2. Materials and Methods

2.1. Research Design

This study was experimental research in which it discusses the methods and procedure involved in the control and manipulation of different treatments in the experiment.

2.2. Location of the Study

The location of the study was conducted at Brgy. Kagtalaba, Sta. Elena, Camarines Norte. This project utilized a 10,000 square meters fishpond area with abundant and good-quality sources of water, which is best suited for

mud crab farming as they are highly tolerant to varying salinity conditions. The sluice gates made of wood were established for the purpose of controlling water levels carried by tidal water with depths of 1.05m and can regulate the inflow and outflow of tidal water.

Figure 1. Location of the study.

2.3. Treatment and Layout of Experiment

The researcher utilised Complete Randomized Design (CRD) wherein it is composed of treatments and replicated three (3) times. Each of the cages contains five (5) pieces of mud crabs to determine the changes in terms of growth performance and protein content using different treatments. There are 45 mud crabs needed in the study.

Treatments for Mud Crabs T1 Trash Fish
T2 Horn Snail T3 Copra

2.4. Collection of Natural Feeds

The different natural feeds such as trash fish, horn snails, and copra are available in the location of the study. Trash fish and horn snail was purchased from local fishermen while copra meat was purchased from a local coconut buyer.

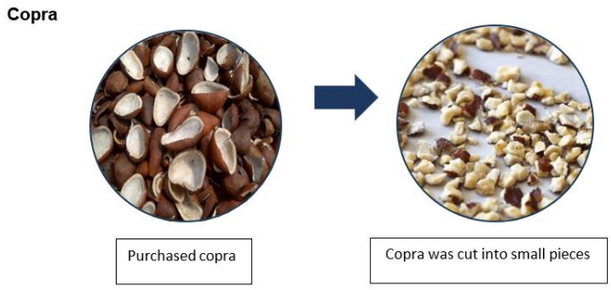

Figure 2. Preparation of Mud Crab Feeds.

2.5. Collection of Crablets

Crablets was collected from Brgy. Kagtalaba Sta. Elena, Camarines Norte. The crablets weigh approximately 60 to 70 grams which are transferred to bamboo cages.

2.6. Species Used in the Study

Scylla serrata locally known as katang and mostly found in many brackish areas in the Philippines. It is one of the most commercially valuable crustacean species globally, known for its delicious taste and high demand in the seafood industry. It has distinct characteristics. Example: smooth, broad carapace, sizable claws used for crushing and cutting and is generally very dark brown to mottled green in color. It reaches a maximum size of approximately 24 carapaces in width and 3.5 kilograms in weight.

2.7. Feeding System

The feeding system is based on the water level at which natural feeds are given to crabs once or twice a day. If it's low tide, feed is given once a day to avoid the suffocation of crabs due to the lack of oxygen. In contrast, feed is given twice a day at a rate of 5-8 percent of its body weight during high tide since it's the time when oxygen is enough, and crabs can move freely.

2.8. Cage Design

The researchers used bobo cage which is constructed from bamboo covered by a plastic net that is designed to accommodate five pieces of mud crabs and are placed in a suitable and good location in the fishpond. These cages have 5 compartments with one crab each per compartment.

2.9. Harvesting Period

Harvesting was done after 3 months in which the mud crab has grown to suitable size.

Table 1. Water Quality Measurement in the Experimental Area.

Salinity	17.9 ppt
Temperature	30 °C
pH	7.86

2.10. Water Quality

Water quality is very important in the growth of mud crabs. As for the requirements, they grow best in water with a salinity of 15-25 ppt, with a temperature of 26-30°C and a pH requirement of 7.9. Salinity in the pond is 17.9 ppt, with a temperature of 30°C and a pH of 7.86

2.11. Sensory Evaluation of Mud Crab Meat Characteristic

The researchers used incidental sampling as the sampling technique. The respondents were composed of 30-member taste panel which are students from PUP Lopez.

2.12. Research Instrument

The researchers used free tasting and rating techniques as an instrument on evaluating the acceptability of the mud crab's meat. Rating included blanks provided for respondent's profile including the name, age, gender, and the name of organizations. The next part includes the sensory attributes of the mud crab meat such as the taste, texture, and general acceptability. The answers of the respondents were tallied and tabulated.

Table 2. Criteria on the Sensory Attributes of Mud Crab Meat

Scale	**Verbal interpretation**			
	Juiciness	**Taste**	**Texture**	**Overall Acceptability**
9	Extremely Juicy	Extremely Flavorful	Extremely Soft	Extremely Acceptable
8	Very Much Juicy	Very Much Flavorful	Very Much Soft	Very Much Acceptable
7	Moderately Juicy	Moderately Flavorful	Moderately Soft	Moderately Acceptable
6	Slightly Juicy	Slightly Flavorful	Slightly Soft	Slightly Acceptable
5	Neither Juicy nor Dry	Neither Flavorful nor Tasteless	Neither soft nor Hard	Neither Acceptable nor Unacceptable
4	Slightly Dry	Slightly Tasteless	Slightly Hard	Slightly Unacceptable
3	Moderately Dry	Moderately Tasteless	Moderately Hard	Moderately Unacceptable
2	Very Much Dry	Very Much Tasteless	Very Much Hard	Very Much Unacceptable
1	Extremely Dry	Extremely Tasteless	Extremely Hard	Extremely Unacceptable

2.13. Data Gathered

The weight (g) of the mud crab was gathered every 3 weeks after stocking in their cages at Brgy. Kagtalaba Sta. Elena, Camarines Norte. The mud crabs are treated with the same management to determine which among the natural feeds are more effective. The weight of mud crab is measured every 21 days by the use of digital weighing scale.

The crude protein (%) was analyzed at (LQCCI) Lipa Quality Control Center Inc. company at 001 J.P. Laurel, National Highway, Purok 4, Brgy. Sico, Lipa City, Batangas 4217. To determine the meat characteristics of mud crabs, a free taste technique was used using Hedonic Scale developed by Peyems and Pilgrims 1957.

2.14. Statistical Analysis

Analysis of Variance (ANOVA) was used in analyzing the significant difference in the weight and organoleptic properties of mud crabs fed with different natural feeds. Other tests used Scheffes to test the significance between means. For the sensory analysis of the meat of mud crabs, the gathered data were interpreted using mean and ANOVA. The Statistical Analysis for Agricultural Research (STAR) is the Software used in the study.

3. Results and Discussions

3.1. Weight of Mud Crab Fed with Different Natural Feeds

Mud crab fattening engages in long-term grow-out culture that usually takes 3-5 months before it reaches its market size. Mud crabs that are fattened are fed once or twice a day depending on their body weight. In this study, for the 3month period of mud crabs in cages, there had been changes observed for every 3 weeks of data gathering. Table 3 shows that there is a significant difference on the weight of the mud crab fed with trash fish and copra but no significant difference on the weight of the mud crab fed with trash fish and horn snail. The weight pattern changes every week, but those fed with trash fish remained at the highest weight from the initial to the final week, making it significantly different among various feeds. Mud crabs fed with horn snails also obtained high weight gain, while those fed with copra incurred the lowest weight increment. The mud crab's feed acceptability plays a pivotal role in growth performance aside from protein content. Trash fish contains 14.4 to 20.8% protein content (Hazan et al., 2016), horn snail contains 52-63% (DM) (Tran, 2016), while copra contains 3.33 grams of protein content (USDA, 2019). Horn snail has a higher protein content than trash fish; however, trash fish obtains the highest mean weight in the first 3 weeks. It can be observed in the table below that the feed acceptability of mud crabs was already visible in those fed with trash fish and horn snails rather than copra. The mud crabs showed excellent acceptability of the trash fish feed from the start, obtaining an 8.83-gram weight gain, whereas horn snail feed has no significant difference, obtaining 8.11 grams. Copra feed showed a weight gain of 5.00 grams in the start, indicating a lower acceptability. Trash fish is regarded as a traditional feed for mud crab. Due to the crab's characteristic as a carnivorous crustacean, it can easily adapt to trash fish and horn snail feed. While copra that is first introduced as plant material feed showed lower acceptability. In addition, the palatability and attractiveness of trash fish meat and smell influence the feed acceptability of the crabs. Furthermore, there had been uncontrollable factors observed in the study, such as cheliped disintegration. It was observed during the six weeks of gathering. Most of the crabs fed with copra had cheliped disintegration, while mud crabs fed with trash fish and horn snails exhibited a lower number of the condition. Out of the 15 mud crabs in the cages for copra treatment, 6 crabs had cheliped disintegration, whereas trash fish and horn snails only had 2-3 mud crabs with the same condition.

Table 3. Weight of Mud Crab Fed with Different Natural Feeds.

Treatment Using	3 Week (g)	6 Week (g)	9 Week (g)	12 Week (g)	15 Week (g)
T1- Trash Fish	8.83 a	29.87 a	40.83 a	60.43 a	74.53 a
T2- Horn Snail	8.11 a	17.23 b	31.60 b	56.50 a	69.83 a
T3- Copra	5.00 b	14.00 b	21.17 c	49.00 b	63.50 b
CV (%)	18.15	9.17	7.44	6.12	3.48

Note: *Means with the same letter are not significantly different at P≤0.5 using Least Significant Difference (LSD) Test

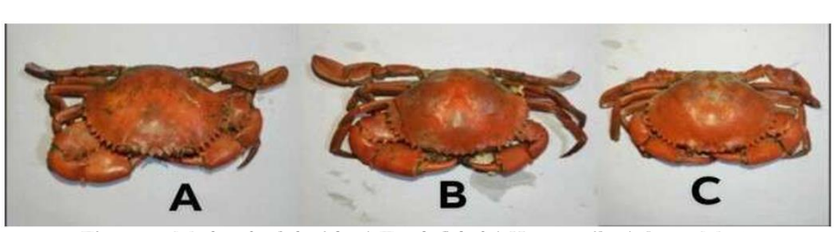

Figure 3. Mud crabs fed with a.) Trash fish, b.) Horn snail, c.) Copra Meat.

As highlighted in the study of Liew et al. (2022), diet attractiveness and palatability are important criteria for feeding mud crabs. Contrary to the test feed study of Ahamad Ali et al. (2011), the test feed, which contained crude protein, nitrogen-free extract, and ash, exhibited excellent acceptance with a weight gain of 36.73% when compared to crabs fed with trash fish meat, which obtained a 33.54% weight gain. Similarly, horn snail feed gained the highest weight increment in the study done by Zurbano et al. (2021) and showed excellent acceptability from the start, which gained 278.05 grams in the final week. The study by Cholik and Hanafi (1991) shows similar results, where trash fish feed has the inferiority as it increased the feeding rate by 10-15% of body weight. Contrast results were found in the study of Oluwole et al. (2020), where crabs grow less after being fattened for three (3) months with trash fish.In addition, Rabia (2015) reported that mud crabs fed with golden apple snails have higher weight gain than those fed with trash fish. Silva et al. (2010) reported that the size and form of the cheliped of crabs are known to be related to feeding performance. According to Drew et al. (2013), the crabs often show negative growth after losing claws or limbs, due to loss of foraging opportunities or a reduced opportunity to feed. On the study of

Imbuk et al. (2023), stingray feed showed better growth performance than trash fish despite having uncontrollable factors such as cheliped disintegration.

3.2. Feed Conversion Ratio of Mud Crab

Feed Conversion Ratio (FCR) is a critical metric in mud crab farming, measuring the efficiency with which feed is converted into biomass. It is calculated by dividing the amount of feed consumed by the weight gain of the crabs. A lower FCR indicates better feed efficiency and cost- effectiveness in farming operations. Table 4 shows that mud crab fed with trash fish achieved a weight of 152g, resulting in the lowest FCR of 6.90, indicating greater efficiency and cost- effectiveness compared to other natural feeds. In contrast, mud crab fed with horn snails yielded a harvest weight of 145g, and resulting in an FCR of 7.43. However, mud crab fed with copra yielded the lowest weight at 140g and had the second highest FCR of 7.28, indicating it is second efficient and cost-effective natural feeds for mud crab. Trash fish exhibited the highest weight increment using the highest amount of feed intake, producing the low feed conversion rate unlike copra feed. Copra feed obtained the lowest amount of feed intake, likely due to consistent leftover feeds after feeding, which are removed before fresh feed is provided to the crabs. However, those fed with copra meat still gained the lowest weight increment.

Table 4. Feed Conversion Ratio of Mud Crab Per Treatment.

Treatments			
	T1- Trash Fish	**T2- Horn Snail**	**T3- Copra**
Total Feed Intake	634.3g	601.65g	509.88g
Initial Weight	60g	64g	70g
Final Weight	152g	145g	140g
FCR	6.90	7.43	7.28

Similar result reported by Danilo and Alur (2011), after 15 days of fattening those fed with mussel and trash fish has the highest weight increment of 33.11g which also obtained the best feed conversion ratio (8.71) among other feed combinations. Similarly, Hadi et al. (2024) found that chicken intestines provided the best FCR value (7.53±5.15), likely due to their high nutritional content and soft texture, which made the feed more digestible, allowing crabs to convert it into body mass more efficiently. However, Gabito and Baltar (2023) presented a different outcome, demonstrating that mud crabs fed with african land snail achieved the highest growth performance, with a significantly better FCR of 1.38. This feeds not only proved to be high quality but also showed an impressive return on investment (ROI) of 96.8% making it a viable option for commercial and industrial-scale operations. These contrasting results suggest that while chicken intestine and traditional feeds can support mud crab growth, alternative feeds like african land snails may offer superior growth efficiency and economic benefits.

3.3. Protein Content of Mud Crab

Mud crab fattening is a sustainable aquaculture that is aimed at increasing the market value, by improving their weight and meat quality in a short period of time. Using nutrient-rich feeds, crabs are grown in controlled environments like pond or cages. Known for their rich flavor and high protein content (15 -20%), mud crabs are nutrious and popular seafood choice. Table 5 shows that mud crab fed with trash fish had the highest crude protein content (19.72%), followed by horn snail (19.09%) and copra (16.06%). This means that trash fish and horn snail could be better feeds for mud crab. Meanwhile, trash fish meat has better performance over horn snail while copra is the cheaper alternative. Mud crabs fed with trash fish and horn snail are richer protein than those fed with copra because trash fish and horn snail are high in animal protein, which is essential for the crab's growth and muscle development. These feeds provide essential amino acids that are more bioavailable and suited for crabs' dietary needs. In contrast, copra is plant based, and primary consists of fats and carbohydrates, with lower protein content, making it less effective in promoting protein - rich meat in crab.

Table 5. Protein Content of Mud Crab Fed with Different Natural Feeds.

Treatment	**Crude Protein (%)**
T1 - Trash Fish	19.72 a
T2 - Horn Snail	19.09 a
T3 - Copra	16.06 b
CV (%)	2.98

Note: *Means with the same letter are not significantly different at p<0.05 using Least Significant Difference (LSD) Test.

Studies on mud crab (Scylla serrata) feeding show varying results depending on the feed source. Trash fish, while yielding a lower protein content (16.44% in Zurbano et al., 2021; 19% in Severo et al., 2016) compared to other treatments (16.76% and 18.00% in Zurbano et al., 2021), resulted in high final weight (233.62 grams) and high overall acceptability (7.31% rating for flavor and juiciness). However, Imbuk et al. (2023) noted slower growth after 30 days due to factors like cheliped disintegration. Horn snail, conversely, produced the highest weight (278.05 grams) in Zurbano et al. (2021), with a higher protein content (18.00%), aligning with Gonzales et al. (2019) who reported 22-28% protein in horn snails. Despite this, Gabito and Baltar (2022) found no significant growth difference between horn snail and trash fish, showing an average growth of only 3.9%. These findings highlight the complex interplay between protein content, growth rate, and other factors influencing mud crab aquaculture. Formulating a balanced diet rich in protein and essential nutrients are crucial for enhancing the growth of aquatic animals (Garcia et al., 2018).

While coconut can be a component of such a diet, it's important to note that its protein content is relatively low. The United States Department of Agriculture (2019) reports that 100 grams of raw coconut contains 3.33 grams of protein. This translates to approximately 3% protein content on a wet weight basis. Copra, the dried coconut meat, has a higher protein content than raw coconut. Studies indicate that copra can contain between 6-8% protein on a dry weight basis. This makes copra a more suitable protein source for aquatic animal diets compared

to raw coconut. However, it's essential to consider that copra is still relatively low in protein compared to other common feed ingredients like fishmeal, which can contain 60-70% protein. Therefore, copra should be used as a supplemental ingredient in aquatic animal diets, alongside other protein-rich sources, to ensure adequate protein intake. Furthermore, the protein quality of copra, meaning the digestibility and amino acid profile, may not be as optimal as other sources. Research is needed to evaluate the effectiveness of copra as a protein source for different aquatic species. In conclusion, while copra can contribute to a balanced diet for aquatic animals, it's not a primary protein source. Further research is necessary to determine its optimal inclusion levels and the potential for improving its protein quality through processing or supplementation. Horn snail shows the highest potential as a protein source based on reported protein content and maximum weight gain in one study.

3.4. Sensory Attributes of Mud Crabs

Due to mud crab's exceptional meat quality, distinct taste and flavour, crab meat is the most preferred seafood item and holds a special place on restaurant menus across countries (Anupama et al. (2018). Table 6 shows the sensory attributes of mud crab meat as evaluated by respondents based on three different treatments including trash fish, horn snail, and copra. Copra treatment scored the highest in all categories, it produced the very much juicy, flavorful, soft and acceptable crab meat. One characteristic of coconut meat is its sweet taste, which derives from a combination of its natural chemical composition. The sweetness of the edible flesh is due to its sugar content for approximately 6-7% primarily in the form of fructose and glucose (Food and Agriculture Organization, 2017). In addition, coconut meat contains various amino acids that have been found essential in seafood's flavor or taste. Thus, could be the reason for the juiciness and flavorful taste of mud crab fed with copra.

Table 6. Sensory Attributes of Mud Crabs Meat as Perceived by the Respondents.

Treatment	Juiciness	Descriptive Interpretation	Taste	Descriptive Interpretation	Texture	Descriptive Interpretation	Overall Acceptability	Descriptive Interpretation
T1- Trash Fish	7.03	Moderately Juicy	7.4	Moderately Flavorful	7.67	Very Much Soft	7.63	Very Much Acceptable
T2- Horn Snail	7.13	Moderately Juicy	7.53	Very Much Flavorful	7.17	Moderately Soft	7.60	Very Much Acceptable
T3- Copra	7.53	Very Much Juicy	7.56	Very Much Flavorful	7.80	Very Much Soft	7.67	Very Much Acceptable

According to a study published by Yamaguchi & Ninomiya (2000), sweet-tasting amino acids can enhance the overall flavour profile of seafood, including crab. Crab meat sweetness arises not only from the sugar content but also from the effect of multiple amino acids. As highlighted in the study of Liu et al. (2024). the free amino acids serve as a crucial indicator for assessing the taste of aquatic products. Results had found that aspartic acid and glutamic acid were identified as umami taste contributors, while glycine, alanine, threonine, proline, and serine contributed to the sweet taste profile. USDA Food Data Central reported that dried coconut meat contains amino acids such as glutamic acid (1574 mg), glycine (326 mg), proline (284 mg), serine (356 mg), threonine (251 mg) and alanine (352 mg) which are essential to food flavor.

3.5. Mortality of Mud Crab

Mud crab mortality is a significant challenge in mud crab aquaculture, often caused by factors such as poor water quality, overcrowding, disease outbreaks, and inadequate nutrition. High mortality rates can reduce production efficiency and profitability, making it crucial to address these issues through proper management practices, including maintaining optimal environmental conditions, biosecurity measures, and balanced feeding. As shown in Table 7, the mud crab fed with copra has the highest mortality rate with (3%). The trash fish has the mortality rate of (2,67%) while the horn snail was almost identical with (2.66%). These rates show that both diets were similarly effective in maintaining low mortality. In contrast, the copra treatment indicates that it may not be as effective as the other two diets in minimizing crab mortality. Overall, the results demonstrate that trash fish and horn snail are more favorable for reducing mud crab mortality compared to copra. Mud crab survival is heavily influenced by cheliped disintegration. Limb damage and loss significantly affected the survival of the mud crabs as it can reduce the ability to feed. Most of the crab fed with copra exhibited the highest number of cheliped disintegration were both limbs are loss resulting in inability to feed themselves for survival. It was observed that during the implementation, due to unexpected rainfall which resulted to sudden influx of freshwater leading to decrease salinity levels of the water. Poor water quality increases the risk of stress and mortality.

Table 7. Mortality of Mud Crabs.

Treatment Using	Week 3	Week 6	Week 9	Week 12	Week 15	Total
T1- Trash Fish	0.67	2	0	0	0	2.67%
T2- Horn Snail	2.33	0.33	0	0	0	2.66%
T3- Copra	0	1	2	0	0	3%

Similarly, Imbuk et al. (2023), reported that mud crabs' survival rate fed with stingray (68%) and trashfish (65%) was influence by cheliped disintegration resulting to high mortality rate compared to other studies. The seemingly contradictory findings regarding mud crab survival rates when fed trash fish or horn snails highlight the complexity of this issue. While some studies report high survival rates (100%) for both feeds (Capiña and Salibay, 2020; Zurbano et al., 2021), others show significant mortality in trash fish-fed crabs (16%, Zurbano et al., 2021) and no significant difference between trash fish and stingray-fed crabs (Imbuk et al., 2023). These discrepancies likely stem from variations in feed quality (nutritional content and potential contaminants), environmental conditions (water parameters stocking density), and study methodologies (experimental duration, crab size/age). To resolve

these inconsistencies and gain a clearer understanding, future research should focus on standardizing feed quality, controlling environmental factors, comparing survival across different crab life stages and conducting long-term studies to assess the long-term effects of various diets on mud crab health and reproductive success. Similarly, Huang et al. (2019) reported that low salinity caused stress and impact the survival of the crabs than high salinity level of water. In addition, De Jesus et al. (2019) reported that obstruct salinity changes due to environmental factors, such as rainfall, significantly impact the growth rates and survival of the crabs.

3.6. Profitability of Mud Crabs

Mud crab farming has the potential of earning income and ensuring food security, particularly in coastal areas. However, profitability is influenced by production costs. Table 8 shows the cost and return analysis of mud crabs fed with different natural feeds. The given computation does not include the expenses involved in making the mud crab cages, as this was only part of the experimentation. The total expenses are based on those incurred in traditional mud crab fattening. Considering that mud crab fattening is often conducted in large ponds, a common practice that is still used by local mud crab growers today. The highest harvest weight of 1.087 kg was obtained by mud crabs fed with trash fish and generated the greatest income at PhP 434.8, leading to a profit of Php 108.52 despite obtaining the highest total expenses among the different natural feeds. In contrast, horn snail feed yielded a lower harvest weight of 0.810 kg and generated a profit of Php 30.73. However, mud crab fed with copra produced the smallest harvest weight of 0.787 kg and generated the lowest profit of PhP 24.21. Mud crabs fed with trash fish achieve higher weight, resulting in greater profit due to their improved growth, unlike those fed with horn snails and copra. These findings underscore the economic advantage of trash fish as a feed, given its balance of cost and growth efficiency. Feed acceptability plays a critical role in determining production outcomes, with trash fish showing high acceptance by mud crabs, translating to better growth and profitability. Trash fish remains the most cost- efficient feed, producing the highest profit among horn snails and copra.

Table 8. Profitability of Mud Crab Farming Fed with Different Natural Feeds Costing and Return on Investment of Mud Crabs Per Treatment.

Treatments			
Cost of Materials	**T1-Trash Fish**	**T2-Horn Snail**	**T3-Copra**
Crablets	80.00	60.00	60.00
Feeds	121.28	108.27	105.59
Transportation	25.00	25.00	25.00
Labor	100.00	100.00	100.00
Total Expenses	326.28	293.27	290.59
Total Harvest (kg)	1.087kg	0.810kg	0.787
Income (Php400/kg)	434.8	324	314.8
Profit	108.52	30.73	24.21
ROI	33.26%	10.48%	8.33%

As discussed in the study of Cabito, F. M. & Baltar, F. J. (2002), titled " Evaluating different diets on the growth performance of mud crabs," trash fish has lower production costs compared to other natural feeds. Their findings emphasize that trash fish is a cost-effective feed option, providing favorable profitability and return on investment (ROI), though expenses varied based on local availability and sourcing. Similarly, Zurbano et al. (2021) in their study " Growth and protein content of mud crabs (Scylla serrata) fed with different natural feeds," noted that while horn snails are slightly more expensive than trash fish, they offer significant offer significant growth benefits for mud crabs due to their high protein content. They estimate total expenses for horn nail feed at Php1,364.00 over three months and reported a higher ROI than trash fish despite the additional cost. In addition to this, Capiña and Salibay (2020) observed that trash fish and horn snail are among the most used feeds in mud crab farming. They reported that horn snails are slightly costly due to the labor involved in collection and preparation but remain a viable option for sustainable aquaculture sue to their impact on growth and survival.

4. Conclusions and Recommendations

4.1. Conclusions

Trash fish resulted to highest growth performance, protein content, and significantly different with the other natural feeds. While crabs fed with copra received the highest ratings for juiciness, taste, and texture. This suggests that copra may improve sensory attributes despite its lower nutritional contribution. Moreover, trash fish and horn snail were effective in maintaining lower mortality rates, while copra -fed crabs experienced the highest mortality. Generally, trash fish proved to be the most cost-effective feed option, with the lowest production costs and the highest return on investment (ROI). It also obtained the lowest feed conversion ratio, indicating greater cost-effectiveness and feed efficiency.

4.2. Recommendations

Trash fish is highly recommended as a natural feed for mud crab. It shows consistent growth and increase of weight and gets the highest crude protein and conducted to be cost -effective. However, when it comes to meat characteristics, it is recommended to use copra to achieve a certain taste and quality of meat. Furthermore, future researchers could explore the combination of trash fish and copra meat as feed for mud crabs and investigate the causes of cheliped disintegration and develop effective preventive measures.

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