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PRODUCTION AND ECONOMIC PERFORMANCE OF MUD CRAB (***SCYLLA OLIVACEA***) FATTENING WITH GIFT TILAPIA (***OREOCHROMIS NILOTICUS***) IN EARTHEN PONDS AND CAGES

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Abstract

Mud crab (*Scylla olivacea*) is a significant food and high economic resource in many countries including Bangladesh. Integrated aquaculture employs the co-products of one species, which are automatically recycled as inputs for another species to obtain higher profits. Considering the integrated farming, a vertical intensification of mud crab production conducted earthen ponds and floating cages over the period of February to April 2025. Genetically improved farmed tilapia (GIFT), *Oreochromis niloticus* was integrated with crabs in the free pond areas to enhance the productivity. There were three treatments: crab and tilapia stocked together in earthen ponds (T_1), tilapia stocked in ponds with crab reared in floating cages (T_2), and crab and tilapia stocked together in ponds while crab reared in floating cages (T_3). Water quality was checked regularly so as to maintain the parameters of the optimum range for cultured species. Crab survival rate in pond was greater in T_1 (81.00 ± 2.00%) compared to T_3 (77.00 ± 3.00%) and in floated cages it was higher in T_2 (92.00 ± 2.00%) than T_3 (90.00 ± 2.00%). Moreover, T_3 (3.10 ± 0.43 kg/m^2) and T_2 (1.76 ± 0.04 kg/m^2) were also considerably greater in crab production than T_1 (1.46 ± 0.47 kg/m^2. Crab productions in the floated cages were significantly ($p<0.05$) higher than productions in the ponds. Tilapia growth was also observed to be in concurrence with a moderate survival rate (70.00-73.00%). The GIFT production (0.67 ± 0.09 kg/m^2) in the T_3 was slightly lower than T_1 (0.69 ± 0.15 kg/m^2) and T_2 (0.73 ± 0.11 kg/m^2.The combined output and net profit of integrated crab fattening and GIFT farming were significantly ($p<0.05$) higher in T_3 (3.77 ± 0.52 kg/m^2, BDT 1481.93 ± 31.25/m^2) and followed by T_2 (2.49 ± 0.15 kg/m^2, BDT 850.55 ± 69.51/m^2) and T_1 (2.15 ± 0.62 kg/m^2, BDT 620.88 ± 23.56/m^2), respectively. This study demonstrates that integrated culture of mud crab and tilapia is a promising and viable aquaculture approach for the coastal regions of Bangladesh. The most effective culture strategies involve rearing tilapia in earthen ponds while culturing mud crab in floating cages, or adopting a combined system where both species are reared in earthen ponds with supplementary crab culture in floating cages.

Key words: Coastal region, crab fattening, Integrated aquaculture, benefit-cost ratio, Shellfish production

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Introduction

Mud crab (*Scylla olivacea*) is considered one of the most economically significant coastal species in Bangladesh after tiger shrimp, owing to its high market value and strong international demand. This species is widely distributed across the country's coastal zones, especially in estuarine areas, the Sundarbans Reserve Forest swamps, and shrimp ponds/farms. Out of the 16 marine crab species found in Bangladesh, only the mud crab holds notable commercial importance. As one of the largest crabs in the Portunidae family, it can grow up to 2 kg in weight (Rahman, 2022). Millions of resource less people who work in transportation, trading, and fishing depend on the live export of crab for their lives. It also makes a substantial contribution to Bangladesh's foreign exchange profits (Chandra *et al*., 2012; Islam *et al.*, 2021). The export of live crab has significantly boosted interest in commercial crab aquaculture. Due to growing international and domestic demand, especially in regions like Khulna and Chattogram, crab farming has gained popularity among coastal communities (Washim *et al*., 2022).

Southeast Asia has long practiced crab culture, which mostly relies on capturing and fattening young crabs from the wild. *S. olivacea* is a viable aquaculture candidate due to its widespread distribution in brackish coastal and estuarine waters. In South Asia, the crab farming and fattening are still in the developmental or experimental stage (Islam *et al.*, 2021). The farming process generally involves collecting juvenile crabs from natural habitats and fattening them in a short cycle to enhance their market value (Mirera, 2011; Sujan *et al*., 2021). Female crabs with underdeveloped gonads are less attractive in both domestic and international seafood markets, whereas gravid females with mature, bright orange-red egg masses are highly valued in Southeast Asian restaurants. To meet this market demand, farmers began rearing juvenile female crabs in enclosures and feeding them until the gonads matured and filled the mantle cavity (Huq *et al*., 2015). Among the various mud crab farming techniques, fattening is especially popular due to its short production cycle and high economic return, making it a preferred practice in many coastal communities of Southeast Asia (Rahman *et al.*, 2020). Communities in the southeast and southwest coastal regions of Bangladesh have shown keen interest in crab fattening as a livelihood (Washim *et al*., 2022). Despite its strong potential, mud crab aquaculture in South Asia remains largely in the experimental stage (Muhd-Farouk *et al*., 2016). However, large-scale fattening operations are already being carried out in different countries such Thailand, Taiwan, Malaysia, Singapore, India, Indonesia, the Philippines, Vietnam, and Bangladesh (Islam *et al.*, 2021). In 2023-24, Bangladesh's annual mud crab production was estimated at 10,782 metric tons (DoF, 2025), with most fattening activities concentrated in enclosed earthen ponds along the coastal regions.

Crab fattening is a widely adopted method to enhance the production of commercially valuable crab species. This practice involves rearing juvenile or undersized crabs—often those excluded during landing and sorting—and growing them to marketable sizes (Islam *et al.,* 2021). According to Kamal *et al*. (2022), local farmers in Bangladesh often use lightweight female crabs (weighing around 180–200 g) for fattening, thereby turning previously underutilized biological resources into economic assets. To ensure optimal growth, farmers follow consistent feeding routines, typically using affordable feed sources such tilapia and trash fish, which reflects the economic resilience and adaptability of the region's aquaculture practices. Fattening in earthen ponds is especially effective in Bangladesh's coastal belt due to its naturally estuarine environment, which supports ideal conditions for crab growth (Islam *et al.,* 2021). Research shows that such ponds provide nutrient-rich sediments beneficial for crab development and that the sediment microbial communities are influenced by surrounding agricultural activities (Zhang *et al*., 2021). The layered distribution of nutrients within these ponds plays a key role in ensuring the productivity and sustainability of crab fattening systems (Pouil *et al*., 2019). According to Hasanuzzaman *et al.* (2022), this activity improves livelihoods and creates more job chances in coastal areas.The investment in crab fattening can yield significant financial benefits, which in turn support larger community development initiatives, according to cost-benefit studies carried out in a variety of scenarios (Sujan *et al*., 2021).

However, the practice is not without its challenges. One persistent issue is cannibalism among crabs, which contributes to high mortality rates. Nivas *et al*. (2023) suggests that placing crabs in individual compartments or cages can greatly reduce this problem. In line with this, Mwaluma and Kaunda-Arara (2021) emphasize that implementing improved and ecologically responsible farming techniques can significantly enhance both the survival and growth rates, encouraging farmers to adopt sustainable best practices. Nutritional management is also crucial during the fattening phase. Das *et al*. (2020) point out that the type and protein content of feed directly influence the growth performance of crabs. Considering these facts, the present research aimed to explore concurrent fattening of crabs in both ponds and floating cages, while integrating hypo-saline tolerant fish like mono-sex tilapia to optimize overall farm production and profitability.

Materials and Methods

The current research was carried out at the earthen ponds to exhibit the methods to the farmers over the period of 90 days (February to April 2025) for gift strain and 16-20 days (01-20 February 2025) for fattened mud crab as a single crop. The experimental ponds were located at Shibbati in Paikgacha upazila under Khulna.

Experimental design of study: The experiment was set to consist of three varied treatments, and each treatment was replicated thrice for attaining precision and accuracy to the production. The first treatment (T_1) was stocking crabs at a stocking density of 10 crabs per square meter in the pond. The second treatment (T_2) involved with cage culture, where the crabs were stocked at the rate of 10 crabs per square meter in floating cages. Each cage was divided into ten equal compartments. The third treatment (T_3) was a multi-species integrated culture system, with crabs stocked in earthen ponds at 10 crabs per square meter and floated cages at the same stocking rate. In addition to four genetically improved farmed tilapias (GIFT) were stocked per square meter under each treatment. This was to establish the feasibility and advantage of mixed culture of different ecological niches in the same production system.

Pond preparation: Three successive earthen ponds were properly dried and re-excavated for their structural and functional optimization in order to prepare all ponds for the research. With an area of 80 m² (two decimals), each pond was ready to start the experiments. Each pond was meticulously divided into three equal compartments, each measuring 26.7 m², using firm bamboo barriers to provide controlled aquaculture conditions. Furthermore, bamboo splits were used to stabilize the pond's sides, and nylon nets were used to keep undesired species outside and cultured organisms inside.

Agricultural lime (CaCO3) was applied @ 250 kg/ha to improve the quality of the soil and water. After a seven-day stabilization phase, ponds were gradually filled with tidal water from the neighboring river to a depth of around one meter. A fertilization regime was carried out to stimulate primary productivity and favor the growth of natural food organisms. A cattle dung @ 500 kg/ha was added as an organic fertilizer to provide a plankton growth stimulus. Inorganic fertilizers in the form of Triple Super Phosphate (TSP) and granular urea were also added @ 25 kg and 20 kg per hectare, respectively. Following fertilization, ponds were carefully watched for about seven days to monitor water quality, the development of natural feed, and to prepare optimal conditions for desired species stocking. This stage of preparation provided a balanced and productive aquatic ecosystem, paving the way for multi species farming (Islam *et al*., 2021).

Preparing and setting of cages: Before the study was started, cages were properly designed and built to ensure a good condition for aquaculture. Thirty cages (1 m^2 space for a single cage; containing 10 chambers; every single chamber with the volume of 30 cm x 31.5 cm x 31.5 cm) were built for a single earthen pond and also having sufficient space for the cultured organism without interfering with proper water circulation and aeration. Cages were carefully set up on the pond surface with consideration of the

individual requirements of the given experimental treatments. Ten floated cages covered the surface area of each pond's compartment.

All cages were strengthened with plastic covers to guard against any stock loss and guarantee the security of the cultured species. The purpose of the covers was to keep crabs within while providing some degree of defense against outside environmental disruptions (predation and sediment settling). Additionally, the durability and ease of handling were guaranteed by the use of plastic. The cage system was made perfect to support the research objectives by carefully planning and setting them up so that controlled conditions would be maintained to provide reliable data for evaluating the study's results.

Stocking of non-gravid crabs and GIFT: Seven days after fertilization, stocking was done carefully to create a well-balanced aquaculture system. Female crabs (with 150 g average body weight and immature gonads) were stocked into the culture system at the provided stocking densities. Ten crabs were stocked in each of the cages in the pond to provide controlled conditions for growth and observation. Also, within the open water area of the pond, crabs were also stocked at a stocking rate of 10 crabs per square meter so these could develop more natural foraging and movement behaviors while still under semi-controlled conditions.

At the same time, all-male fingerlings of GIFT averaging 10.0 g were stocked in the ponds following the pre-designed experimental setup. The stocking was kept at a four tilapias/m^2 to allow for the optimal possible balance between population density and available resources. This stocking strategy was centered on the plan to achieve maximum use of available space and resources and evaluate the interactions between species within the integrated farming.

To enable proper growth and development, a well-designed feeding regime was adopted. Crabs in ponds and cages were fed low-value chopped small trash fish, mainly tilapia, once a day at the rate of 10% of total biomass. The protein diet helped in inducing crab fattening and supplying energy needs to them. Meanwhile, the GIFT tilapia received a particular diet of fish meal and rice bran at a ratio of 25:75 in every other day. Feeding was done at a rate of 10% of their body weight in order to provide them with sufficient nutrients and achieve maximum growth.

There was continuous observation and periodic check-ups during the culture duration to observe the growth of crab fattening and tilapia development. The most important performance indicators as weight gain, survival, and overall health, were monitored closely to determine how well the stocking densities and feeding regimes worked. Any

indication of stress, disease or abnormality was addressed immediately to ensure the well-being of the cultured organisms.

Management of water quality was most important aspects to sustaining a healthy aquatic environment for both tilapia and crabs. About 40% of pond water was replaced with new tidal water every 5–7 days to manage water quality factors like dissolved oxygen, temperature, and nutrient levels. Regular exchange prevented the buildup of metabolic wastes, ammonia, and guaranteed overall system productivity. Adequate aeration and water circulation were also ensured to foster the optimum growth of both the species.

With the appropriate stocking density, control and carefully designed feeding regimes and also regular water quality control, the experimental design purported to maximize growth performance and production while assessing the ecological and economic feasibility of grouping various species together in a multi-species aquaculture setup. The trial's production would be a contribution to the scientific knowledge and innovation on sustainable aquaculture, mainly in mixed-species in pond culture systems.

Water quality parameters: Water quality was monitored in situ every day at 7:30 AM in order to maintain optimal environmental conditions and the health of the cultivated species. To track changes in water quality over time, key parameters like temperature, salinity, dissolved oxygen concentration, and pH were routinely recorded. The American Public Health Association (Bridgewater, 2017) and the Association of Official Analytical Chemists (Latimer, 2023) established standardized procedures that were followed while taking these measures. A high degree of data correctness and dependability was ensured by their application.

Since significant temperature variations would affect crab metabolic rates, feeding habits, and molting cycles, temperature data were monitored to follow seasonal and daily cycles. Because salinity levels are essential for osmoregulation and survival, particularly in an integrated aquaculture system subject to tidal water exchanges, they were regularly monitored. To guarantee proper aeration and avoid a hypoxic condition that would harm both tilapia and crabs, dissolved oxygen levels were tested. Because variations in acidity or alkalinity would impact molting, shell hardening, and nutrient availability, pH was regularly checked to maintain a steady aquatic habitat.

To maintain a stable and healthy state, in addition to these regular inspections, any further changes in water quality metrics were promptly documented and adjusted as needed, such as by changing the water or adjusting the aeration. Monitoring made it feasible to identify potential stresses early on, reducing the likelihood of poor water quality and promoting the successful growth and survival of both tilapia and crabs.

Crab and tilapia growth performance: Weight gain, specific growth rate (SGR), and survival rate (%) were calculated following the equation as cited by Mohiuddin *et al.,* (2024). The equations are as follows:

Weight gain (g) = Mean final weight (g) - mean initial weight (g).

Specific growth rate (SGR) (%/day) = {Ln (final body weight) – Ln (initial body weight) × 100}/cultured period (days).

Survival rate (%) = (Number of crab/fish harvested ÷ total number of crab/fish stocked) × 100

Production of crab/fish= No. of crab/fish caught × average final weight of crab/fish.

Economic analysis: A simple algebraic economic analysis was carried out to determine the net return and benefit cost ratio of crab and fish culture in different treatments. The following equation was used to quantify the profitability of crab and tilapia culture in pond systems: $NR = TR - (FC + VC + Ii)$.

Where NR = net return, TR = total revenue from crab and tilapia sales, FC = fixed/common costs, VC = variable costs and Ii = interest on inputs. The benefit cost ratio (BCR) was determined as total net return/total input cost.

Data analysis: The collected data on crab, GIFT, and various water quality parameters were organized, categorized, calculated, and displayed using Microsoft Excel program. This software was also utilized to perform a one-tailed T-test to compare crab and tilapia survival rates between ponds and cages. Additionally, several statistical analyses aligned with the study's objectives were conducted using Statistical Product and Service Solutions (SPSS) version 25. One-way ANOVA and Tukey were applied to evaluate differences in survival rates and growth parameters across treatments.

Results and Discussion

Survival rate and production performance of mud crab and GIFT: The production of crab and GIFT in all treatments observed variations among treatments due to difference of survival and stocking density. A significant difference was observed in production among three treatments. The total production was calculated on per square meter based on culture period.

Survival rate: The study found that the survival rate of crab in cage were 90.00-92.00%, on the other hand in pond it were 77.00-81.00% respectively, which clearly showed that the survival rate in the cage system was significantly higher ($p<0.05$) than that of pond

system and GIFT tilapia were 70.00-73.00% (Table 1). These observations supported the observations of Begum *et al*. (2009), who had reported a maximum survival of 93.75% of crabs under cage culture and in encircled earthen pond 86.12% respectively. Rattanachote and Dangwatanakul (1992) observed the mud crab fattening practice in earthen pond in Surat Thani province of Thailand and reported 85.20 % of survival rate and 93.77% production rate. Islam *et al.* (2021) observed the survival of crab in cage culture 81.75% and in pond culture 21.17%, which is dissimilar with the current study that may be due high stocking density as well as its burrowing and escape nature. Survival of aquatic animals in farming systems is significantly affected by species behavior, stocking density, and environmental control. As a wild, aggressive, and cannibalistic species, the mud crab are very challenging because of its tendency to escape through burrowing (Rahman *et al*., 2020). Kamal *et al.* (2007) used traditional practice for mud crab fattening and recorded a survival of 80% which was lower than the present study. Kuntiyo (1992) showed a weight increment of 23 to 37 g and survival of 80-100%, 35 days after stocking in net cage battery. The cannibalistic behavior of *S. serrata* is one of the biggest limiting factors to their survival, culture productivity and profitability in aquaculture (Romano & Zeng, 2017).

Growth and production performance of fattened crab and GIFT: The average weights of crab and GIFT fingerlings were 150.27 g and 10.00 g, respectively during the stocking period. By the end of the study, the average final weights of crab in ponds were 180.53 ± 2.08 g in T_1 and 175.36 ± 2.80 g in T_3. In contrary, the average final weights of crab in cages were 190.87 ± 3.28 g in T_2 and 187.91 ± 3.08 g in T_3. The crab in ponds had a significantly lower final weight (180.53 ± 2.08g) compared to those in cages (190.87 ± 3.28g) (Table 1). This finding was in agreement with the finding of Begum *et al*. (2009).

In terms of productivity, the performance of aquaculture is a direct function of both growth performance and survival. Fattening of crab in cage showed that average weight gain was higher (37.64 ± 0.84-40.60 ± 0.71) than the average weight gain in pond (25.09 ± 0.52-30.26 ± 0.85). The difference of weight gain was statistically ($p<0.05$) different. Throughout the trial, mean fattened crab production (F1+F2+F3) in cages was 1.70 ± 0.07-1.76 ± 0.04 kg/m², which was significantly ($p<0.05$) higher than the production (F1+F2+F3) of earthen ponds (1.40 ± 0.36-1.46 ± 0.47 kg/m²) (Table 1). This result was not aligned with that of Islam *et al*. (2021), who reported that crab production in cage culture was 2.12-2.29 kg/m^2 and in pond was 0.53-0.60 kg/m^2. This variance in cage culture may be related to the use of fewer cages and a lower stocking density. Conversely, a high survival rate in pond culture boosted the current study's production

Table 1. Survival and production (mean±sd) of fattened *Scylla olivacea* and *Oreochromis niloticus* in different treatments during the study period.

Species and production parameters	Treatments		
	T_1 (Pond + GIFT)	T_2 (Cage + GIFT)	T_3 (Pond + Cage + GIFT)
***Scylla olivacea* (Pond)**			
Average initial weight (g)	150.27 ± 3.20	-	150.27 ± 3.20
Average final weight (g)	180.53 ± 2.08	-	175.36 ± 2.80
Weight gain (g)	30.26 ± 0.85[b]		25.09 ± 0.52[b]
Survival rate (%)	81.00 ± 2.00[a]	-	77.00 ± 3.00[c]
Fattened crab production (kg/m^2):		-	
F1	1.30 ± 0.41	-	1.28 ± 0.20
F2	0.09 ± 0.04	-	0.08 ± 0.09
F3	0.07 ± 0.02	-	0.04 ± 0.07
Total production (kg/m^2)	1.46 ± 0.47[a]	-	1.40 ± 0.36 [b]
***Scylla olivacea* (Floated cage)**			
Average initial weight (g)	_	150.27 ± 3.20	150.27 ± 3.20
Average final weight (g)	_	190.87 ± 3.28	187.91 ± 3.08
Weight gain (g)		40.60 ± 0.71[a]	37.64 ± 0.84[a]
Survival rate (%)	_	92.00 ± 2.00[a]	90.00 ± 2.00[b]
Fattened crab production (kg/m^2):	_		
F1		1.60 ± 0.01	1.58 ± 0.05
F2		0.16 ± 0.03	0.12 ± 0.02
F3		0	0
Total production (kg/m^2)		1.76 ± 0.04[a]	1.70 ± 0.07[a]
Combined crab production (kg/m^2)	-	-	3.10 ± 0.43
GIFT(*Oreochromis niloticus*)			
Average initial weight (g)	10.00 ± 0.03	10.00 ± 0.03	10.00 ± 0.03
Average final weight (g)	244.38 ± 3.50	250.21± 2.60	240.58 ± 3.08
Survival rate (%)	71.00 ± 3.00	73.0 ± 3.00	70.00 ± 2.00
Daily weight gain (g)	2.71 ± 0.10	2.78 ± 0.06	2.21 ± 0.03
Specific growth rate (%/day)	3.54 ± 0.04	3.56 ± 0.05	3.53 ± 0.02
Production (kg/m^2)	0.69 ± 0.15	0.73 ± 0.11	0.67 ± 0.09
Total combined production (kg/m$^{2)}$	2.15 ± 0.62[c]	2.49 ± 0.15[b]	3.77 ± 0.52[a]

Mean values in the same row with same superscript letters are not significantly different ($p > 0.05$). All values are expressed as mean ± SD (n=3). F1: Weight of individual crab > 180 g with all the appendages unbroken, F2: weight of individual crab between 150 g to 179 g and F3: weight of individual crab between 100 g to 149 g.

more than they reported. Begum *et al*. (2009) obtained 3.3 kg/m^2 in the cage system and 0.37 kg/m^2 in the pond system; however, the results of this study did not agree with their findings because they employed a large number of cages and a low stocking density in the pond culture system. This study revealed that better survival and production can be obtained in fattening by stocking the crabs individually which did not agree with the findings of Islam *et al.* (2021), Begum *et al*. (2009) and Marichamy and Rajapaciam

(2001). The production of GIFT tilapia was 0.67-0.73 kg/m^2 in the present study, which was not coincide with the finding of Islam *et al.* (2021) who found the GIFT production was 0.41 and 0.39 kg/m^2 in year 1 and 2, respectively due to the variation in survival rate and stocking size. In addition the stocking size and survival rate of GIFT in the present study was also higher than their findings.

Among all treatments, T_3 had the highest production (3.77 ± 0.52 kg/m^2), demonstrating that the integrated aquaculture setup not only enhanced survival but also biomass gain. GIFT (*Oreochromis niloticus*), a fast-growing and hardy strain, was included in the integrated farming because of its suitability to diversified environments and acceptance by farmers and consumers (Bhujel, 2014). Tilapia has been extensively used in Southeast Asia in polyculture systems because it integrates well with other aquaculture and agricultural activities such rice-fish culture and livestock integration (Wang and Lu, 2016). Throughout the culture period of this study, GIFT tilapia showed stable performance with average production of 0.67 ± 0.09-0.73 ± 0.11 kg/m^2 and survival rates of 70.00 ± 2.00-73.00 ± 3.00%. At 90 days of culture, weights ranged from 240.58 ± 3.08 to 250.21 ± 2.60 g. These results emphasize the growth potential of the species even in multi-species culture systems. Additionally, tilapia furnished a secondary income and protein source, which improved system productivity overall. Since *Scylla olivacea* is carnivorous, having dead or live small tilapia likely created an added source of protein with the potential to enhance crab health and growth. This predator-prey relationship adds a fascinating ecological aspect to the integrated aquaculture system, one that reflects a more natural trophic dynamic and nutrient cycling.

Profit of fattened mud crab and GIFT culture: Net profits of the current study were BDT 620.88 ± 23.56/m^2 in T_1, BDT 850.55 ± 69.51/m^2 in T_2, and BDT 1481.93 ± 31.25/m^2 in T_3 within one crop (12-16 days per crop for crab and 90 days for tilapia (Figure 1), which was significantly higher than the finding of Chakraborty (2018) who found the net return of BDT 295.45/m^2 from crab fattening in cages. Begum *et al.* (2009) stated that they obtained the net profit of BDT 254.53/m^2 from the crab fattening in cage culture, which was also lower than the present results. The reasons of the variation may be due to high stocking density, high survival rate as well as high sales price in the present study. The benefit-cost ratio (BCR) across the three treatments was 1.43-1.59. The highest BCR was observed in T_3 (1.59), while the lowest was recorded in T_1 (1.43). A significant variation in BCR was noted between T_1 and T_3 but not in the T_2 and T_3 treatments. Begum *et al.* (2009) reported that the benefit-cost ratio (BCR) for mud crab fattening was 1:1.21 for earthen ponds and 1:1.35 for cages. Kamal *et al.* (2007) calculated an annual net income of a farm with an average size of 122±22 (range 90-150)/m^2 at Tk. 23,221±8,490. The

current economic study implied that mud crab fattening in a cage is more profitable and economically viable than the surrounding earthen pond. Crab fattening in cages is also economically feasible (Kamal *et al*., 2007), despite the high labor and maintenance needs (Bensam, 1986).

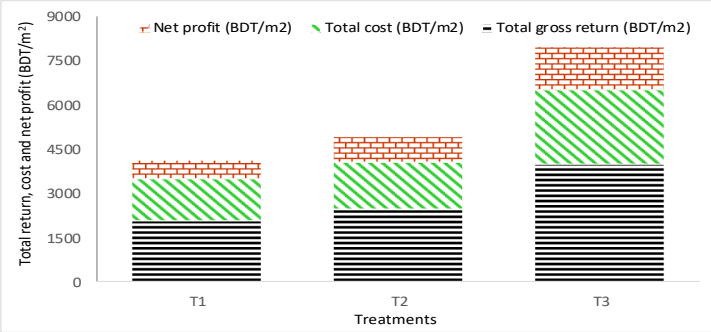


Fig. 1. Not profit, total cost and total gross return of crab and GIFT farming in 3 treatment.

Now-a-days, vertical intensification of agriculture is a novel approach to meet the dietary demand of the hunger world (Singh *et al*., 2020; Babu *et al*., 2021). Similarly, the vertical intensification in aquaculture has become popular to get high output from a single crop. The present study exclusively demonstrated the advantages of the use of the whole water column in a pond. Water quality parameters can play a very important role in terms of aquaculture practices (Brown *et al*., 2020). Suitable and congenial water quality variables ensure higher growth rate, survivability and production by keeping a friendly culture environment (Deswati *et al*., 2022). The temperature of water in this study varied within the range of 24.5-31.5ºC. The range of salinity levels in the study fluctuated between 6.5 ppt and 11.6 ppt. Hereafter, the water pH value and the dissolved oxygen (DO) were recorded within a range of 7.5-8.3 and 4.5-5.6 mg/l, respectively. Furthermore, alkalinity (109-146 mg/l) and total ammonia (0.2-1.3 mg/l) were observed during the experiments. All water quality parameters were found within the optimum ranges for aquaculture. Optimum water parameters provide all necessary nutrients to grow phytoplankton, zooplankton and other arthropods to feed the cultured fish and shellfish. Undoubtedly, proper nutrition in the waterbody ensures high growth and low mortality. Therefore, ideal water quality is very important for fish culture (Ojwala *et al*., 2018).

Conclusion

This study firmly establishes the use of integrated aquaculture as a practical and promising approach for achieving sustainable and high-yield aquaculture. The integration

of tilapia (*Oreochromis niloticus*) and mud crab (*Scylla olivacea*) within a vertically structured, multi-species in integrated aquaculture system demonstrated clear benefits in terms of survival rates, biomass production, and optimized resource utilization. The survival rate of crab in pond was greater in T_1 (81.00%) compared to T_2 (77.00%) but in cage it was higher in T_2 (92.00%) than T_3 (90.00%). Moreover, the gross crab production were significantly higher in T_3 (3.10 kg/m^2) and T_2 (1.76 kg/m^2) than T_1 (1.46 kg/m^2). In comparison between pond and cage culture, cage farming showed higher production than the pond system. The GIFT tilapia also showed a significant survival rate (70.00-73.00%) in this study. However, the total combined outcome and net profit of this experiment were significantly greater in T_3 (3.77 ± 0.52 kg/m^2, BDT 1481.93 ± 31.25/m^2) followed by T_2 (2.49 ± 0.15 kg/m^2, BDT 850.55 ± 69.51/m^2) and T_1 (2.15 ± 0.62 kg/m^2, BDT 620.88 ± 23.56/m^2).

By recycling organic and inorganic wastes across trophic levels, the integrated aquaculture system created a balanced and synergistic aquatic environment that improved water quality, minimized environmental degradation, and enhanced overall system resilience. The co-cultivation of species with complementary ecological functions not only improves economic returns through diversified harvests but also supports long-term ecological stability. This system's adaptability to both earthen ponds and floating cages suggests its suitability for varied physical environments and farmer capabilities. The success of the tilapia-mud crab integration model underlines its potential scalability in coastal and estuarine regions, particularly where space, water quality, and nutrient cycling are critical considerations.

References

Babu, S., K.P. Mohapatra, A. Das, G.S. Yadav, R. Singh, P. Chandra, and A.S. Panwar. 2021. Integrated Farming Systems: Climate-resilient sustainable food production system in the Indian Himalayan region. *Exploring synergies and trade-offs between climate change and the sustainable development goals*. 119-143.

Begum, M., M.M.R. Shah, A.A. Mamun and M.J. Alam. 2009. Comparative study of mud crab (*Scylla serrata*) fattening practices between two different systems in Bangladesh. *Journal of the Bangladesh Agricultural University*. **7**(1): 151-156.

Bensam, P. 1986. A culture experiment on crab, *Scylla serrata* (Forskal) at Tuticorn during 1955-1977 to asses growth and production. In: Symposium on coastal Aquaculture. Marine Biological Association of India, India, pp. 1183-1189.

Bhujel, R.C. 2014. A manual for tilapia business management. In: "Integrated Farming" Bhujel, R.C. (Ed.). CAB International, Noswarthy Way, Wallingford, Oxfordshire, UK, pp. 120-135.

Bridgewater, L.L. 2017. Standard methods for the examination of water and wastewater. American public health association.

Brown, A.R., J. Webber, S. Zonneveld, D. Carless, B. Jackson, Y. Artioli and C.R. Tyler. 2020. Stakeholder perspectives on the importance of water quality and other constraints for sustainable mariculture. *Environmental Science & Policy*. **114**: 506-518.

Chakraborty, B.K. 2018. Culture of soft shell Mangrove crab, Scylla spp. production in the Southwest region of Bangladesh. *International Journal of Oceanography & Aquaculture*. **3**(2).

Chandra, K.J. 2012. A survey on the production and marketing of mud crab, *Scylla serrata* (forskal, 1755) in the south-west part of Bangladesh. *International Research Journal of Applied Life Sciences*. **1**(3).

Das, K., S. Mondal and A. Asif. 2020. Growth and economic performance of different supplementary feed on female mud crab (*Scylla olivacea*) fattening in plastic box. *Asian Journal of Medical and Biological Research*. **5**(4): 303-315.

Deswati, D., E. Yani, S. Safni, T.O. Norita and H. Pardi. 2022. Development methods in aquaponics systems using biofloc to improve water quality (ammonia, nitrite, nitrate) and growth of tilapia and samhong mustard. *International Journal of Environmental Analytical Chemistry*. **102**(19): 7824-7834.

DoF (Department of Fisheries), 2025. National Fish week Compendium (in Bangla). Ministry of Fisheries and Livestock, Bangladesh. 160p.

Hasanuzzaman, A., S. Arafat and K. Huq. 2022. Mud crab (*Scylla* spp.) aquaculture in the south-west Sundarbans region of Bangladesh. *Iraqi Journal of Aquaculture*. **11**(1): 57-83.

Huq, K.A., S.B. Rahaman and A.F.M. Hasanuzzaman. 2015. Mud crab culture as an adaptive measure for the climatically stressed coastal Fisher-Folks of Bangladesh. In: "Environmental Management and Governance." Finkl, C. & Makowski, C. (Eds.), Springer, Switzerland, pp. 175-198.

Islam, M.L., M.H. Sakib and S. Ahmmed. 2021. Fattening of the Mud Crab *Scylla olivacea* (Herbst, 1896): An Integrated Multi-trophic Aquaculture (IMTA) Approach. *Egyptian Journal of Aquatic Biology & Fisheries*. **25**(4): 1035-6131.

Kamal, D., M. Khanom and S. Rheman. 2007. Traditional practice of mud crab (*Scylla olivacea*) fattening in the south west region of Bangladesh. *Khulna University Studies*, **8**(2): 269-285.

Kamal, D., M. Khanom and S. Rheman. 2022. Traditional practice of mud crab (*Scylla olivacea*) fattening in the south west region of Bangladesh. *Khulna University Studies*. 269-285.

Knowler. D., T. Chopin, R. Martínez-Espiñeira, A. Neori, A. Nobre, A. Noce, and G. Reid. 2020. The economics of Integrated Multi-Trophic Aquaculture: where are we now and where do we need to go? *Reviews in Aquaculture*. **12**(3): 1579-1594.

Kuntiyo, A. 1992. Fattening of mud crab, *Scylla serrata* Forskal , in net cages installed in the drain canal of intensive prawn ponds fed with trash fish and prawn pellate. MS Thesis. University of the Philippines in the Visayas. pp. 60.

Latimer, Jr.G.W. 2023. Official methods of analysis of AOAC INTERNATIONAL: 3-volume set. Oxford University Press.

Marichamy, R. and S. Rajapackiam. 2001. The Aquaculture of *Scylla* species in India. *Asian Fisheries Science*. **14**: 231-238.

Mirera, O.D. 2011. Trends in exploitation, development and management of artisanal mud crab (*Scylla serrata*, Forsskal, 1775) fishery and small-scale culture in Kenya: An overview. *Ocean and Coastal Management*. **54**(11): 844-855.

Mohiuddin, M.B., M.S. Islam, M.M. Shamsuzzaman, S.H. Rafi and M. Akter. 2024. Polyculture of freshwater prawn (*Macrobrachium rosenbergii*) with some Indian major carps in coastal earthen ponds of Bagerhat. *Journal of Sylhet Agricultural University*. **11**(1): 9-16.

Muhd-Farouk, H., S. Jasmani and M. Ikhwanuddin. 2016. Effect of vertebrate steroid hormones on the ovarian maturation stages of orange mud crab, *Scylla olivacea* (Herbst, 1796). *Aquaculture*. **451**: 78-86.

Mwaluma, J., and B. Kaunda-Arara. 2021. Growth and survival of mud crab, *Scylla serrata*, reared in bottom and floating cages within mida creek mangroves, coastal Kenya. *Aquatic Ecosystem Health & Management*. **24**(1): 27-34.

Nivas, N., D. Kaippilly and A. Gopalakrishnan. 2023. Efficacy of different wet feeds on the growth performance of mud crab *Scylla serrata* during fattening in cages. *North American Journal of Aquaculture*. **86**(1): 17-25.

Ojwala, R.A., E.O. Otachi and N.K. Kitaka. 2018. Effect of water quality on the parasite assemblages infecting Nile tilapia in selected fish farms in Nakuru County, Kenya. *Parasitology research*. **117**: 3459-3471.

Pouil, S., R. Samsudin, J. Slembrouck, A. Sihabuddin, G. Sundari, K. Khazaidan and D. Caruso. 2019. Nutrient budgets in a small-scale freshwater fish pond system in Indonesia. *Aquaculture*. **504**: 267-274.

Rahman, M. M., M.R.M. Ranju and M.L. Islam. 2022. Study on growth, survival and intactness of sub-adult to adult mud crab aquaculture under low saline earthen pondsin the coastal areas of Bangladesh. *Bangladesh Journal of Fisheries*, **34**(1): 19-26.

Rahman, M.M., S.M. Haque, M.A. Islam, A.K. Paul, S. Iqbal, U. Atique and C. Brown. 2020. Assessment of mud crab fattening and culture practices in coastal Bangladesh: understanding the current technologies and development perspectives. *Aquaculture, Aquarium, Conservation & Legislation*, (2), 582-596.

Rahman, M.R., M. Asaduzzaman, M.M. Zahangir, S.R. Islam, S.A.A. Nahid, D.A. Jahan and M.N.A. Khan. 2020. Evaluation of limb autotomy as a promising strategy to improve production performances of mud crab (Scylla olivacea) in the soft-shell farming system. *Aquaculture Research*. **51**(6): 2555-2572.

Rattanachote, A. and R. Dangwatanakul. 1992. Mud crab (*Scylla serrata* Forskal) fattening in Surat Thani province. In: The mud crab. C.A. Angel (ed.). Bay of Bengal Program, Madras. India. pp. 171-177.

Romano, N. and C. Zeng. 2017. Cannibalism of Decapod Crustaceans and Implications for Their Aquaculture: A review of its prevalence, influencing factors, and mitigating methods. *Reviews in Fisheries Science & Aquaculture*, **25**(1): 42-69.

Singh, B.R., A. Safalaoh, N.A. Amuri, L.O. Eik, B.K. Sitaula and R. Lal. 2020. Knowledge Gaps and Research Priorities. In: "Climate Impacts on Agricultural and Natural Resource Sustainability in Africa." Singh, B.R. Safalaoh, A. Amuri, N.A. Olav, L. Sitaula, B.& Lal, R. (Eds.). Springer International Publishing, Switzerland, pp. 607-623.

Sujan, M., M. Kazal, M. Ali and M. Rahman. 2021. Cost-benefit analysis of mud crab fattening in coastal areas of Bangladesh. *Aquaculture Reports*. **19**: 100612.

Wang, M. and M. Lu. 2016. Tilapia polyculture: a global review. *Aquaculture research*. **47**(8): 2363-2374.

Washim, M.R., A.K.M. S.A. Rubel, S. Ahmmed, S.L. Rahman and M.L. Islam. 2022. Stocking density optimization of juvenile mud crab (*Scylla olivacea*) cultivation in bamboo fetched earthen ponds. *AACL Bioflux*. **15**(1):384-394.

Zhang, J., C. Ge, J. Fang and Q. Tang. 2018. Multi-Trophic Mariculture Practices in Coastal Waters. Aquaculture in China: success stories and modern trends. In: 'Aquaculture in China: success stories and modern trends.' Gui, J.F.; Tang, Q.; Li, Z.; Liu, J. and Silva, S.S.D. (Eds.). John Wiley and Sons, Inc. United States, pp. 541-554.

Zhang, Z., Q. Deng, L. Wan, X. Cao, Y. Zhou and C. Song. 2021. Bacterial communities and enzymatic activities in sediments of long-term fish and crab aquaculture ponds. *Microorganisms*. **9**(3): 501.

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