Asian Journal of Advanced Multidisciplinary Researches (AJAMR), Vol. 3, Issue No. 2, August 2023
ISSN Online: 2782 - 9057

Available online at https://msubuug.edu.ph/journal

Asian Journal of Advanced Multidisciplinary Researches

Fattening of Mangrove crab *(Scylla olivacea)* using Singapore Vinegar Crab *(Episesarma singaporense)* and Mud *clam (Polymesoda erosa)* Meal as Trash fish Replacement

Ledivie G. Quimno, Ronie B. Claro, Floriefe G. Torino

College of Fisheries, Mindanao State University Buug – R.T. Lim Extension, R.T. Lim Zamboanga Sibugay, Philippines
*Email: floriefe.torino@msubuug.edu.ph

ABSTRACT

This study investigated the potential of Singapore vinegar crab (*Episesarma singaporense*) and mud clams (*Polymesoda erosa*) as a low-cost diet for crab fattening. The performance of these natural diets was evaluated on the growth and survival of mangrove crabs (*Scylla olivacea*) over a period of twenty-eight days. Fifteen healthy mangrove crabs with an average body weight of 130 grams and an average carapace length of 3.46 inches were used as experimental organisms. The study comprised three treatments: Treatment 1 (TFM) served as the control group using Trash Fish Meal, Treatment 2 (MCM) involved Mud Clam Meal, and Treatment 3 (SVCM) utilized Singapore Vinegar Crab Meal. Each treatment was replicated five times, and the feeding rate was set at 10% of the crab's average body weight. The results of the study shows that SVCM exhibited superior performance in terms of weight gain, carapace increment, survival rate, FCR, and FCE. However, statistical analysis (ANOVA) revealed no significant differences in mean weight gain, mean carapace increment, survival rate, FCR and FCE among the mangrove crabs fed with SVCM, MCM, and TFM, indicating there was no adverse effects on the crabs as it shows normal growth and survival. The results suggest that, in the absence of readily available trash fish meal, both MCM and SVCM can serve as suitable alternatives, as all treatments exhibited survival rates exceeding 80%. Further investigations are warranted to explore the long-term effects and nutritional composition of these alternative diets on mangrove crab growth and health.

Keywords*:* crab fattening, low-cost diet, fish meal replacement, aquaculture, growth performance

1. INTRODUCTION

The mangrove crab of the genus Scylla holds significant importance as a valuable food source and a means of income for numerous tropical Indo-Pacific countries, including the Philippines, Indonesia, Vietnam, China, Taiwan, Sri Lanka, Bangladesh, and Malaysia (Bir et al., 2020). In the Philippines specifically, research conducted by Cabacaba (2022) has highlighted that Scylla olivacea ranks as the third most abundant species of mangrove crab. It exhibits a relative abundance of 22.29% in the regions of Cagayan Valley, Bicol, Eastern Visayas, and Northern Mindanao.

The increasing demand for mangrove crab in both local and international markets has spurred a growing interest in mangrove crab farming across the Philippines (Quinitio, 2004). One key factor influencing the success of mangrove crab farming is the selection of appropriate feed, which promotes faster growth and optimal nutrition for the crabs (Koshio et al., 1993). Traditionally, trash fish has been widely used as the primary feed for crab fattening, as it is easily available and relatively inexpensive (Yxtung, 2020). However, the reliance on trash fish raises concerns regarding its sustainability and the potential depletion of wild fish stocks. Additionally, the availability of trash fish can be unpredictable due to weather conditions, posing challenges for farmers in securing a consistent supply.

In light of the challenges associated with the availability of trash fish, there is a need to explore alternative, locally available feed sources that are cost-effective, nutritionally balanced, and environmentally friendly for the fattening of mangrove crabs. Thus, this study focuses on investigating the potential of two species, Singapore vinegar crab (*Episesarma singaporense*) and mud clam (*Polymesoda erosa*), as alternative meal options to replace trash fish. Singapore vinegar crab is abundantly found in mangrove habitats and has even been considered a pest in fish farm growers in Zamboanga Sibugay. Additionally, mud clam represents a readily accessible feed resource in the region. By investigating the efficacy of Singapore vinegar crab and mud clam meal as mangrove crab diet, this study seeks to address the pressing need for sustainable aquaculture practices while promoting resource utilization and reducing dependence on unsustainable feed sources.

2.METHODOLOGY

2.1 Experimental Organism

ISSN Online: 2782 - 9057

A total of fifteen (15) mangrove crabs, with an average body weight of 130 grams, were selected as experimental organisms (Fig.1). These mangrove crabs were collected by local fishermen from Laih, Siay, Zamboanga Sibugay, and transported to the College of Fisheries Laboratory at Kolambugan, RT Lim, Zamboanga Sibugay where the experiment was conducted for 28 days.

Fig. 1. Mangrove crab (*Scylla olivacea*)

2.2 Experimental Set-up and Design

A total of fifteen (15) crab fattening trays with dimensions 43cm x 32cm x 13cm (43cm long, 32cm wide and 13cm height) were utilized in this study. The experiment consists of three (3) treatments with five (5) replicates laid out in a completely randomized design (CRD) using draw lots as shown in Figure 2.

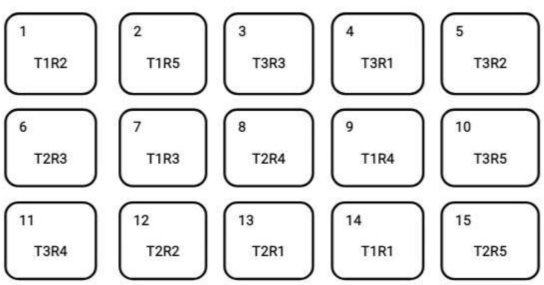


Fig. 2. Experimental Lay-out

The different treatments are shown in Table 1. Treatment 1 is the control group fed with trash fish meal (TFM), Treatment 2 is fed with mud clam meal (MCM) and Treatment 3 is fed with Singapore vinegar crab meal (SVCM).

Table 1. The treatments with the different experimental diet of Mangrove crab

Treatment	Experimental Diet
1	TFM (Trash Fish Meal)
2	MCM (Mud Clam Meal)
3	SVCM (Singapore Vinegar Crab Meal)

2.3 Preparation of Experimental Diet

Trash fish, an important component of the experimental feeding regimen, were collected weekly from Laih, Siay Zamboanga Sibugay. The collected trash fish were promptly transported to the experimental site and stored in a refrigerator upon arrival. This refrigeration step was implemented to prolong the shelf life of the trash fish, ensuring its freshness and suitability as feed for the crabs.

In contrast, the collection of Singapore vinegar crab and mud clam occurred on a daily basis from nearby ponds located at the experimental site in Kolambugan, RT Lim. This daily collection ensured that the Singapore vinegar crab and mud clam were obtained fresh and maintained their optimal quality when fed to the crabs. The shells of Singapore vinegar crab and mud clam were crushed to extract the meat. The raw meat was then given to the mangrove crabs as their diets.

2.4 Feeding and Feed Ration

The trash fish, mud clams and Singapore vinegar crab meal was provided to mangrove crab at a rate of 10% of their average body weight (SEAFDEC, 2011). Feeding ration was increased based on the average body weight of the crabs measured every sampling. Feeding was done once daily at 5:00 pm in the afternoon. Daily feed ration was computed based on the following: DFR=ABW x 10%, where, DFR is the Daily Feed Ration and ABW is the Average Body Weight.

2.5 Sampling Procedure

Sampling was done every seven (7) days for twenty-eight (28) days at 6:00 am in the morning to avoid stress of the experimental organisms. The crabs were retrieved from the fattening tray by using the net and the container.

Each of the experimental organisms in every treatment was weighed using a digital weighing scale and the carapace length was measured using Vernier caliper. After collecting the data, the crabs were returned in their respective trays and proper handling was observed in order to avoid stress of the experimental organism.

2.6 Growth Determination

The growth of the experimental organisms was determined using the formula:

Growth as represented by

Weight gain = Final weight – Initial weight

Carapace Length Increment = Final carapace length t – Initial carapace length

2.7 Survival Determination

The study was monitored three (3) times daily. Bamboo sticks were used to touch the experimental organism to check if the experimental organism is still alive.

At the end of the experiment, the survival rate of the study was computed by using the formula:

% of survival=final stock ÷ initial stock × 100

2.8 Feed Conversion Ratio and Efficiency

The feed conversion ratio and efficiency of the different treatments were computed using the following formula (Laman, 2010).

FCR= total feeds consumed (g) ÷ weight gain (g)

FCE= weight gain (g) ÷ total feeds consumed (g) x 100

2.9 Monitoring of Physico-chemical Parameters

Monitoring of physico-chemical parameters was done twice (2) daily at 7:00 am in the morning and 5:00 pm in the afternoon to monitor fluctuations in the water parameter. A digital multi-parameter probe was used to determine the water's temperature, salinity, dissolved oxygen (DO), and pH on a regular basis.

2.10 Statistical Analysis

One-way Analysis of Variance (ANOVA) was used to determine if there is a significance of using Singapore vinegar crab and mud clam meal as a replacement for trash fish on the growth, survival, FCR and FCE of Mangrove crabs.

3.RESULTS AND DISCUSSION

3.1 Growth of mangrove crab

Growth in terms of weight gain

The growth of mangrove crab (*Scylla olivacea*) in terms of weight gained after 28 days of culture period fed with trash fish, mud clams and Singapore vinegar crab meal is presented in Table 2. An increasing trend of weight gain can be seen in Figure 3. It reveals that Treatment 3-SVCM has the highest mean weight gain with 49.24 grams followed by Treatment 2-MCM with 28.82 grams and Treatment 1-TFM with 28.56 grams.

Table 2. Weight gain of Mangrove crab *(Scylla olivacea)* fed with TFM, MCM, and SVCM in 28-day culture period

Treatment	Weight (g)					Weight Gain (g)
	Day 0	Day 7	Day 14	Day 21	Day 28	
T1 (TFM)	99.80	108.10	116.52	127.05	132.95	28.56[a]
T2 (MCM)	165.70	173.80	178.96	188.52	168.08	28.82[a]
T3 (SVCM)	123.70	133.00	141.84	151.16	172.94	49.24[a]

Superscripts with the same letter within the same column are not significantly different from each other

However, upon conducting statistical analysis, no significant difference ($p>0.05$) in mean weight gain was observed among the treatments. While Treatment 3-SVCM displayed the highest mean weight gain, the lack of statistical significance suggests that all three treatments yielded comparable results in terms of promoting growth in the mangrove crabs.

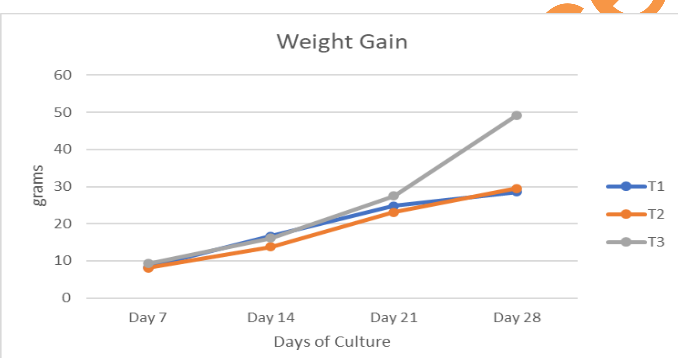


Fig 3. Weight gain of Mangrove crab *(Scylla olivacea)* fed with TFM, MCM, and SVCM in 28-day culture period

The growth of crustaceans, including mangrove crabs, has been widely studied, and it is commonly understood that weight gain is primarily influenced by the nutritional composition of the feed provided (Koshio et al., 1993). In the case of this study, the nutritional content of the feed sources used is crucial in understanding the observed growth patterns. Trash fish, specifically *Leiognathus splendens*, has been reported to contain approximately 14.57% protein content (Kasthuri et al., 2020). Mud clams, on the other hand, have a protein content of around 10.68% (Normah and Noorasma, 2014). Comparatively, crab meat is known to have varying protein contents depending on the species, with values reported as 13.34% and 18.82% (Islam et al., 2022).

It is notable that the protein content of the three low-value aquatic feed sources used in this study did not exhibit significant differences. Therefore, the similar protein content of the feeds may explain the absence of a significant difference in the growth of the experimental organisms. Since protein is a key nutrient for growth and development in crustaceans, the comparable protein content among the feed sources likely contributed to the similar growth outcomes observed.

Growth in terms of carapace increment

The carapace increments of mangrove crabs were measured to assess the impact of different feeding treatments: trash fish, mud clams, and Singapore vinegar crab meal. The results, shown in Table 3, indicate the growth of carapace size after a 28-day culture period. Among the treatments, Treatment 3-SVCM exhibited the highest carapace increment, measuring 0.50 inches. It was followed by Treatment 1-TFM with a carapace increment of 0.49 inches, and Treatment 2-MCM with a minimal increment of 0.06 inches.

Table 3. Mean carapace increment (inch) of Mangrove crab *(Scylla olivacea)* fed with TFM, MCM, and SVCM in 28-day culture period

Treatment	Carapace Length (inch)					Carapace increment (inch)	Molting Occurrence
	Day 0	Day 7	Day 14	Day 21	Day 28		
T1 (TFM)	3.15	3.18	3.26	3.79	3.80	0.49[a]	1
T2 (MCM)	3.71	3.72	3.73	3.76	3.67	0.06[a]	0
T3 (SVCM)	3.50	3.52	3.48	3.62	4.00	0.50[a]	2

Superscripts with the same letter within the same column are not significantly different from each other

Like most creatures, crabs (and other crustaceans) do not experience linear growth. They must molt their shells because they have a hard outer covering (called the exoskeleton) that prevents them from growing. Crabs outgrow their shells in order to grow. In this study, Treatment 3-SVCM has the greatest number of molting occurrences with 2 followed by Treatment 1 with 1 occurrence while Treatment 2-MCM has no molting occurrence. This explains why Treatment 3-SVCM obtained the highest mean weight gain and mean carapace increment because it has molted twice showing growth. Meanwhile Treatment 2-MCM has the lowest mean carapace increment because not even one of the mangrove crabs molted.

Statistical analysis showed no significant difference ($p>0.05$) observed in the mean carapace increments among the experimental groups fed with the three different meals. This suggests that the choice of meal did not have a significant effect on the carapace growth of the mangrove crabs during the 28-day culture period.

Interestingly, the present study's treatment protocol was identical to that of Rabia's (2016) investigation. Rabia's study focused on the effects of administering the Singapore vinegar crab treatment, and it revealed a statistically significant increase in the average size of mangrove crabs. This finding suggests that the administration of Singapore vinegar crab treatment may have potential for enhancing the growth and size of mangrove crabs, although this effect was not observed in the present study when comparing all three feeding treatments.

3.2 Survival rate of Mangrove crab

The data presented in Table 5 represents the survival rates of mangrove crabs (*S. olivacea*) that were fed with mud clams and Singapore vinegar crab meal as substitutes for trash fish meal during a 28-day culture period.

Among the treatments, Treatment 3-SVCM achieved the highest survival rate of 100%, while Treatments 1-TFM and 2-MCM showed a survival rate of 80%. However, the statistical analysis conducted on the data, did not reveal a significant difference among the treatments. The findings suggest that mud clams and Singapore vinegar crab meal can be viable alternatives to trash fish meal in terms of supporting the survival of mangrove crabs during the culture period. The similarity in survival rates across the treatments indicates that these alternative feed sources were capable of meeting the nutritional requirements of the crabs adequately.

Table 4. Mean survival rate of Mangrove crab during 28 days culture period.

Treatments	Survival rate (%)
T1 (TFM)	80.00[a]
T2 (MCM)	80.00[a]
T3 (SVCM)	100.00[a]

Superscripts with the same letter within the same column are not significantly different from each other

3.3 Feed Conversion Ratio and Efficiency

Figure 4 reveals the feed conversion ratio and efficiency of mangrove crabs fed with mud clams and Singapore vinegar crab meal as a replacement for trash fish. The lower the FCR the better. The lowest feed conversion ratio (FCR) was obtained by Treatment 3-SVCM with 9.46, this was followed by Treatment 1-TFM with 10.94 and Treatment 2-MCM with 15.80 (Table 5). Meanwhile, Treatment 3-SVCM achieved the highest feed conversion efficiency (FCE) with 13.87, followed by Treatment 1-TFM with 12.88 and Treatment 2-MCM with 7.50. Analysis of variance showed no significant difference in the feed conversion ratio and efficacy of mangrove crabs fed with mud clams and Singapore vinegar crab meal as a replacement for trash fish. Just like the growth of the mangrove crabs that were fed with the three different treatments mentioned above, there is no significant difference because the protein content of the three treatments did not vary much.

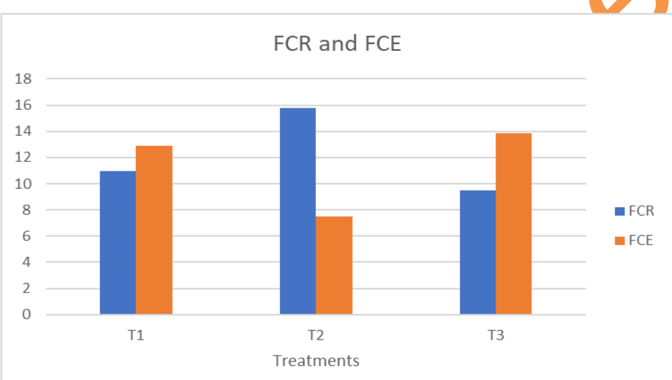


Figure 4. FCR and FCE of Mangrove crab

Table 5. Feed Conversion Ratio and Efficiency of Mangrove crab

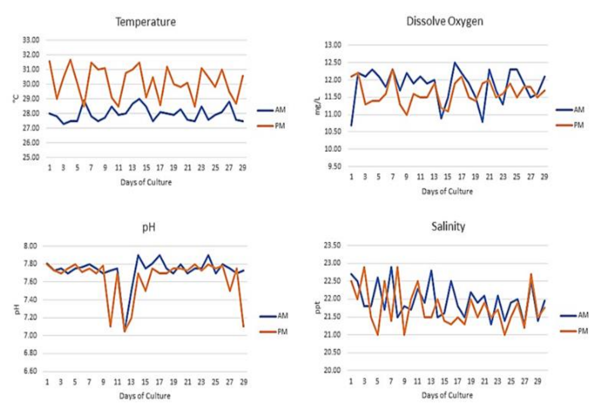
Treatment	Total amount of feed given (g)	weight gain (g)	FCR	FCE
T1 (TFM)	293.78	28.56	10.94[a]	12.88[a]
T2 (MCM)	447.20	28.82	15.80[a]	7.50[a]
T3 (SVCM)	378.99	49.24	9.46[a]	13.87[a]

Superscripts with the same letter within the same column are not significantly different from each other

The feed conversion ratio (FCR) is a conventional metric for evaluating the efficiency of livestock production, calculated by dividing the weight of feed input by the weight gain of the animal. According to Boyd (2021) effective aquaculture operations are identified as having a low FCR. On average the feed conversion ratios (FCRs) for mangrove crabs that are raised in farms vary between 1.0 and 2.4. The interference that can be made from this is that the FCR level in the culture mud crab surpasses the standard level.

3.4 Physico-chemical parameters

The physico-chemical parameters of the water during the twenty-eight (28) days culture period are shown in Figure 5. Throughout the culture period, the water temperature fluctuated between 27ºC to 31ºC. FAO (2011) stated that the suitable cultivation location for mud crabs are muddy ponds with temperature of 25ºC to 35ºC.
The dissolve oxygen ranges from 10.70mg/L to 12.30mg/L, according to FAO (2011) the suitable DO for mud crab is > 5 ppm.
The recorded pH of the culture water was between 7.05 to 7.90 and is within the suitable pH for crab cultivation of 7.0-9.0 (FAO, 2011).
The water salinity during the culture period varied between 21.00ppt and 22.90ppt. Salinity fluctuate due to rainfall and evaporation by sunlight. RAS Aquaculture (2020) stated that the suitable salinity for mangrove crabs is 15 to 25ppt.



4.CONCLUSION

The focus of this study is to find an alternative low-cost meal that can be used for crab fattening if trash fish is not available. Based on the results, the study suggests that Singapore vinegar crab and mud clam meal can be potential replacements for trash fish in the diet of mangrove crabs. The use of Singapore vinegar crab showed promising results in terms of weight gain, carapace increment, survival rate, and feed conversion ratio and efficiency. However, further research may be required to validate these findings and optimize the incorporation of Singapore vinegar crab and mud clam meal in the diet of mangrove crab.

5. RECOMMENDATIONS

The following recommendations are suggested for future studies:
1. Long-term evaluation should be conducted in other culture systems such as ponds or cages rather than on a fattening tray.
2. Additional research should be done on the use of various mollusk and cephalopods species as a natural feed for mangrove crab.

3. The use of a uniform initial body weight for the experimental organism in future studies is highly recommended to avoid bias and have accurate findings.

ACKNOWLEDGEMENT

The researchers would like to express their heartfelt gratitude to the people who helped and made this research possible. The efforts and time given with this study are very much appreciated.
To their panelist, Ms. Floriele M. Gonzaga, Ms. Noraisa E. Salipada and Mrs. Jecelle Lou F. Alajas, for their constructive criticisms, commendable suggestions, and corrections.
To their beloved parents, who sustained and supported them financially, emotionally, physically, and spiritually. For being so understanding and supportive, the motivation and inspiration shared means a lot to surpass those difficult days.
Above all, to our Almighty God, who guided them throughout the study, for the wisdom, patience, good health, and understanding, and who is worthy of all the praises and thanksgiving, for without Him, this study would not have been possible.

REFERENCES

Aaqillah-Amr, M., Hidir, A., David, M., Agmad-Ideris, A., Muhammad-Zulhilmi, R., Julius, Y., et al. (2022). Development of semi-moist formulated feed for female orange mud crabs, *Scylla olivacea* (Herbst, 1976) broodstocks with graded lipid levels. Animal Feed Science and Technology | ScienceDirect.

Aiis. (2021). Different Feeding on Survival and Growth Performance of Mud Crab (*Scylla spp*.).

Bir, J., Islam, S., Sabbir, W., Islam, R., & Huq, K. (2020). Ecology and reproductive biology of *Mud Crab Scylla* spp: A stusy of commercial mud crab in Bangladesh. International Journal of Academic Research and Development, 01-07.

Boyd, C. E. (2021). A low feed conversion ratio is the primary indicator of effecient aquaculture. Global Seafood Alliance.

Cabacaba, N. S., Jumawan, C. I., Celino, S., Quizon, E., Boiser, E.-M., & Campo, C. (2022). Resource Asessment of Mangrove Crabs (*Scylla spp*.) in the Philippines. 13th Asian Fisheries and Aquaculture Forum. Tainan, Taiwan.

Das, K., Mondal, S., & Abdulla-Al-Asif. (2019). Growth and economic performance of different supplements fed on female mud crab (*Scylla olivacea*) fattening in plastic boxes. Asian Journal of Medical and Biological Research.

Herbst. (1796). *Scylla olivacea.* Retrieved from Wikipedia: en.m.wikipedia.org

Ingole, B. S., Naik, S., Furtado, R., Ansari, Z. A., & Chatterji, A. (2002). Population characteristics of the mangrove clam *Polymesoda erosa* (Geloina) erosa (Solander, 1786) in the Chorao mangrove, Goa. Food and Agriculture Organization of the United Nations.

Islam, T., Saha, D., Bhowmik, S., Nordin, N., Islam, S., Nur, A.-A., et al. (2022). Nutritional properties of wild and fattening mud crab (*Scylla serrata)* in the south-eastern district of Bangladesh. National Library of Medicine.

Jagdish. (2021). Mud Crab Fattening Profits and Cost. Agri Farming.

Karniati, R., Sulistiyono, N., Amelia, R., Slamet, B., Bimantara, Y., & Basyuni, M. (2021). Mangrove ecosystem in North Sumatran (Indonesia) forests serves as a suitable habitat for mud crabs (*Scylla serrata* and *S. olivacea*). Biodiversitas Journal of Biological Diversity.

Kasthuri, S., Sathees, D., & WHMK, W. (2020). Proximate composition analysis of trash fish from the selected landing sites of Jaffna district, Sri Lanka. International Journal of Fisheries and Aquatic Studies, 215.

Koshio, & Shununsuke. (1993). The effect of dietary content on growth, digestion and nitrogen excretion of juvenile Kuruna prawns, *Paneeus japonicas*. 101-111.

Le Vay, L. (2001). Ecology and Management of Mud Crab Scylla spp.

Mud Crab Project Report, Culture Profit, and Cost. (n.d.). Asia Farming.

Normah, I., & Noorasma, M. (2014). Physiochemical properties of mud clam (*Polymesoda erosa*) hydrolysates obtained using different microbial enzymes. International Food Research Journal 22(3): 1103-1111 (2015), 1106.

Orario, H. P., Cai, Q. W., Chua, J. C., Magpayo, E. N., Po, A. G., Sanchez, J. O., et al. (2021). How Filipino Fishers Use Traditional Knowledge in Identifying Species of Juvenile Mangrove Crabs for Grow-out Culture. The Philippine Journal of Fiseries, 119-128.

Quinitio, E. T. (2004). Mud crab hatchery and grow-out status in the Philippines. SEAFDEC INSTITUTIONAL REPOSITORY.

Quinitio, E. T. (2017). Overview of the mud crab industry in the Philippines. SEAFDEC/AQD INSTITUTIONAL REPOSITORY.

Rabia, M. S. (2016). Length and Weight Characteristics of Mud Crab (*Scylla serrata*) Fed with Indigenous Feeds in Plastic Container. Environmental Science, Vol. 4, 53-61.

RAS Aquaculture. (2020). Overview of the Mud Crab Industry in the Philippines (Q3-2019) | Industry Report.

Salinity Requirements for Mud Crab Aquaculture | Aquaculture Technology. (n.d.). Retrieved from RAS Aquaculture: ras-aquaculture.com

SEAFDEC Aquaculture Department. Mangrove crab hatchery and nursery operations (brochure). Tigbauan, Iloilo, Philippines. (2016).

Sivasothi, N. (2000). Niche preferences of tree-climbing crabs in Singapore mangroves. Department of Biological Sciences.

Solander. (1876). Plymesoda erosa. Retrieved from Sealifebase: sealifebase.ca

Sujan, M., Kazal, M., Ali, M., & Rahman, M. (2021). Cost-benefit analysis of mud crab fattening in coastal areas of Bangladesh. ScienceDirect.

The State of World Fisheries and Aquaculture. (2011). Food and Agriculture Organization.

Trino, A. T., Rodriguez, E. M., Coniza, E. B., & Juanga, B. P. (1999). Mudcrab. Aquaculture Extension Manual No. 27 , 1-16.

Tweedie , M. (1936). On the Crabs of the Family Grapsidae in the Collection of the Raffles Museum. The Bulletin of the Rafles Museum, 44-70.

Walton, M., Vay, L., Lebata, J., Binas, J., & Primavera, J. (2006). Seasonal abundance, distribution and recruitment of mud crabs (*Scylla spp*.) in replanted mangroves. Estuarine Coastal and Shelf Science 66(3), 493-500.

Widianingsih, W., Hartati, R., Nuraeni, R., Endrawati, I., & Redjeki, S. (2020). The morphological variance *Polymesoda erosa* and *Polymesoda expansa* (Mollusc; Corbiculidae) in the Laguna Segara Anakan, Cilacap, Indonesia. The 5th International Conference on Tropical and Coastal Region Eco Development (p. 2). IOP Conf. Series: Earth and Environmental Science 530 (2020) 012021.

Yulianto, B., Sunaryo, Taufiq-Spj, N., Djunaedi, A., Subagiyo, S., Santosa, A., et al. (2019). Survival and Growth of mud crab (*Scylla serrata* Forsskal, 1775) reared in crab bucket recirculating aquaculture system. ResearchGate.

Yuwei, W., & Ho Kit Ian, J. (2020). National University of Singapore. Retrieved from Episesarma singaporense - Singapore vinegar crab: wiki.nus.edu.sg

Yxtung. (2020). What to feed mud crabs? | Top 5 feeds for mud crabs. RAS Aquaculture.