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Natural Feed Administration During Fattening Stage for the Growth of Mud Crabs (*Scylla* sp.) Under Different Rearing Systems

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ABSTRACT

Mud crab (*Scylla* spp.*)* aquaculture holds significant potential in supporting food security, economic growth, and ecological balance. This study aims to summarize various findings related to critical factors in mud crab farming, such as feed types, rearing systems, and stocking density, and their impact on productivity, feed conversion ratio (FCR), and economic profitability. The review highlights that trash fish feed at 15% of body weight yields optimal growth and feed efficiency due to its high protein content. Feed diversification, including stingray and janitor fish, offers promising results with reduced costs. Various rearing systems are employed, ranging from cages and earthen ponds to advanced technologies such as Recirculating Aquaculture Systems (RAS). Small bamboo floating cages demonstrate superior outcomes in growth and survival rates (SR). Mangrove habitats significantly enhance crab growth, while silvofishery systems provide a sustainable farming alternative. Optimal stocking density, such as 4 crabs/m², balances growth and production. Additionally, *Scylla serrata* exhibits the best growth rate compared to other species, particularly males. Innovations like soft-shell farming technology add economic value to the product. Overall, the success of mud crab aquaculture depends on the optimal combination of feed, rearing systems, and environmental management. This review offers strategic insights for developing efficient, sustainable, and economically viable crab farming practices.

INTRODUCTION

The cultivation of mud crabs (*Scylla* spp.) holds significant potential in supporting food security and economic development, particularly in coastal areas. Mud crabs, comprising various species such as *Scylla serrata*, *Scylla olivacea*, *Scylla paramamosain*, and *Scylla tranquebarica*, are highly valued for their economic importance, especially in the food industry and export markets (Adila *et al*., 2020; Usman *et al*., 2024; Permadi & Juwana, 2016; Gunarto *et al*., 2024). Beyond their economic value, mud crabs play a crucial role in maintaining the balance of mangrove ecosystems, which serve as habitats for various marine species and act as natural barriers against coastal erosion. These economic and ecological benefits position mud crab aquaculture as a strategic sector for sustainable coastal development (Natan, 2014).

However, achieving optimal production in mud crab aquaculture involves addressing several challenges. Key factors, such as feed type, maintenance systems, stocking density, and crab species, significantly influence growth, survival rate (SR), and economic efficiency (Akbar *et al*., 2023; Putri *et al*., 2024; Andayani *et al*., 2022). Proper feeding practices, for instance, can enhance growth and improve product quality, while excessive stocking density may compromise crab health and increase mortality rates (Herlinah *et al*., 2017; Hanif & Herlina, 2021; Putri *et al*., 2014; Pasi *et al*., 2022; Sayuti *et al.*, 2012). Consequently, research on these factors is essential to develop more efficient cultivation methods.

Previous studies have explored various approaches to improve the efficiency and productivity of mud crab farming. Notable innovations include the use of protein-rich trash fish-based feed and the development of more efficient and eco-friendly maintenance systems, such as floating cages, battery systems, and Recirculating Aquaculture Systems (RAS) (Adila *et al*., 2020; Suryono *et al*., 2016; Maulana *et al*., 2012; Natan, 2014; Imbuk *et al*., 2022). Furthermore, selecting suitable habitats, such as mangrove environments (Suryono *et al*., 2016), is critical to ensuring the success of aquaculture practices. Considering the high operational costs, there is an urgent need for cost-effective and sustainable feeding technologies and maintenance systems to enhance the competitiveness of the industry.

In addition to feed and maintenance systems, local feed diversification and the application of advanced aquaculture technologies, such as soft-shell farming, are key priorities for increasing production value. Locally available and affordable feed options can reduce dependency on costly imported feeds, thereby lowering production costs. Moreover, soft-shell farming technology, which enables the cultivation of crabs with soft shells (Agustiyana *et al*., 2024), presents an opportunity to produce high-value products favored by the market. This study aims to summarize findings on the cultivation of Scylla spp. mud crabs, focusing on key species and examining the relationship between cultivation factors and optimal production outcomes. The insights from this review are expected to provide valuable guidance for developing more efficient, sustainable, and economically viable strategies for mud crab aquaculture.

METHODS

This review utilizes articles derived from experimental studies, observational research, literature reviews, technical reports, and conference proceedings. The subject of this study focuses on mangrove crabs (*Scylla* spp.) during the fattening stage, with a particular emphasis on the use of natural feed. The variables examined include species of mangrove crabs, natural feed types, maintenance systems, growth performance, feed conversion ratio (FCR), and economic impact.

The study includes research conducted in Indonesia and internationally, with relevance to the local context. Articles reviewed were written in both English and Indonesian, following a similar approach to previous studies (Aeni & Diamahesa, 2024; Aulia & Diamahesa, 2024; Yusrin & Diamahesa, 2024; Diamahesa & Affandi, 2024; Maudina & Diamahesa, 2023). Publications were selected from the last 15 years (2010–2024). International databases used in this review include Scopus, ScienceDirect, PubMed, and Web of Science. Local and national sources include SINTA-indexed national journals, technical reports, and university repositories. Additional sources such as Google Scholar, local conference proceedings, and fisheries research institution publications were also utilized. Keywords employed in the search included "Mangrove crab fattening feed Indonesia," "*Scylla* spp.," and "crab feed efficiency FCR."

The selection process began with an initial screening of titles and abstracts to meet inclusion criteria. This was followed by a full-text evaluation for final selection. Extracted information included crab species, natural feed types, maintenance systems, growth performance, FCR, and economic impact. The measured variables comprised FCR, growth performance, and economic outcomes.

RESULTS AND DISCUSSION

Table 1. Natural Feed Provision for Mangrove Crab (*Scylla* spp.) in Various Rearing Systems

Crab Species	Crab Size	Feed Type	Rearing System	Results	Reference
Scylla serrata	200 g	Trash fish (5%, 10%, 15%)	Cage (1 x 1 x 1 m³) (15 days)	Feeding 15% trash fish yielded the best results: GR: 77.37 g, SR: 92%, FCR: 7.39	Adila *et al.*, 2020
Scylla serrata (female)	110 g	Trash fish	Mangrove and non-mangrove systems (1 month)	The best location was mangroves with a density of 4 crabs/m² (biomass increase: 81.7 g)	Suryono *et al.*, 2016
Scylla serrata	150-210 g	Tilapia (*Oreochromis mossambicus*) (5%, 10%, 15%)	Battery system (28 days)	Feeding 15% tilapia resulted in the best growth performance	Maulana *et al.*, 2012
Scylla serrata (Male and Female)	100-325 g	Trash fish and small crabs	Bamboo cages (4 months)	Male growth rate was higher than females	Natan, 2014
Scylla serrata	100-110 g	Stingray (*Taeniura* sp.) and sardines (*Sardinella* sp.)	Plastic cages (30 days)	Stingray feed provided the best SR and growth	Imbuk *et al.*, 2022
Scylla serrata (female)	204 g	Minced tilapia	Earthen pond system and bamboo compartment system	Bamboo compartment system produced better outcomes than earthen ponds	Begum *et al.*, 2009
Scylla serrata	225 g	Trash fish	Wooden mesh and plastic containers	SR was the same, but economic	Lopulalan *et al.*, 2021

Crab Species	Crab Size	Feed Type	Rearing System	Results	Reference
				benefits favored wooden mesh	
Scylla olivicea	200 g	Trash fish	Silvofishery	Best SR and growth achieved with feeding frequency of 1-2 times daily	Karim *et al.*, 2019
Scylla olivicea (Male and Female)	150-200 g	Beef liver, tilapia, squid, clam meat	Recirculating aquaculture system (RAS) with vertical crab house	Crabs grew well in RAS over a short duration	Usman *et al.*, 2024
Scylla sp.	82 g	Yellow mackerel (trash fish)	Apartment system	Produced soft-shell crabs with an R/C ratio of 1.21	Agustiyana *et al.*, 2024
Scylla sp. (male)	200 g	Suckermouth catfish (*Pterygoplichthys* spp.) (5%, 10%, 15%, 20%)	Bamboo enclosure (180 x 40 x 50 cm^3) (1 month)	Optimal dose: 20%, with weight gain of 21.8 g, SGR: 1.28, protein content: 67.89%	Wamnebo *et al.*, 2022
Scylla paramamosain	115-500 g	Trash fish (10%, 15%, 20%, 25%)	Bottom net cage (5 x 5 m^2) (13 days)	Feeding 15% trash fish produced the best growth results	Permadi and Juwana, 2016
Scylla tranquebarica (female)	0.116 g	Trash fish	Layered pond (90 days)	Densities of 1 and 4 individuals/m^2 resulted in better growth compared to 8/m^2	Gunarto *et al.*, 2024

Based on the review summarized in Table 1, it can be seen that feed type is a key factor in the success of crab aquaculture. Most studies we reviewed used trash fish as the main feed, yielding optimal results, particularly at a dosage of 15% of body weight (Adila *et al*., 2020; Maulana *et al*., 2012; Permadi and Juwana, 2016). This is attributed to the high protein content of trash fish, which ranges from 50% to 72% (Diamahesa *et al*., 2024; Fauzi *et al*., 2008; Gultum, 2020). This high protein value supports optimal growth and enhances crab metabolism efficiency.

In addition to trash fish, stingray (*Taeniura sp.)* has been used as crab feed, producing better survival rates (SR) and growth performance compared to trash fish under a plastic cage system (Imbuk *et al*., 2022). This indicates that diversifying feed types can improve aquaculture performance. The study was conducted over 30 days, involving 12 adult crabs (100–110 g) placed individually in compartments and fed at 10% of their body weight. Results showed that stingray feed led to significantly higher weight gain during the first 10 days

($p>0.05$), though this advantage diminished by the end of the study. Specific growth rates (SGR) were significantly higher in crabs fed with stingray (0.25 ± 0.20%/day) compared to trash fish (-0.70 ± 0.27%/day) over 30 days, though survival rates were unaffected by the feed ($p<0.05$). The study noted issues such as cheliped disintegration, which likely affected crab weight. While stingray shows promise as a sustainable fattening feed, further research is recommended to confirm these findings.

A combination of feeds such as beef liver, tilapia, squid, and clam meat proved effective in Recirculating Aquaculture Systems (RAS) (Usman *et al*., 2024), demonstrating crabs' flexibility in utilizing high-quality feed sources. The study discussed major challenges in mangrove crab (*Scylla olivacea*) aquaculture, including long maintenance periods, limited farming space, and water quality issues, which were mitigated by using RAS technology. The RAS setup involved 20 L water gallon containers arranged vertically on racks with gravity-fed water flow and filtration units consisting of charcoal, coral stones, sand, and seaweed. The study tested different feed types—beef liver, tilapia, squid, and clam meat—on the growth and survival of mangrove crabs. Results showed that feed type did not significantly affect growth or survival rates for either male or female crabs. The study concluded that the RAS design is effective for short-term mangrove crab aquaculture in limited spaces, ensuring good water quality.

Local feed such as suckermouth catfish (*Pterygoplichtis spp.),* used at a 20% dosage, was shown to increase absolute weight gain up to 21.8 g due to its high protein content (Wamnebo *et al*., 2022). More specifically, the experiment tested four treatments with three replications each: Treatment A (5% feed dosage), B (10%), C (15%), and D (20%). The best results were obtained in Treatment D (20% feed dosage), yielding an 84% survival rate, 21.8 g absolute weight gain, 1.280 g specific growth rate (SGR), and the highest body chemical change at 67.89 g. These results support the use of more economical local feed options.

Different maintenance systems exhibit varying advantages depending on environmental conditions and farming management. The review in Table 1 highlights that small cage systems (1x1x1 m^3) and earthen ponds, using an optimal 15% dosage of trash fish, produced the highest growth rate (GR) of 77.37 g and a survival rate (SR) of 92% in a short period (15 days) (Adila *et al*., 2020). Floating bamboo compartments outperformed earthen ponds by providing better oxygen access and waste management (Begum *et al*., 2009). The natural habitat of mangrove crabs is in mangrove environments, which support crabs by providing natural shelter and additional food sources, leading to biomass growth of up to 81.7 g with a stocking density of 4 crabs/m^2 (Suryono *et al*., 2016).

Another system used is the apartment system (Sukardi *et al*., 2024). Crab farming in the apartment system has long been developed to enhance aquaculture production in controlled environments. Hastuti *et al*. (2020) emphasized the importance of shelters in increasing the production of mangrove crabs (*Scylla serrata*) in RAS. Shelters reduce mortality from cannibalism and lower stress levels. Conducted in 60 L culture boxes with a density of 10 crabs each, the study tested four treatments: no shelter (control), two shelters (S2), four shelters (S4), and six shelters (S6). S6 treatment yielded the best results, achieving a 73.33% survival rate, 0.886% specific growth rate, 0.024 cm/day carapace width growth rate, and the lowest feed conversion ratio. It also significantly increased the total hemocyte count at the start of cultivation, highlighting the importance of optimal shelter density in improving mangrove crab aquaculture. Economically, the apartment system enables the production of soft-shell crabs with good profitability (R/C ratio of 1.21) (Agustiyana *et al*., 2024). The RAS offers spatial efficiency and environmental management, though it is only suitable for short-term cultivation (Usman *et al*., 2024).

Regarding stocking densities, research by Gunarto *et al*. (2024) showed that stocking density in brackish water ponds significantly affects growth, survival, and crab production. The study aimed to determine the optimal stocking density for *Scylla tranquebarica* juveniles in layered ponds to support the soft-shell crab industry. Over 90 days, three stocking densities (1, 4, and 8 crabs/m²) were tested, with crabs fed low-value fish (*Leiognathus equula*) starting at 100% of total body weight, gradually reduced to 3%. Lower densities (1 and 4 crabs/m²) showed better growth and daily performance compared to the highest density (8 crabs/m²), where deformities were more common. A moderate density of 4 crabs/m² provided a balance of survival, efficient feed conversion, and the highest production (19.65 ± 0.10 kg/100 m²), yielding a net income of USD 6,845.60 per hectare for two harvests annually. Therefore, a stocking density of 4 crabs/m² is recommended for effective pond-based rearing due to lower competition and stress.

Overall, *Scylla serrata* exhibits the best growth rates among species in various maintenance systems, particularly with males showing faster growth than females (Natan, 2014). Specifically, Natan (2014) studied growth rates of undersized crabs caught by fishermen in Wael waters through fattening. Male and female crabs weighing 100–325 g were separated into individual bamboo cages, each containing 15 individuals. Over four months, growth remained exponential, with males gaining an average of 532.3 g per individual and females 499 g. These results suggest that female growth is slower than males, and fattening could continue as growth had not plateaued.

In silvofishery systems, mangrove crab aquaculture can be conducted alongside mangroves, utilizing their resources without damaging the ecosystem. Research in Pangkep, South Sulawesi, aimed to determine efficient and effective feeding frequencies for fattening mangrove crabs while maintaining silvofishery patterns. Using 200 ± 10 g male crabs reared in bamboo cages within mangrove areas, trash fish was fed at 10% of the crab biomass. Results showed that feeding frequency significantly affected crab stability and growth ($p<0.01$). Feeding once or twice daily provided optimal SR and growth (Karim *et al*., 2019).

Aside from biological aspects, economic profitability is a crucial consideration in evaluating crab aquaculture. Technologies such as wooden nets are more cost-effective than plastic containers without affecting SR (Lopulalan *et al*., 2021). Additionally, diversifying local feeds like suckermouth catfish can reduce operational costs without compromising production (Wamnebo *et al*., 2022).

CONCLUSION

The success of *Scylla* spp. crab farming is influenced by the optimal combination of feed type, husbandry system, and stocking density management. Approaches that consider feed efficiency, habitat diversification, and innovations in farming systems offer opportunities to enhance productivity and sustainability. Strategies based on local feed resources and modern farming technologies can also improve cost efficiency, leading to higher economic returns.

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