Boosting the sustainability of aquaculture feed for the lucrative business of mangrove crab grow-out culture

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Conventional feeds for mangrove crab (*Scylla serrata*) are highly fixated on the use of fish-by-products (FBC) and other slaughter wastes. These feeds, however, are highly polluting that can easily cause water quality spoilage, and may affect the health of the mangrove crab. They can likewise bring about problems in supply shortage, reliability in quality, and as carriers of disease agents.

In order to support the sustainability of the mangrove crab industry in Southeast Asia, there is a need to produce an efficient and viable aquaculture feed for this species. Although SEAFDEC has started venturing into researches with emphasis on crab feed development, it was deemed necessary to work on further improvement of feed formulation with the inclusion of ingredients that are less expensive based on published nutritional requirements and physical properties of mangrove crab.

This study assessed the efficiency of the refined crab feed in land-based tanks. Refinement of this feed formulation focused on partial replacement of fishmeal with alternative ingredients such as mussel meat meal. Cholesterol was added to refined crab feed to improve molting processes affecting the growth of the animal (Coloso *et al.*, 2017). The same diet was evaluated for its proximate composition, water stability, amino acid and fatty acid compositions, digestibility of nutrients, attractability and palatability, and its biological effects on cultured mangrove crabs. Overall, results indicated that refined crab feed can potentially be used as sole feed for the grow-out culture of crabs as it can enhance the animals' growth and survival in tanks.

The mangrove crab (*Scylla serrata*) farming industry is one of the more lucrative industries in the Southeast Asian region. Its world aquaculture production was pegged at 248,800 t and approximately 2.2 % of the total crustacean production (FAO, 2022). This figure of mangrove crab may well be expanded for better sustainability of the industry. Its further expansion may enable the provision of livelihood opportunities especially in remote control communities. However, this may entail the need to produce an efficient and viable aquaculture feed that may provide all the nutrients required by the animal.

Several research studies have been conducted and have shown that mangrove crabs are able to accept alternative feed options such as dry-formulated feed. Researches focused on their nutritional requirements which are very useful in the formulation of nutritionally balanced and cost-effective diets. Feeding trials did not show any significant difference in growth, molt, and survival with diets containing 35 % and 40 % crude protein (How-Cheong *et al*., 1992). In the study of Unnikrishnan and Paulraj (2010), on the other hand, mangrove crab's best growth performance as well as nutrient turnover was recorded with 45 % crude protein in the diet. Lipid requirement ranged from 5.3 % to 13.5 % (Sheen & Wu, 1999). Sheen (2000) reported that 0.5–0.79 % dietary cholesterol level is adequate for higher weight gain in *Scylla serrata*. Reports are available for the essentiality of highly unsaturated fatty acids for juvenile mangrove crabs (Sheen & Wu, 2002).

SEAFDEC likewise has started venturing into researches with a focus on crab feed development in different stages. The use of synthetic binders in the feed resulted in higher pellet water stability. The apparent digestibility coefficient of the nutrients varied among the different binders tested (Catacutan *et al*., 2003). Reports have shown that a formulated diet with 48 % protein and an energy level of 1,723 MJ/kg when fed to mangrove crabs showed survival of up to 60 % (Catacutan, 2017). Effective attractants are a strict recommendation for incorporation in the feed formula for better diet attractability. Water stability must be strictly considered since crabs are slow-eating animals. Physical properties of the feed such as size, shape, or texture can likewise affect its acceptability to the animal. Feeding trials showed mangrove crabs eating more with spherical- and tubular-shaped diets (Coloso, 2017). Further, the preference of the animal for attractants such as *Ascetes* and squid meal was highly noted.

To boost the performance of a refined crab feed formulation as the sole source of feed for the mangrove crab, refinement was done using other ingredients such as mussel meat meal and cholesterol. Refined crab feed (RCF) in combination with fish-by-catch (FBC) at different ratios was tested parallel to commercial crustacean feed (CCF) for mangrove crabs.

Promoting positive growth and survival of mangrove crabs

The feeding trial was done to test the efficiency of a refined crab feed to 30 juvenile crabs (0.4–0.8 g) for 150 days. Fifteen 250-L fiberglass tanks (**Figure 1**) were utilized to follow a completely randomized design (CRD) of an experiment. Each tank was equally divided into two partitions using a corrugated plastic sheet to accommodate two individual mangrove crabs. Dietary treatments consisted of **T1**: 0 % RCF:100 % FBC; **T2**: 50 % RCF: 50 % FBC; **T3**: 75 % RCF:25 % FBC; **T4**: 100 % RCF:0 % FBC; and **T5**: 100 % CCF. Each treatment was randomly distributed in three tanks.

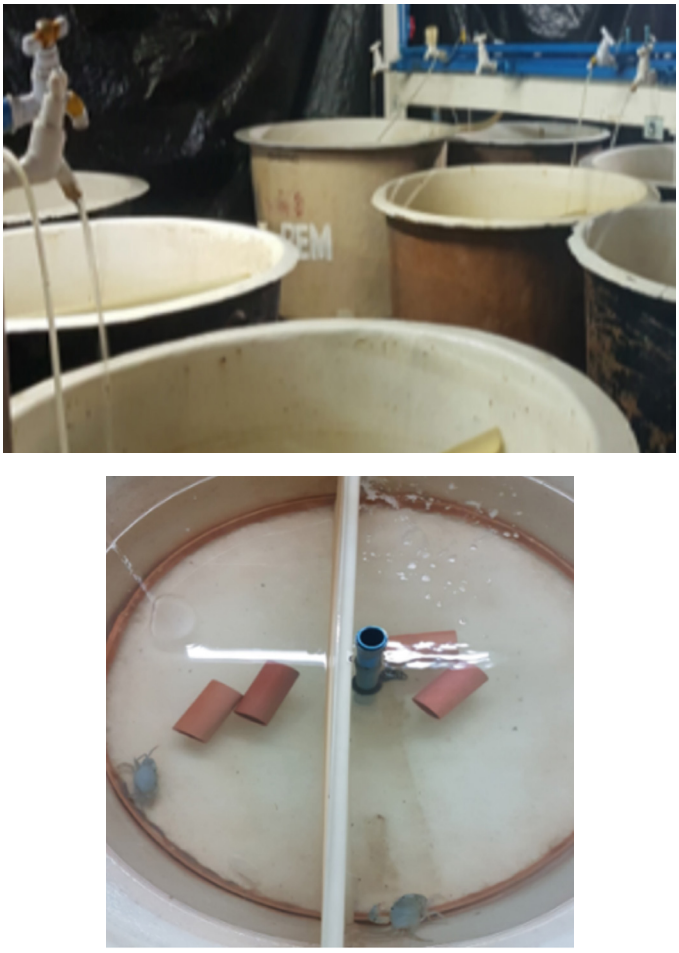

Figure 1. 250-L experimental tanks for mangrove crabs

The mangrove crabs fed on refined crab feed (RCF) as sole feed given showed significantly higher growth rates in terms of body weight gain, carapace width, length gain, and specific growth rate as compared to trash fish or commercial feed fed singly. No statistical difference, however, was observed in the growth of crabs fed 100 % RCF and crabs fed the combination feeds (50 % RCF: 50 % FBC and 75 % RCF:25 % FBC). Feed conversion ratio (FCR), though statistically comparable among experimental diets, was observed to be lowest in crabs fed RCF alone. Moreover, the survival rate (% SURV) was much higher for crabs fed 100 % RCF compared to the survival in other treatments. Crabs given 100 % RCF also showed the shortest average intermolt period and the highest molting frequency. Overall, comprehensive findings from this study suggest that feeding the mangrove crabs with 100 % RCF) yielded significantly higher growth and survival as compared to 100 % feeding of either traditional (trash fish) or commercial feed. Growth of mangrove crab fed with 100 % RCF in a land-based tank for 150 days is shown in **Figure 2** and **Figure 3**.

Figure 2. Initial carapace width (16.0 mm) of crab fed with 100 % RCF

Figure 3. Final carapace width (59.0 mm) of crab fed with 100 % RCF after 150 days

Enhancement of feed's nutritional profile

The improvement in growth and survival of mangrove crabs fed with 100 % RCF can be attributed to the refinement of the current feed formulation which is based on published nutritional studies on the grow-out culture of mangrove crabs. The formulation contains dietary nutrients that are within the range recommended for mangrove crabs. Crude protein for RCF at 50 %, is close to the levels recommended for good growth of crabs (Catacutan *et al*., 2017; Unnikrishnan & Paulraj, 2010). The analyzed crude fat of 6.47 % corresponds to the optimum requirement suggested by Catacutan (2017) as well as Sheen and Wu (1999). The level of NFE or digestible carbohydrate in the diet at 26.38 % is within the 20–30 % range required by crustaceans (Wang *et al*., 2016). Crude ash, which is crucial for the molting, growth, and survival of crustaceans, is at 11.18 %. This level is slightly lower than the figure presented by Catacutan (2017) at 15 %. The bioavailability of essential amino acids and fatty acids in the RCF is comparable to the profiles in mangrove crab flesh which can be considered as contributory to the animal's positive growth.

The inclusion of certain feed ingredients such as cholesterol and mussel meat meal has also contributed to the improvement of the performance of RCF. Cholesterol, supplemented at 0.5 % in the RCF, is found to be an essential nutrient compound that plays a vital role in the physiological processes of crustaceans (Kumar *et al*., 2018). In a preliminary study conducted by Coloso *et al*. (2017), it was determined that the addition of dietary cholesterol to feeds can enhance the mangrove crab's molting success and survival. Furthermore, an analogous study by Sheen (2000) revealed that the lowest survival rate and molting frequency were observed in crabs fed a diet without cholesterol supplementation. Sheen (2000) also suggested that the optimum dietary cholesterol requirement for mangrove crabs was 0.51 %. Mussel meat meal, on the other hand, was used to partially replace fishmeal in the formulated diet. According to studies conducted by Berge and Austreng (1989), Jönsson *et al*. (2011), and Rasidi (2022), mussel meat meal has an excellent nutrient profile that is comparable with that of fishmeal thus making it a great alternative to the latter. Additionally, mussel meat has also been recognized as a good feed attractant and palate stimulant (Berge & Austreng, 1989; Nagel *et al*., 2013). Results of attractability and palatability tests using a rectangular maze system and Y-maze system for RCF and CCF in the present study further confirm these findings as RCF containing 21 % mussel meat meal was deemed more attractive and palatable by crabs than CCF.

The rectangular maze system (**Figure 4**) made use of a glass aquarium divided by two barriers, thereby forming three compartments. The crab was placed in the middle section of

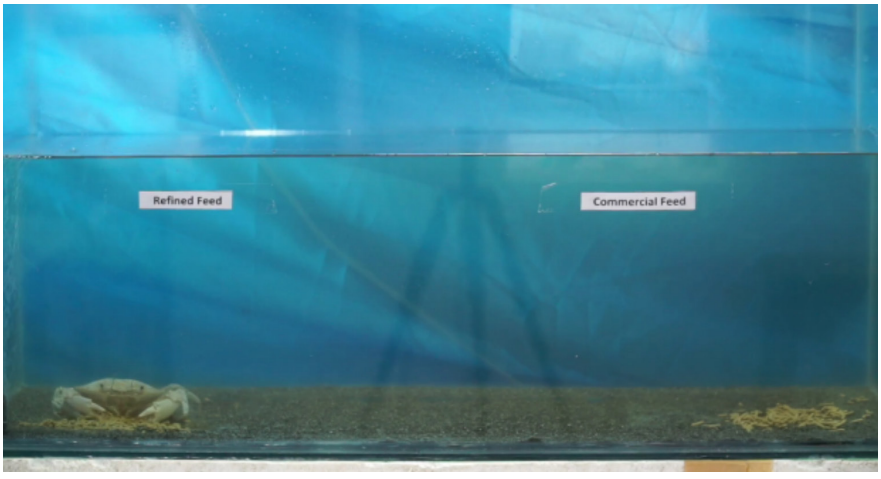

Figure 4. Rectangular maze setup for feed attractability and palatability tests for mangrove crab

Figure 5. Y-maze setup for feed attractability and palatability tests for mangrove crab

Figure 6. Chromic oxide analysis of feeds and feces for digestibility study (clockwise: thawing of collected frozen species; ashen feeds and feces samples; concentrated digested sample; and diluted digested samples for spectrophotometer reading)

the aquarium, while test diets (RCF and CCF) were placed into the two outer compartments. The barriers were pulled out 10 min after the feeds were placed. The Y-maze system (**Figure 5**), on the other hand, utilized a y-shaped, wooden setup. The crab was isolated in the central chamber of the y-maze by a wooden gate, whereas RCF and CCF were placed in the arm chambers of the system. The wooden gate was lifted 10 min after the feeds were placed. Video recording was conducted for both systems to quantify the time at which the crab had first contact with either feed (attractability) and the time at which the crab had fully consumed the feeds (palatability).

Good nutrient digestibility and high water stability in RCF were also considered crucial factors in the superior performance of the formulated feed in the growth and survival of crabs. **Figure 6** shows some of the methods in the chromic oxide analysis of feeds and feces for the digestibility study. The apparent digestibility tests for dry matter, crude protein, and crude fat of RCF and CCF revealed that RCF was more efficiently digested by the experimental animals than CCF. The apparent dry matter digestibility (ADMD = 83.20 %), apparent crude protein digestibility (ACPD 93.70 %), and apparent crude fat (ACFD = 97.10 %) values for RCF were close to the levels in the crab reference diet formulated by Catacutan *et al*. (2003). Both the RCF and CCF exhibited considerably high percent stabilities even after 24 h of submersion in water. Since crustaceans such as crabs are slow-eating animals, a physically stable feed that can withstand being submerged in water for several hours without disintegration is a must (Obaldo *et al*., 2002).

Way Forward

Mussel meat meal and cholesterol were supplemented as means of refinement for the mangrove crab grow-out feed. The 100 % provision of refined crab feed enhanced the growth and survival of the experimental animals in land-based tanks. For a better understanding of the success of the tank study on the refinement of formulated diet for the mangrove crab culture, a similar study will be conducted in brackish water ponds using the same *Scylla serrata* species.

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