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Research Article

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Effects of Seed Transfer Distance on Production Success of Mud Crab (*Scylla serrata*) in Recirculating Aquaculture Systems

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Abstract

Mud crab (*Scylla serrata*) culture using recirculating aquaculture systems (RAS) with vertical crab boxes offers a sustainable model for urban aquaculture, particularly in land-limited coastal cities such as Jakarta, Indonesia. However, the dependence on wild-caught seeds from surrounding mangrove areas raises production costs and may affect seed quality due to variations in transport distance and handling. This research evaluated the production and economic performance of mud crab culture in RAS vertical boxes using seeds sourced from three coastal regions: Tangerang, Bekasi, and Subang, which represent different transfer distances. Ninety crabs (60–120 g/crab) were individually reared for 30 days following a completely randomized design with three treatments and three replications. Growth parameters (survival rate, daily growth rate, molting percentage, and feed conversion ratio) and profitability indicators (cost of goods sold, revenue cost ratio, and payback period) were analyzed. Production performance did not differ significantly among seed sources ($p > 0.05$), with survival rates ranging from 50–73% and daily growth rates from 0.60–0.69 g/day. Nevertheless, profitability varied markedly: culture using Tangerang-sourced seeds achieved the highest economic return (profit = USD 153.4/year; R/C = 1.3; payback period = 6.8 years), while Subang-sourced seeds resulted in financial loss, primarily due to prolonged transport and lower seed vitality. Seed source influenced economic outcomes but not biological productivity. Shorter transfer distances and improved seed handling practices enhance profitability. Developing hatchery-based seed production is essential to strengthening the sustainability of urban mud crab aquaculture.

Keywords RAS, *Scylla serrata*, Seed source, Urban aquaculture, Vertical crab box

Mud crab (*Scylla serrata*) is one of the most economically valuable crustaceans in tropical and subtropical regions due to its rapid growth, high meat quality, and strong market demand for both live and soft-shell products (Waiho et al., 2021). The species contributes significantly to coastal livelihoods and export earnings across the Indo-Pacific, particularly in countries such as Indonesia, the Philippines, and Vietnam (FAO, 2023). Indonesia ranks among the top producers of mud crabs globally, with production reaching more than 20,000 tons annually, supported by domestic consumption and international demand from China, Singapore, and Malaysia (MMAF, 2022).Aquaculture innovations such as recirculating aquaculture systems (RAS) combined with vertical crab boxes have been introduced to enhance productivity and environmental efficiency (Usman et al., 2024). These systems allow individual rearing of crabs, effectively reducing cannibalism, improving survival, and optimizing limited space in urban settings. Moreover, RAS minimizes water use and effluent discharge, making it a sustainable model for urban aquaculture, particularly in densely populated areas like Jakarta, where land and clean water are scarce (Agustiyana et al., 2024).Seed supply remains the primary constraint in scaling mud crab aquaculture. The sector still dependson capture-based aquaculture,where juveniles are collected from

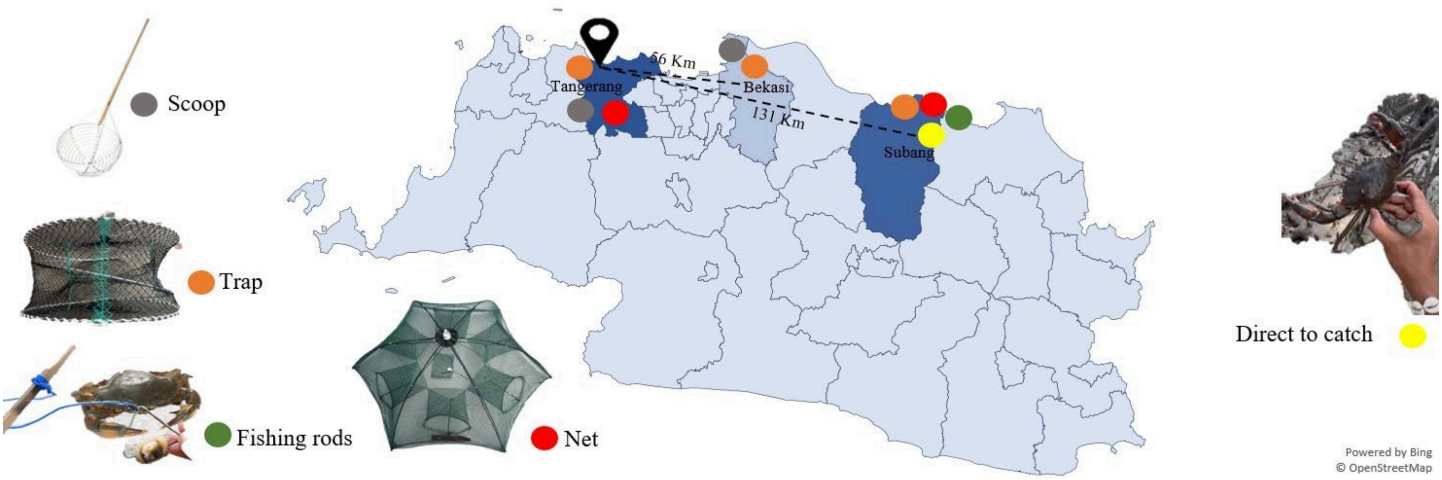

Figure 1. Location of mud crab seed sources from Tangerang, Bekasi, and Subang Regency with various fishing tools

mangrove ecosystems and stocked for grow-out (Shelley & Lovatelli, 2011). However, mangrove degradation and overharvesting have led to declining seed availability and smaller seed sizes (Hayati et al., 2025). In Jakarta, urban mud crab aquaculture relies on seeds from nearby coastal regions such as Tangerang, Bekasi, and Subang Regency. Variations in distance, handling, and transport duration can affect seed vitality, survival, and growth performance during culture (Paran et al., 2022).

Several research results show that soft shell mud crab product type is more profitable, has a higher selling price, a shorter rearing period, relatively less feed usage, and brighter business prospects (Waiho et al., 2021; Agustiyana et al., 2024). Various efforts have been made to improve the production and culture of mud crabs by increasing the frequency and percentage of molting (Waiho et al., 2021). Given these challenges, this study aimed to evaluate the production and economic performance of mud crab cultured in RAS vertical boxes using seeds from different coastal sources. The results are expected to provide insights for optimizing seed sourcing strategies, improving profitability, and strengthening the sustainability of urban mud crab aquaculture systems in Indonesia.

MATERIALS AND METHODS

Time and location

This research was conducted from February to July 2023 during the dry season. The location of mud crab rearing in vertical boxes with RAS was carried out at the IPB Fisheries and Marine Observation Station (IFMOS), Ancol, North Jakarta, DKI Jakarta. Field observations, interviews, and focus group discussions with fishermen and mud crab collectors were conducted in Pakuhaji District, Tangerang Regency, Muaragembong District, Bekasi Regency, and Blanakan District, Subang Regency in Indonesia.

Research design

This research consists of two parts, namely: 1) a survey of the location of the seed source for observation, interviews, and focused group discussions with fishermen and mud crab collectors, and 2) the experiment followed a completely randomized design (CRD) consisting of three treatments based on seed source (Tangerang, Bekasi, and Subang), each with three replications. A total of 90 mud crabs (*S. serrata*) with an initial weight of 60-120 g were used, with 30 crabs allocated per treatment and 10 crabs per replication. Each crab was reared individually in a separate vertical crab box connected to a RAS unit. Data from the 10 boxes within each replication were averaged for analysis. The location of the seed source was designed as follows: Tangerang and Bekasi are regencies bordering Jakarta, so they have a relatively close distance and a relatively short travel time (1–2 hours), while Subang Regency is the furthest (2–3 hours) using land transportation (Figure 1).

Survey techniques

A survey was conducted in three seed-source regions Tangerang, Bekasi, and Subang Regency to obtain an overview of the capture, collection, and distribution (supply chain) of mud crabs in the field. Data were collected through structured interviews and focus group discussions (FGDs) involving 45 respondents, including crab collectors, fishermen, and local traders. The interviews followed a semi-structured format with a standardized questionnaire covering socioeconomic characteristics, seed handling, and mortality during transport, and market prices. FGDs were conducted to validate and triangulate the information gathered from individual interviews. Respondents of fishermen and crab collectors were determined by purposive sampling according to Rai & Thapa (2015). All responses were coded and analyzed using descriptive statistics and thematic analysis to identify recurring patterns and factors affecting seed quality and cost. Ethical considerations were observed by ensuring voluntary participation, confidentiality of responses, and informed consent from all participants prior to data collection.

Rearing Techniques

Mud crabs measuring initial weight 60-120 g, as many as 90 crabs came from fishermen and crab collectors in Pakuhaji Tangerang, Muaragembong Bekasi, and Blanakan Subang, with 30 crabs from each source. The distances from Pakuhaji Tangerang, Muaragembong Bekasi, and Blanakan Subang to the respective rearing locations were 40, 56, and 130 km. Although the fishing techniques varied among the three regions (baited traps in Tangerang, lift nets in Bekasi, and bamboo traps in Subang), only active and undamaged mud crabs within a uniform size range of 60-120 g were selected as seed stock. Crabs exhibiting missing appendages, injuries, or lethargic behavior were excluded to minimize bias related to capture stress. The selection process ensured that all treatments began with comparable initial size composition and vitality, reducing potential effects of the different capture methods. Mud crabs were transported to the research location dry, in plastic baskets measuring 48 cm × 35.5 cm × 16.5 cm with a moisturizer cloth on the bottom, using land transportation. Upon arrival at the rearing location, the mud crabs were acclimatized by splashing 25 g/L brackish water for 15 minutes and soaking in the brackish water for one hour, then placed in a rearing vertical box measuring 20 cm × 33 cm × 18 cm and equipped with RAS (Figure 2).

Mud crab rearing consists of a 1,000 L main reservoir connected to 90 individual vertical crab boxes (each measuring 40 cm × 25 cm × 30 cm) via PVC pipes. The system is equipped with a mechanical filter (sponge and filter mat), a biological filter (bio-ball media), and an aeration unit supplied by an air blower. Water circulation is maintained continuously at a flow rate of approximately 1.5 L/min per box, ensuring complete recirculation of the system's water once daily. Mud crabs were fed once daily 5–7% of body weight per day, using chopped trash fish at satiation once in the afternoon (4.00–5.00 p.m.). The exact feeding rate was estimated based on the average biomass of crabs per treatment and adjusted weekly according to observed consumption and leftover feed. The amount of feed consumed by mud crabs was calculated from the amount of feed given minus the amount of remaining feed from siphoning the water of the rearing media. Molting observations were carried out every day, and every 14 days, all crabs were measured for length and weighed using a digital scale with an accuracy of 0.01 g.

Figure 2. Mud crab rearing in vertical boxes with recirculating aquaculture systems (RAS) was carried out at the IPB Fisheries and Marine Observation Station (IFMOS) Ancol, North Jakarta, DKI Jakarta

Mud crabs were fed once daily 5–7% of body weight per day, using chopped trash fish at satiation once in the afternoon (4.00–5.00 p.m.). The exact feeding rate was estimated based on the average biomass of crabs per treatment and adjusted weekly according to observed consumption and leftover feed. The amount of feed consumed by mud crabs was calculated from the amount of feed given minus the amount of remaining feed from siphoning the water of the rearing media. Molting observations were carried out every day, and every 14 days, all crabs were measured for length and weighed using a digital scale with an accuracy of 0.01 g. In the RAS vertical box system, uneaten feed and feces were siphoned from each crab box daily between 07:00 and 09:00 WIB to maintain water quality. Water temperature, pH, salinity, and dissolved oxygen were measured in situ in each box, while total ammonia nitrogen (TAN), nitrite, nitrate, and alkalinity were analyzed ex situ every seven days. Water samples were analyzed at the Aquaculture Environmental Laboratory, Department of Aquaculture, IPB University (Table 1).

Table 1. Physical chemistry of water in the rearing media for mud crabs (*Scylla serrata*) in vertical boxes with RAS for 30 days

Parameter	Value Range	Optimum Range *
Temperature (°C)	28.1–29.2	25–35°C
pH	7.3–8.4	7.5-9.0; <0.5 variation diurnally
DO (mg/L)	3–6.3	≥5 mg/L
Salinity (g/L)	26–29	10–35 g/L
TAN (mg/L)	0.32–0.52	<3 mg/L
Nitrite (mg/L)	0.083–0.104	<10 mg/L on salinity >15 g/L
Nitrate (mg/L)	0.087–0.1	0.09–3.5 mg/L
Alkalinity (mg/L)	80–93	>80 mg/L (Ideally 120 mg/L)

*Shelley & Lovatelli (2011)

Production performance

The production performance measured includes survival rate (SR), daily growth rate (DGR), molting speed and percentage, and feed conversion ratio (FCR). SR in percent is calculated using the SR formula. = $(\frac{(\mathrm{Nt})}{(\mathrm{N})_{\mathrm{b}(0)}})$ × 100, Nt and No are the number of crabs at the end and beginning of rearing (crab), respectively. DGR in g/day is calculated using the DGR formula = $\frac{(\mathrm{Wt\ x\ W0})}{(\mathrm{t})}$, where Wt and W0 are the average weights at the end and beginning of rearing (g), respectively, and t is the length of rearing (days). FCR is calculated using the FCR formula = $(\frac{(\mathrm{F})}{((\mathrm{Bt}-\mathrm{B0}))(+\mathrm{D})})$ with F being the amount of feed consumed (g), Bt and B0 being the biomass of crabs on day t and day 0, respectively (g), and D being the weight of dead crabs (g). Molting of mud crabs was observed every day to calculate the molting percentage (MP) using the formula MP = $(\frac{(\mathrm{Nt})}{(\mathrm{N})_{(0)}})$ × 100, where Nt and No respectively the number of molts at the end and the beginning of the rearing period (crab).

Profitability analysis

Production performance indicators including survival rate, molting percentage, soft-shell crab yield, and size distribution were directly obtained from the 30-day experimental results. These empirical values were then used as inputs for the profitability analysis. Profitability analysis is calculated by the cost of goods sold (CGS), the ratio of revenue and total costs (revenue/cost, R/C), and the length of return on capital (payback period, PP). CGS calculates CGS in USD/crab= MP = $\frac{\mathrm{Total\ cost\ (USD)}}{\mathrm{Total\ production\ (Crab)}}$, R/C calculated with formula R/C = MP = $\frac{\mathrm{Total\ revenue\ (USD)}}{\mathrm{Total\ cost\ (USD)}}$,), while PP is calculated using the formula PP (years) = MP = $\frac{\mathrm{Investment\ cost\ (USD)}}{\mathrm{Profit\ (USD)}}$. All parameters used in the profitability analysis including survival rate, molting percentage, and soft-shell crab yield were obtained directly from the 30-day RAS culture experiment. These empirical data served as input values for calculating production cost, revenue, and profit margin for each seed source treatment.

Sensitivity analysis

A sensitivity analysis was carried out to evaluate how changes in key production and cost parameters affect the economic performance of mud crab (*Scylla serrata*) culture in RAS vertical boxes. The analysis used the empirical baseline values reported in Table 5 consist of investment, fixed and variable costs, product weights and prices, survival rate, and molting percentages as the reference scenario. Baseline (observed) values taken directly from Table 5, survival rate is increased to 100% while all other biological parameters molting percentage, percentage product types, weight gains per category are held constant at their observed values. This isolates the effect of improved survival on revenue and profitability. The feed component of variable costs is increased by 50%; production output (product weights and composition) is held constant, so revenue is unchanged and only costs increase.The feed component of variable costs is decreased by 50%; again production output is held constant so revenue is unchanged and only costs decrease. All scenarios assume the currency conversion 1 USD = IDR 16,309 for consistency with the baseline data.

Data analysis

Data on survival rate (SR), daily growth rate (DGR), feed conversion ratio (FCR), and molting percentage were analyzed using one-way analysis of variance (ANOVA) with a 95% confidence interval to evaluate differences among seed source treatments (Tangerang, Bekasi, and Subang). Prior to ANOVA, data normality and homogeneity of variance were verified using the Shapiro–Wilk and Levene's tests, respectively. When significant differences were detected ($p < 0.05$), means were compared using Tukey's Honestly Significant Difference (HSD) post-hoc test. Economic parameters, including cost of goods sold (COGS), revenue–cost ratio (R/C), and payback period (PP), were analyzed descriptively to compare trends among treatments. Statistical analyses were conducted using Microsoft Excel 2010 and IBM SPSS Statistics version 25.0. Results are presented as mean ± standard deviation.

RESULTS AND DISCUSSION

Mud crab habitat and supply chain

Tangerang Regency has eight coastal sub-districts, one of which is Pakuhaji Sub-district, which had a mangrove forest area of 487.5 ha in 1996 and is estimated to be only 182.14 ha now (Marlianingrum et al., 2021). In the Pakuhaji Sub-district itself, there are 130 ha of mangrove forest spread across four villages, namely Kohod, Kramat, Sukawali, and Suryabahari Villages, half of which have moderate density, and the rest have dense and sparse density. The existence of mangrove forests in this sub-district is threatened by the high rate of development, especially housing and industry, due to its proximity to the metropolitan city of Jakarta (Haryanti et al., 2020; Mahardika et al., 2022; Nufus, 2025). Based on information from respondents in the Pakuhaji Sub-district, there are around 100 fishermen catching mud crabs and swimming crabs, with around 10 collectors, most of whom are small (Table 2). Bekasi Regency still has coastal areas of mangrove forests, especially in Muaragembong District, which are in worrying conditions. Some of the mangrove forest areas have been converted into fish farms, industry, and settlements and have shrunk due to coastal abrasion, which in 2020 was estimated to be only 1,028.64 (9.81%) of the 10,481.15 ha when it was designated as a protected forest area (Nugraha et al., 2019; Suryadi et al., 2021). In Muaragembong, around 20 fishermen and three collectors catch mud crabs. Subang Regency has a mangrove forest area of 7,345 ha, and around 131.7 ha is located in Blanakan District. The mangrove forest area in this district has been converted into fish farms and other uses (Asy'ari et al., 2023). Blanakan District has around 90 fishermen catching mud crabs and four collectors.

The natural habitat of mud crabs is the mangrove forest area. Generally, fishermen catch mud crabs using traps, scoops, nets, fishing rods, and various fishing methods. Traps are a standard tool for catching mud crabs, such as in the Tangerang Regency. The operation of this tool is relatively simple and does not require much labor (Limbong, 2020). This fishing activity consists of installing and placing fishing gear and then checking it after being placed overnight. The caught mud crabs are immediately tied by their claws and walking legs, then taken to be sold to collectors. The size of the crabs caught is 30-200 g/crab, relatively small, and based on information from respondents, the size of those caught tends to continue to decrease. Collectors collect these mud crabs until they reach an economical transport scale in baskets, styrofoam boxes, plastic drums, or sacks. The storage period is around 1-5 days, and during that time, the crabs are watered with brackish water to maintain the humidity of the gills. The storage capacity of each collector ranges from 10-100 kg/day, depending on the fishermen's catch. Collectors generally sell the crabs to Jakarta using land transportation modes such as motorbikes or pick-up trucks, usually together with the transportation of other fishery products. Collectors sell mud crabs to collectors in Jakarta or directly to seafood restaurants. The natural habitat of mud crabs is the mangrove forest area. The conversion of mangrove areas into aquaculture ponds has resulted in these ponds functioning as secondary habitats where mud crabs.

Traps (*bubu* or net) are a standard tool for catching mud crabs, such as in the Tangerang Regency. The operation of this tool is relatively simple and does not require much labor (Limbong, 2020). This fishing activity consists of installing and placing fishing gear and then checking it after being placed overnight. The caught mud crabs are immediately tied by their claws and walking legs, then taken to be sold to collectors. The size of the crabs caught is 30-200 g/crab, relatively small, and based on information from respondents, the size of those caught tends to continue to decrease. Collectors collect these mud crabs until they reach an economical transport scale in baskets, styrofoam boxes, plastic drums, or sacks. The storage period is around 1–5 days, and during that time, the crabs are watered with brackish water to maintain the humidity of the gills. The storage capacity of each collector ranges from 10-100 kg/day, depending on the fishermen's catch. Collectors generally sell the crabs to Jakarta using land transportation modes such as motorbikes or pick-up trucks, usually together with the transportation of other fishery products. Collectors sell mud crabs to collectors in Jakarta or directly to seafood restaurants.

The price of mud crabs at the collector level depends on the size of this commodity, ranging from USD 18.39 to USD 42.92/kg. There are three sizes of mud crabs marketed to Jakarta, namely less than 100 g/crab, between 100 and 150 g, and above 150 g/crab The larger the size of the mud crab, the higher the price. The collectors' desire for the size exceeds 150 g/crab because consumers desire it. It is already challenging to get mud crabs measuring above 350 g/crab, let alone above 500 g/crab at the research location, due to intensive fishing so far to meet the needs of mud crabs for seafood restaurants and hotels in Jakarta and the Jabodetabek metropolitan area (Jakarta, Bogor, Depok, Tangerang, and Bekasi). Although seed crabs were standardized by size and condition prior to stocking, local differences in capture techniques may still have influenced initial vitality. However, the absence of significant differences ($p > 0.05$) in survival and growth among seed sources suggests that capture method effects were minimal under the controlled RAS rearing conditions.

The results of this research showed that the production performance of mud crab culture in RAS vertical boxes did not differ significantly among seed sources from Tangerang, Bekasi, and Subang ($p > 0.05$), with survival rates ranging from 50-73% and daily growth rates between 0.60-0.69 g/day. These values are slightly lower than those reported by Usman et al. (2024), who achieved survival rates above 80%

Table 2. Location condition of the source of mud crab seeds in Bekasi, Tangerang, and Subang. 1 USD = IDR 16,309

Parameter	Seed Source Location		
	Tangerang	Bekasi	Subang
Number of Fishermen	100 fishermen	20 fishermen	90 fishermen
Number of Collectors	10 people	3 people	4 people
Fishing Habitat	Pond and mangroves	Pond	Pond
Fishing Gear	*Bubu*, scoop, net	*Bubu*, scoop	*Bubu*, net, fishing rods, direct to catch
Time of Catch	5 a.m. to 5 p.m. or vice versa for installation and checking	8 or 10 p.m. installation of the trap, 7 a.m. checking	7 to 12 a.m. or 5 p.m., 9 p.m. to 1 a.m.
Organs Tied	Claws	Claws and walking legs	Claws and walking legs
Duration of Storage	1–2 days	1–3 days	1–5 days
Storage Container	Baskets, styrofoam boxes	Plastic drums, sacks, and baskets	Basket, styrofoam box
Collector Capacity (kg/day)	15–84	10–30	20–100
- Crab Selling Price (USD/kg):	1.84–2.45	2.45–3.07	1.84
- <100 g/crab (USD)	1.84–2.45	3.68	3.06
- 100 – 150 g/crab (USD)	3.07–3.68	4.90–9.20	18.40–42.92
Location distance (km)	40	56	131
Delivery duration	1 Hours 30 Minutes	2 Hours	2 Hours 30 Minutes

in RAS vertical boxes systems using *S. olivacea* and fresh feed, and comparable to those reported by Agustiyana et al. (2024) in apartment-type RAS systems producing soft-shell crabs (SR 65-75%). The lower survival rate in the present research is likely associated with stress from seed collection and transport, particularly from the distant Subang site, as indicated by Hayati et al. (2025), who demonstrated that prolonged holding before stocking significantly reduced crab vitality and molting performance. The molting percentage in this research (6.67-33.33%) was within the range reported by Waiho et al. (2021), who noted that molting success in soft-shell crab production depends heavily on water stability and seed condition prior to culture. The relatively low molting observed in Subang-sourced crabs may reflect longer storage duration and higher stress, corroborating findings by Paran et al. (2022) that handling and transportation affect post-molt survival and growth. Economically, the R/C ratio for Tangerang-sourced crabs at 1.3 exceeded that of Bekasi at 1.0 and Subang at 0.8, consistent with the observation by Lahiri et al. (2021) that shorter supply distances and better seed conditioning improve profitability in capture-based crab farming. Overall, these results confirm that seed source affects the economic viability of urban mud crab aquaculture through differences in seed quality and handling, even when production performance appears statistically similar.

The lower production performance observed in this research, particularly the reduced survival rate and molting percentage of mud crabs originating from Subang, can be attributed to differences in handling and transport conditions of the seeds prior to stocking. The mud crabs collected from Tangerang, Bekasi, and Subang were primarily intended for consumption in seafood markets and restaurants rather than for aquaculture use, resulting in rough handling practices during capture, storage, and transportation. Such practices, including prolonged binding of claws and walking legs, extended storage duration (up to five days), and limited moisture control, likely caused physiological stress and weakened vitality before stocking. This interpretation aligns with the findings of Hayati et al. (2025), who reported that longer pre-transport holding durations significantly increased stress indicators and mortality in mud crabs, and with Paran et al. (2022), who demonstrated that improper handling reduces post-transport survival and molting success in *Scylla serrata*. Similarly, Rangka (2007) noted that extended tying of crabs' appendages leads to paralysis and death in severe cases. In contrast, Tangerang-sourced crabs, which experienced shorter transport distances and milder handling, exhibited the highest molting percentage and profitability in this research. These results highlight that the post-capture handling and transport practices of wild-sourced crabs play a crucial role in determining seed quality and directly influence the biological and economic performance of urban mud crab aquaculture systems.

Mud Crab Cultivation Production Performance

The culture performance, including survival rate, daily growth rate, molting percentage, amount of feed consumption, and

Table 3. Production performance of mud crab culture in vertical crab boxes with RAS with different seed sources after 30 days of rearing

Parameter	Seed Source Location		
	Tangerang	Bekasi	Subang
Survival Rate (%)	70.00 ± 15.27[a]	73.33 ± 17.32[a]	50.00 ± 5.77[a]
Initial crab weight (g/crab)	90[a]	79[b]	92[a]
Daily Growth Rate (g/day)	0.69 ± 0.25[a]	0.63 ± 0.24[a]	0.60 ± 0.22[a]
Molting Percentage (%)	33.33 ± 10.00[a]	23.33 ± 20.81[a]	6.67 ± 15.27[a]
Amount of Feed Consumption (g)			
Molting crab	128.64 ± 21.86[a]	65.40 ± 69.11[a]	17.02 ± 93.49[a]
Non-molting crab	416.46 ±130.52[a]	464.36 ±168.48[a]	262.46 ±102.77[a]
Feed Conversion Ratio			
Molting crab	0.53 ± 0.06[a]	0.38 ± 0.16[a]	0.16 ± 0.35[a]
Non-molting crab	1.64 ± 1.28[a]	2.26 ± 0.79[a]	0.65 ± 0.59[a]

feed conversion ratio of mud crab culture in vertical boxes with RAS after 30 days of rearing, was not affected by seed source (Table 3). In general, the survival rate of mud crabs was 50-73%, the daily growth rate was 0.60–0.69 g/day, and the molting percentage was 6.67–33.33%. A pattern of higher feed consumption was seen in mud crabs with a high molting percentage, especially in mud crab culture efforts with seeds originating from Tangerang 128.64 ± 21.86, and the opposite for seeds originating from Bekasi 17.02 ± 93.49. Statistical analyses were conducted using one-way ANOVA at a 95% confidence level, and p-values ($p > 0.05$) indicated production performance differences. Results showed no significant differences ($p > 0.05$) among seed sources for survival rate, DGR, molting percentage, or FCR (Table 3). Superscript letters in Table 3 indicate results of Tukey's HSD, and error values represent standard deviations (mean ± SD).

To reach the transportation scale, collectors collect mud crabs for 1 and 5 days in baskets, Styrofoam boxes, sacks, or plastic drums. There is a pattern of storage time with the location of the seed source. The closer the distance between the location of the mud crab seed source and Jakarta, the shorter the storage time, which is related to the cost of transporting mud crabs. In Tangerang, which is relatively closer to Jakarta, collectors generally collect mud crab seeds for only 1-2 days, while in Subang, which is relatively the furthest, it can take up to 5 days of storage. During that time, the crabs are watered with brackish water to maintain the humidity of the gills. Hayati et al. (2025) research showed that storing mud crabs with tied legs and claws caused stress from the first day; the gill cuticles had begun to be damaged (wavy) and were most severe at five days of storage. The survey data provide crucial context for the culture experiment, as crabs from regions with gentler handling and shorter transport (e.g.,Tangerang) demonstrated higher survival and profitability during the 30-day rearing trial. Both of these efforts must be carried out immediately to ensure the sustainability of the mud crab culture business with an urban farming system, namely utilizing the seed supply chain (Lahiri et al., 2021). Thus, field and experimental results complement each other to link differences in local seed management practices to biological performance to achieve business viability in RAS vertical crab box systems.

Profitability analysis

Analysis of mud crab production business in RAS vertical boxes with seed sources from Tangerang, Bekasi, and Subang within one year is calculated using several assumptions and production performance variables obtained (see also Table 2). The assumptions used are as follows:

1) business analysis is calculated per month, 2) business scale of 120 vertical boxes or 120 crabs for each origin or seed source, 2) initial crab weight is location specific, 3) production cycle length is 30 days, which is marked by the purchase of new mud crab seeds from the seed source location, 4) the products of this mud crab culture business are divided into three types, namely soft shell crabs, live crabs, and dead crabs sold fresh or frozen, 5) the price of each type of product varies. The stocking density and culture duration used in this research were determined based on the physical capacity of the experimental RAS facility and the results obtained during the trial. A total of 120 mud crabs were cultured individually in 120 vertical crab boxes connected to the RAS unit. The 30-day rearing cycle corresponded to the observed molting and soft-shell production period under controlled environmental conditions.

Investment costs for purchasing a vertical crab box complete with RAS installation, seawater reservoir, freezer, water pump, culture equipment (scales, dip net, baskets, buckets, and so

Table 4. Assumptions were used to analyze the culture of mud crabs in RAS vertical boxes, using seed sources originating from Tangerang, Bekasi, and Subang. 1 USD = IDR 16,309

Assumptions (unit)	Seed Source Location		
	Tangerang	Bekasi	Subang
Initial crab count (crab)	120	120	120
Initial crab weight (g/crab)	90	79	92
Initial biomass (kg)	10.8	9.48	11.04
Survival rate (%)	70.00	73.33	50.00
Mortality rate (%)	30.00	26.67	50.00
Molting percentage (%)	33.33	23.33	6.67
Product Weight Gain (%)			
a) Soft shelled mud crab (%)	52.14	66.27	70.08
b) Live mud crab (%)	8.54	9.19	14.60
c) Dead mud crab, fresh or frozen (%)	0.36	0.46	0.21
Product Price			
a) Soft shelled mud crab (USD/kg)	9.19	9.19	9.19
b) Live mud crab (USD/kg)	3.68	3.68	3.68
c) Dead crab (fresh or frozen) (USD/kg)	2.15	2.15	2.15

on), water quality measurement equipment (refractometer, DO-meter, pH-meter, thermometer, and so on). Investment costs are calculated as fixed costs in the form of monthly depreciation costs by considering each item's technical life. In addition to depreciation costs, fixed costs include technician salaries, electricity costs, and the purchase of seawater. Variable costs consist of purchasing mud crabs and shipping costs (seed transportation costs), trash fish feed, and plastic packaging. Variable costs vary for each seed source location due to differences in transportation costs due to different distances or travel times between Tangerang, Bekasi, and Subang (Table 1). This causes the total cost to be location-specific. Profitability calculations in Table 4 were based on the actual biological performance observed during the experiment. Survival, molting percentage, and soft-shell yield data were directly measured at harvest, and these empirical results formed the basis for cost–benefit computations. These biological outcomes formed the foundation for estimating production outputs and financial performance under the tested RAS system.

Crabs that molt produce the high-value soft-shell product. Lower survival reduces the number of crabs available for premium sale and increases the proportion classified as dead product. Revenue is calculated as the sum over product categories of (product weight × price (USD)/kg). Because soft-shell has a substantially higher price (USD 9.19/kg) than live (USD 3.68/kg) or dead (USD 2.15/kg), small differences in soft-shell yield have a large impact on total revenue. Although Subang produced relatively high totals of live (70.85 kg) and dead (66.38 kg) crab biomass, it yielded only 7.51 kg of soft-shell crabs because the molting percentage from Subang seeds was very low (6.67%). Since soft-shell crabs command the highest price (USD 9.19/kg), the low soft-shell yield greatly reduced total revenue. In addition, lower survival (50%) converted potential premium product into dead or downgraded categories sold at lower prices, further depressing income for the Subang treatment.

The sales value of products consisting of soft shell crabs, live mud crabs, and dead mud crabs (fresh or frozen) depends on production performance: survival rate, mortality rate, molting percentage, weight gain, and price for each product obtained from this research. This causes a significant variation in income between seed source locations; the highest business income was achieved in soft shell crab culture businesses with seeds originating from Tangerang, followed by Bekasi and Subang (Table 4). This income difference impacts the profits obtained from each mud crab culture business with different seed source locations compared to the total costs. Mud crab culture businesses with seeds originating from Tangerang, then seeds from Bekasi, achieved the highest profit, while mud crab culture businesses with seeds originating from Subang experienced losses. Table 5 shows the profitability analysis of mud crab culture efforts for a year in RAS vertical boxes with different seed sources. Investment and fixed costs are identical across all locations. The highest variable costs were in Tangerang at 464.5 USD and the lowest in Subang at 449.8 USD. Subang has the lowest revenue, 472.2 USD (E.g., Subang revenue = 7.51×9.19 + 70.85×3.68 + 66.38×2.15 ≈

Table 5. Profitability analysis of mud crab culture efforts for a year in RAS vertical boxes with different seed sources

Components	Seed Source Location		
	Tangerang	Bekasi	Subang
Cost (USD)			
a) Investment Cost	1,041.3	1,041.3	1,041.3
b) Fixed Cost	130.4	130.4	130.4
c) Variable Cost	464.5	461.6	449.8
d) Total Cost	594.9	592.0	580.2
Product Sales (kg)			
a) Soft shelled mud crab	46.00	32.36	7.51
b) Live mud crab	65.65	69.83	70.85
c) Dead mud crab (fresh or frozen)	39.02	30.48	66.38
Revenue (USD)	748.4	619.9	472.2
Profit (USD)	153.4	27.9	-108
Revenue/cost ratio	1.3	1.0	0.8
Payback period (years)	6.8	37.3	-9.6

Table 6. Sensitivity analysis of mud crab culture profitability under different survival and feed cost scenarios. 1 USD = IDR 16,309

Scenarios	Total revenue (USD) Tangerang; Bekasi; Subang	Profit (USD) Tangerang; Bekasi; Subang	R/C ratio Tangerang; Bekasi; Subang	Payback period (years) Tangerang; Bekasi; Subang
Baseline (Observed)	748.4; 619.9; 472.2	153.4; 27.9; −108.0	1.3; 1.0; 0.8	6.8; 37.3; −9.6
SR = 100%	1,069.0; 846.8; 680.3	474.0; 254.8; 100.1	1.8; 1.4; 1.2	2.8; 5.9; 10.4
Feed cost +50%	748.4; 619.9; 472.2	136.8; 10.7; −125.1	1.2; 1.0; 0.8	7.6; 39.2; −11.0
Feed cost – 50%	748.4; 619.9; 472.2	170.0; 45.1; −90.9	1.4; 1.1; 0.9	6.1; 33.8; −7.9

USD 472.2), despite high live and dead crab sales in kg, implying a lower price per kg or less premium quality. Tangerang is the most profitable location, with a healthy 20.5% margin. Tangerang achieved the highest profitability primarily because of its higher molting percentage, which produced a greater proportion of soft-shell crabs. The highest-value product category resulting in increased revenue compared to Bekasi and Subang.

A sensitivity analysis was conducted to assess the robustness of profitability in mud crab (*Scylla serrata*) culture under various production and cost scenarios. The analysis simulated three alternative scenarios—(1) survival rate (SR) of 100%, (2) feed cost increased by 50%, and (3) feed cost decreased by 50%—to assess their influence on revenue, profit, revenue–cost ratio (R/C), and payback period. The conversion rate used for all calculations was 1 USD = IDR 16,309. The survival rate reached 100%, and total revenue and profit increased substantially across all seed sources. Tangerang achieved the highest profit (USD 474.0) and a shortened payback period of 2.8 years, indicating that improving survival through better seed handling and biosecurity would strongly enhance economic performance. Bekasi and Subang also became profitable under this condition (R/C = 1.4 and 1.2, respectively). Increasing feed costs by 50% reduced profitability, with the R/C ratio dropping slightly for all locations. Profit margins declined to USD 136.8 for Tangerang and USD 10.7 for Bekasi, while Subang remained unprofitable. Conversely, reducing feed costs by 50% improved profitability and shortened payback periods, confirming feed price as a key determinant of financial viability in mud crab farming systems. Overall, the sensitivity analysis indicates that profitability in RAS-based mud crab culture is most sensitive to improvements in survival rates, followed by fluctuations in feed costs. Ensuring high survival through proper seed transport and handling, combined with feed efficiency optimization, can significantly strengthen the economic sustainability of urban mud crab aquaculture operations.

CONCLUSION

This research demonstrated that the source of mud crab (*Scylla serrata*) seeds influences the economic performance but not the biological productivity of culture in RAS vertical boxes. While survival rate, daily growth rate, and molting percentage did not differ significantly among seed origins, the profitability indicators revealed apparent differences. Using Tangerang-sourced crabs resulted in the highest economic return (R/C = 1.3; profit = USD 153.4/year; payback period = 6.8 years, whereas culture with Subang-sourced crabs led to financial loss. These outcomes are likely linked to seed handling and transport conditions, where shorter distances and better post-capture care improved survival and molting performance. The study highlights the need for standardized seed handling protocols and the development of hatchery-based seed production to reduce dependence on wild-caught juveniles. Implementing these improvements will strengthen the reliability and sustainability of urban mud crab aquaculture and enhance its role in supporting local food security and coastal community livelihoods.

Ethical Statement: All operations followed accepted aquaculture practices and relevant criteria for the care and use of aquatic animals in research. This study was conducted under the ethical and biosafety guidelines of IPB University, which require adherence to humane handling of aquatic organisms and informed consent for human respondents during surveys and interviews. The research protocol was reviewed and approved at the Faculty of Fisheries and Marine Sciences, IPB University. As no invasive procedures were applied to the crabs, a formal animal ethics clearance was not required.

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References

Agustiyana, C., Hadiroseyani, Y., Diatin, I., & Effendi, I. (2024). Optimization of the production of soft shell crab (*Scylla* sp.) cultivation using the apartment system. *Egyptian Journal of Aquatic Research, 50*(4), 552–557. https://doi.org/10.1016/j.ejar.2024.05.003

Asy'ari, R., Rahmawati, A. D., Dzulfigar, A., Marfi, K. P., Aulia, U., Puspitasari, R. F., Raihan, F., Aslam, M. F., Saputri, H. R., Madinu, A. M. A., Jouhary, N. A., Hidayat, M. A. D., Fadhil, M. H., Nurrahmah, A. C., Inanda, I. A., Zamani, N. P., Pramulya, R., & Setiawan, Y. (2023). Mangrove damage vs succession: An opinion on the journey of mangrove investigation studies in Subang Regency coast area. *SSRS Journal A: Agro-Environmental Research, 1*, 1–6. Retrieved from https://publishing.ssrs.or.id/ojs/index.php/ssrs-a/article/view/11

FAO. (2023). The State of World Fisheries and Aquaculture 2023: Towards Blue Transformation. Food and Agriculture Organization of the United Nations (FAO), Rome.

Haryanti, R., Fahrudin, A., & Susanto, H. A. (2020). Analysis degradation of mangrove vegetation in Tangerang District, Banten Province. IOP Conference Series: Earth and Environmental Science, *441*(1), 012109. https://doi.org/10.1088/1755-1315/441/1/012109

Hayati, M. A., Effendi, I., Hadiroseyani, Y., & Budiardi, T. (2025). Performance of mud crab farming in natural seed-based apartment systems with various pre-transportation holding durations. *Jurnal Akuakultur Indonesia, 24*(1), 32–42. https://doi.org/10.19027/jai.24.1.32-42

Lahiri, T., Nazrul, K. S., Rahman, M. A., Saha, D., Egna, H., Wahab, M. A., & Mamun, A. A. (2021). Boom and bust: Soft-shell mud crab farming in south-east coastal Bangladesh. *Aquaculture Research*, *52*(10), 5056–5068. https://doi.org/10.1111/are.15377

Limbong, M. (2020). Performance of capture fisheries in Tangerang District waters. *Jurnal Penelitian Perikanan Indonesia, 26*(4), 201–210. http://dx.doi.org/10.15578/jppi.26.4.2020.201-210

Marlianingrum, P. R., Adrianto, L., Kusumastanto, & T., Fahrudin, A. (2021). Sistem sosial-ekologi mangrove di Kabupaten Tangerang. *Jurnal Ekobis: Ekonomi Bisnis & Manajemen*, *11*(2), 351– 364. https://doi.org/10.37932/j.e.v11i2.386 (In Indonesian)

MMAF. (2022). Indonesian Aquaculture Statistics 2022. Ministry of Marine Affairs and Fisheries (MMAF), Jakarta.

Nufus, S. (2025). Dampak pembangunan PIK 2 terhadap pelanggaran hak ekonomi sosial dan budaya masyarakat lokal. *Doktrin: Jurnal Dunia Ilmu Hukum dan Politik*, *3*(1), 229–236. https://doi.org/10.59581/doktrin.v3i1.4757 (in Indonesian)

Nugraha, R. B., Syaharani, L., Iska, R., Mulyana, D., Wahyudin, Y., Purbani, D., Jayawiguna, H., Setiawan, A., & Fajar, P. (2019). The impact of land used changes on mangrove forest and shoreline dynamic in Muara Gembong, Bekasi, West Java. IOP Conference Series: Earth and Environmental Science, *241*(1), 012018. https://doi.org/10.1088/1755-1315/241/1/012018

Paran, B. C., Jeyagobi, B., Kizhakedath, V. K., Antony, J., Francis, B., Anand, P. S., Radhakrishnapillai, A., Lalramchhani, C., Kannappan, S., Marimuthu, R. D., & Paulpandi, S. (2022). Production of juvenile mud crabs, *Scylla serrata*: captive breeding, larviculture and nursery production. *Aquaculture reports, 22*, 101003. https://doi.org/10.1016/j.aqrep.2021.101003

Rai, N., & Thapa, B. (2015). A study on purposive sampling method in research. *Kathmandu: Kathmandu School of Law, 5*(1), 8–15.

Rangka, N. A. (2007). Status usaha kepiting bakau ditinjau dari aspek peluang dan prospeknya. *Jurnal Neptunus*, *14*(1), 90–100. (in Indonesian)

Shelley, C., & Lovatelli, A. (2011). Mud crab aquaculture–A practical manual. FAO Fisheries and aquaculture technical paper No. 567. Rome.

Suryadi, T., Yulianda, F. & Susanto, H. A. (2021). Analisis kesesuaian kawasan konservasi mangrove di Muara Gembong, Kabupaten Bekasi Provinsi Jawa BaratMangrove conservation land suitability analysis in Muara Gembong, Bekasi District, West Java Province. *Enviro Scienteae, 17*(3), 11–24. https://doi.org/10.20527/es.v17i3.11635

Usman, Z., Alauddin, M. H, Syahrir, M., Leilani, A., Saridu, S. A., Wahid, E., Renitasari, D. P., Rasnijal, M., Hardianto, T., Regan, Y., & Kurniaji, A. (2024). Mud crabs (*Scylla olivacea*) fattening in recirculating aquaculture system (RAS) using vertical gallons crab house with different feed types. IOP Conference Series: Earth and Environmental Science, *1410*(1), 012020. https://doi.org/10.1088/1755-1315/1410/1/012020

Waiho, K., Ikhwanuddin, M., Baylon, J. C., Jalilah, M., Rukminasari, N., Fujaya, Y., & Fazhan, H. (2021). Moult induction methods in soft-shell crab production. *Aquaculture Research, 52*(9), 4026–4042. https://doi.org/10.1111/are.15274