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Mangrove crab aquaculture practices and challenges: The case of Capalonga, Camarines Norte, Philippines

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Abstract

Mangrove crabs (*Scylla* spp.) are economically important aquaculture commodities and a source of livelihood, particularly in impoverished coastal communities. However, the aquaculture practices and challenges of small-scale mangrove crab farmers in poor coastal areas are often overlooked and poorly understood, exposing them to a higher risk of economic loss. This study assessed the current mangrove aquaculture practices and challenges in Capalonga, Camarines Norte. A mixed-method research approach combining descriptive surveys and focus group discussions was employed to gather data from all crab farmers (n=42) in the study area. Results showed that most participants, ages 30 to 70, were dominated by males (76%) and practiced only grow-out culture, with *Scylla serrata* as the preferred culture due to higher economic returns. Despite its economic potential, it is confronted with numerous challenges, including changes in weather conditions and natural disasters, disease outbreaks, limited technical knowledge, a lack of government intervention, and quality seed scarcity. These problems underscore the imperative need for targeted interventions such as the provision of training and technical support for the crab farmers, the establishment of a local hatchery, disease management, and the inclusion of the study's findings in local management plans to enhance the sustainability and profitability of mangrove crab aquaculture in Capalonga.

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Introduction

Mangrove crabs (*Scylla* spp.), locally known as "Kinis," "Putian," "Alimango," or "Bulik," are widely distributed and economically essential crabs associated with mangroves in the Indo-West-Pacific region (Macintosh *et al.*, 2002; Siahainenia *et al.*, 2016; Bhuiyan *et al.*, 2021). Among crab species, *S. serrata* is particularly preferred for aquaculture due to its rapid growth, hardiness, disease resistance, high market demand, and export potential (Radhakrishnan and Nair, 2015; Raghavan and Nair, 2016). These favorable characteristics of this species have led to a significant increase in both fishing and crab farming (Salam *et al.*, 2012; Jahan and Islam, 2016), particularly in the Philippines, where many fishers depend on crabs for their livelihood due to their significant economic importance in both domestic and foreign markets (Rodriguez *et al.*, 2007; Quinitio *et al.*, 2015; Castrence-Gonzales *et al.*, 2018). However, this growing interest has made the mangrove crab vulnerable to overfishing, as evidenced by declining harvests (Castrence-Gonzales *et al.*, 2018). While efforts are underway to breed them artificially, the primary source of crablets for aquaculture remains the wild due to limited hatchery supply (Vince-Cruz-Abeledo *et al.*, 2020).

In the Philippines, mangrove crabs are considered a vital economic resource and livelihood for many Filipino farmers in coastal areas, particularly in Southern Luzon and the Visayas, where production levels are high (Gabiota, 2017). Camarines Norte, a province in Southern Luzon with a long history of supplying high-quality crab seeds and live crabs (Fortes, 1999; Triño *et al.*, 1999; Ladra and Lin, 1992), is known for its abundance of mangrove crabs at all life stages, including instars, juveniles, and adults. This abundance is attributed to its strategic location at the center of three principal fishing grounds: San Miguel Bay, Lamon Bay, and the Philippine Sea facing the Pacific Ocean and a vast mangrove area measuring 5,460 ha (Gaillard, 2010). The province currently utilizes diverse farming practices in its ponds, including nurseries, fattening pens, polyculture with other species (e.g., milkfish, tilapia, grouper, shrimp, or prawn), and soft-shell crab production. However, despite its advantageous resources and status as a significant producer in the Bicol Region, pond production in Camarines Norte remains marginal and inconsistent, accounting for only 33.7% of the Bicol Region and a mere 0.54% nationally (Philippine Statistics Authority, 2023).

While numerous undertakings have been conducted regarding the mangrove crab industry in the province, most need to be updated. They generally focus on the whole province or specific parts near San Miguel Bay (Gaillard, 2010) and concentrate only on aspects of their capture fisheries (Nieves *et al.*, 2013; Nieves *et al.*, 2014). Meanwhile, the northern part of the province bordering Lamon Bay, such as Capalonga, needs to be better documented and is rarely touched by research.

Capalonga is a 3rd class coastal municipality in the northwestern part of Camarines Norte, surrounded by several marine water bodies such as Tanao Strait, Lamon Bay, and the Pacific Ocean. Capalonga's shoreline boasts one of the richest mangrove systems, with an approximate area of 2649 ha, in the Bicol Region, called Capalonga Mangrove Reserve, officially proclaimed under Presidential Proclamation No. 2152. The municipality possesses extensive brackish water and mangrove zones suitable for mangrove crab culture, serving as a livelihood source for the coastal communities.

However, information and documentation regarding aquaculture practices, production statistics, and challenges confronted by crab farmers still need to be improved and under-researched. Understanding these aspects is crucial for promoting sustainable practices, improving livelihoods, and optimizing production within the mangrove crab aquaculture sector. Hence, this present study aims to fill this knowledge gap by investigating the aquaculture practices and challenges in mangrove crab farming in Capalonga, Camarines Norte, Philippines.

Materials and methods

The study was conducted purposively in the mangrove crab farms in the municipality of Capalonga, Camarines Norte, from December 2022 to January 2023. Located at 14°10' to 14°22' latitude and 122°20' to 122°35' longitude, Capalonga experiences a Type II climate based on the Modified Coronas Classification, with a very pronounced wet season and no distinct dry season. Rainfall occurs all year round except during March when no rainfall is observed. Almost 90 percent of the typhoons that pass through the Philippine area of responsibility affect the area. The areas also possess coastal areas with extensive brackish water and mangrove zones (2,649 ha) suitable for the culture of mangrove crabs. The study employed a mixed-methods research design, including qualitative and quantitative approaches. For the quantitative component, the descriptive survey method utilizing a validated guide questionnaire and personal interview was administered to all 42 registered crab farmers identified by the Municipal Agriculture Office of Capalonga. The questions were centered on items such as mangrove crab species grown, type of production system and practices used, and income per cropping, and challenges met. The study participants are 30 to 70 years old, predominantly males (76%), with an average crab farming experience of 17 years. In the qualitative research design, a focused group discussion was used to clarify the issues and concerns regarding the production practices and challenges encountered in crab farming. The focused group discussion comprises growers, selected consumers, municipal agriculturists, and fish vendors.

The data collected were encoded, tabulated, and analyzed using thematic analysis (Aranson, 1993) to rank the problems, while descriptive statistics were applied to other data collected.

Results and discussion

Mangrove crab aquaculture practices

Most farmers (52%) in the area practice monoculture crab grow-out farming. Other farmers engaged in polyculture, raising other species of mangrove crab, such as Orange Mud crab (*Scylla olivacea* Herbst, 1796) (36%), or incorporating other aquaculture species (12%), such as shrimp, milkfish, and tilapia. However, among the two *Scylla* species, Giant Mangrove Crab (*Scylla serrata* Forskål, 1775) is the most preferred in the area, aligning with global trends (Quinitio, 2017). Its tolerance to lower temperatures and extended periods out of water makes it suitable for live export (Lalramchhani *et al.*, 2019). The mangrove crab seeds weighing 1 gram to 4 grams used in grow-out culture are collected mainly from the wild in the nearby mangrove forest using traps and pots or naturally entering the ponds. The mean stocking density is 1,754 crabs/ha, ranging from 200 to 5,000 crabs/ha. The farmers preferably stock their crabs before the rainy season due to lower salinity-related mortality and the risks of flooding and typhoons. Despite knowing the cannibalistic tendencies at high densities, farmers maximize stocking, believing it increases survival chances and may result in higher income. This practice is attributed to a lack of alternative options for surplus seeds, as selling them is prohibited by Fisheries Administrative Order No. 264, also known as Regulation on the Catching, Possession, Transporting, Selling, Trading and Exporting of Mangrove Crablets, Juvenile Mangrove Crabs and Gravid Mangrove Crabs (*Scylla* spp.). They also mentioned that they do not own other extra ponds to stock the crab surplus.

Prior to stocking, pond preparation is done at the start of cropping. The water in the fishpond was flushed out, so undesirable debris and dirt were removed, and the pond was sun-dried for 5-14 days or until the soil cracked. However, some farmers skipped sun drying since their ponds cannot be entirely flushed out due to the pond design. They also checked potential dike problems for repair and the drainage system. Several traps were placed in the pond to eliminate potential predators before stocking. Pond water was replenished twice a day during high tide and low tide. When the tide is low, the water is flushed out of the pond, and when the tide is high, the

water is permitted to enter the pond and is confined by the sluice gates. It should be noted that some farmers install coconut twigs and rock shelters from the sides of the pond to minimize the cannibalistic activities of the crabs. The installation of shelters aligns with the recommendation of Quinitio (2015) and Rahman *et al.* (2020) that mortality caused by cannibalism can be minimized by installing shelters in the pond.

Also, a few of them used ammonium phosphate (16/20/0) to encourage the growth of filamentous algae or "lumut" to serve as food for the stock and the polyculture species with the crabs. The crabs were mainly fed with fresh feeds such as trash fish (jacu), apple snails (golden kuhol), telescope snails (bagungon), and corn. The feeding frequency of the crabs varied and did not follow a standard feeding scheme ranging from daily to thrice a week at a rate of 3 to 5% wet-weight. Monthly feed consumption was estimated at a maximum of 100 kg of mixed feeds per hectare of pond. The mean survival rate estimated by farmers was 60%, ranging from 30% to 80% survival. It should be noted that farmers who installed shelters in the pond reported higher survival rates, up to 80%. The farmers did not practice monitoring crab growth to adjust the feeding rate. They feed as long as the crabs are eating. It was also observed that conditioning of the crabs before stocking was not practiced in the area. This observation is similar to that of the crab farmers in Teresita, Cagayan, Philippines (Manzano *et al.*, 2023).

The number of cropping varies from 1-4 cropping per year, but most farmers (81%) practiced 2-3 cropping per year. The cropping also varies, but most farmers start in March and end in September, ranging from 6 months to 1 year. The generation of income from aquaculture varies, either full-time or occasionally. A full-time basis refers to the day-to-day operations until the crabs are harvested. In contrast, an occasional basis refers to seasonal activities such as pond preparation, stocking, and harvesting, to name a few. The caretaker's wage for caring for the farm ranges from ₱1,500 to ₱3,000 monthly. However, some farm owners also assume the role of the caretaker or involve his/her family members for free to minimize the cost of hiring labor. The wife or children of the male operator or the owner of the pond engaged in some aquaculture activities (e.g., feeding, feed preparation, assistance during harvesting, among others) to support their business as it is located near their residences. The involvement of women is also documented on other aquaculture farms, where women play a role in aquaculture activities (Pandey and Upadhayay, 2012). Women also significantly contribute to selling their harvested crabs to contribute to household income. This finding agrees with the observation of Ndanga *et al.* (2013), where women play a significant role in fish vending and market negotiations. There is also an existing incentive system for harvest of about 5–50%, but it varies from farm to farm.

In harvesting the crabs, all farmers follow a complete harvesting procedure rather than partial harvesting. They replenish all their stock after harvesting. They used a crab lift net and crab pot to harvest their crab, which lasted for a few days. The method is laborious and challenging, as some farmers' ponds cannot be drained due to the pond design. The target marketable size for crabs is ≥500 g or two pieces per kg, amounting to ₱1000–1200 per kg. However, small and medium sizes were also harvested and sold for ₱300–350 and ₱500–650 per kilo, respectively. However, the prices of these sizes vary depending on the season and demand, as shown in Table 1. According to Gaillard (2010), mud crab prices increase during peak seasons such as holidays and local celebrations. Mangrove crab prices vary with markets, seasons, and supply and demand (Baliao *et al.*, 1999). The average harvest per cropping was 445 kg in the 1-hectare pond, yielding a net income of ₱154,827. The market distribution of harvested mangrove crabs is complex. They sold their harvest indirectly and directly to Capalonga Public Market, house-to-house selling in the barangay, intermediaries, and online platforms like Facebook.

Table 1. Size and prices per kilogram by season of mangrove crabs in Capalonga, Camarines Norte

Size	Weight (g)	Price range/kg (₱) by season	
		Off-Season	Peak Season
Large	≥500	1000	1200
Medium	≥350	500	650
Small	≥200	300	350

Challenges in mangrove crab aquaculture

The challenges encountered by the mangrove crab farmers in mangrove crab farming are shown in Table 2. Most crab farmers (98%) experienced problems with weather conditions and other natural disasters such as typhoons, droughts, floods, and heavy rainfall. The heavy rainfall and flooding in the area caused significant changes in the salinity of the pond water. There are also times when the pond water level is above the pond dike, causing the elimination of some crab stocks in the pond. This problem incurs high economic losses. In fact, in the mangrove crab farms in Sta. Teresita, Cagayan, flooding is also one of the significant problems of mangrove crab culture, causing changes in salinity and requiring proper layout design and structures to maintain the required water level (Manzano *et al.*, 2023; Southeast Asian Fisheries Development Center, 2016).

Table 2. Challenges met by mangrove crab farmers in Capalonga, Camarines Norte

Challenges met	% of crab farmers who encountered challenges
Changes in weather conditions and natural disasters	98
Cannibalism and other unknown cause	88
Limited technical knowledge	80
Lack of government Intervention	67
Availability of high-quality seed supply	50

Another significant challenge that most farmers encounter is cannibalism and the unknown cause of the mortality of crab stocks. According to the farmers, cannibalism happens during the molting or shedding of the crab's exoskeleton, making the early molted crabs vulnerable as prey for non-molted crabs. They also observed that cannibalism was often high during the shift from the rainy season to the wet season or vice versa when the temperature suddenly changed. According to Syafaat *et al.* (2021) and Bortolin *et al.* (2011), the temperature change contributes to a high chance of molting in mangrove crabs, indicating that temperature management is critical in aquaculture settings to optimize growth and health. Because of this, some farmers opt to install shelters to serve as hideouts for the molted crabs. This idea is patterned after the experiences of other crab farmers they met elsewhere.

Aside from cannibalism, 88% of the participants mentioned an unknown cause of mortality among the crabs. They described how the crabs become weak and do not eat or move. Some have observed white patches and colonies of white patches in their carapace. They also mentioned that this occurrence coincides with the polyculture of shrimp in their ponds. The disease might be a White Spot Syndrome Virus (WSSV). It can lead to severe mortality in mud crabs, particularly when they are cultured in proximity to infected shrimp populations (Gunasekaran *et al.*, 2018). However, robust information and further investigation should be needed to confirm this potential disease occurrence.

The limited technical knowledge of mangrove crab farming was perceived by 80% of the participants as a challenge. They mentioned that they must be aware of improved and effective aquaculture methods and best practices. Currently, they are still confined to traditional methods and personal experiences. This gap in knowledge makes farmers struggle to implement effective aquaculture practices, which contributes to inefficient farming and lower productivity in mangrove crab culture (Rahman *et al.*, 2020). Studies have shown that groups of farmers with less or no training experienced high mortalities in their culture systems (Mirera *et al.*, 2014). Trained farmers achieved 22% higher productivity than non-trained farmers in mangrove crab farming (Mahmud and Mamun, 2012). Hence, it is imperative to empower the farmers with the most recent technologies and best practices in aquaculture to minimize poverty and improve their financial and social welfare (Jiang, 2010).

Another challenge mentioned by more than half of the participants (67%) is the need for increased government intervention, such as marketing support, credit, transportation, and farm-to-market roads. Though some farmers receive government interventions, some still need to receive such interventions to improve their farm productivity. Other farmers emphasize that they are not reached by the government when there are existing trainings regarding mangrove crab farming since they are located in remote areas where communication is difficult. Also, their market is limited to the municipality and nearby barangays, where most of the harvested stocks were sold at a lower price to avoid continuous farm inputs to hold their stocks that may incur a high-profit loss. A study revealed that mangrove crab farmers face challenges due to inadequate government policies and support systems. It emphasized that with proper government intervention, farmers can access the needed resources and training to enhance their aquaculture practices and profitability (Mirera *et al.*, 2014).

Lastly, the availability of high-quality crab seed supplies all year round is another major challenge in mangrove crab farming in Capalonga. The farmers rely heavily on their single source of crab seeds from the wild because of the unavailability of hatcheries in the municipality and even the province. They also perceived that buying from crab hatcheries outside town incurs a high input cost compared to wild collection. Thus, research efforts should focus on developing low-cost mangrove crab technology to generate higher survival against cannibalism and minimize wild stock pressure (Rahman *et al.*, 2017). Research indicates that the natural availability of crab seeds is declining, leading to increased pressure on wild stocks. The absence of reliable hatchery production contributes to this challenge, making it difficult for farmers to access quality crab seeds for cultivation and threatening biodiversity and the sustainability of wild crab populations (Apine *et al.*, 2023; Islam *et al.*, 2023).

Conclusion

Mangrove crab aquaculture is an economically important livelihood in Capalonga, Camarines Norte, but it is hindered by numerous challenges that must be addressed. While farmers have primarily practiced a grow-out system in large-scale ponds, low technical knowledge, limited access to quality seed, and adverse weather conditions pose substantial barriers to increased productivity and profitability. Cannibalism and disease further complicate the industry, along with solid market constraints. Therefore, government support in the form of better infrastructure, extension services, and market development is imperative to understand the potential of mangrove crab aquaculture in the municipality. These constraints can be addressed through focused interventions to improve farmers' livelihoods and sustainably facilitate coastal resource management.

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