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Study on growth, survival and intactness of sub-adult to adult mud crab aquaculture under low saline earthen pondsin the coastal areas of Bangladesh

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Abstract. To assess the growth, survival and intactness of mud crabanexperiment was conducted for a period of 120 days from July to October 2021 in the farmers ponds of Betbunia village under Paikgacha upazilla at Khulna Districts, Bangladesh. The crab Juvenile was collected from adjacent Shibsha River and stocked in a pond of 0.01 ha area with the stocking density at 1 m^2,2m^2, 3 m^2in T_1,T_2 and T_3 treatments with 2 replications each. Fresh choppedtilapiafish was fed and the feed was adjusted periodically in accordance with the growth performance. Production and physico-chemical parameters were recorded and analyzed according to standard methodsduring the culture period. Among these parameters salinity has significant (p<0.05) role on survival of mud crab.After 120 days of rearing, obtained average final weight was 97.8±13.86g, 94.22±9.25gand 117.77±14.34g; with the estimated yield of 371.56 kg/ha, 433.12 kg/ha and 376.56 kg/ha, survival was 38%, 46% and 32% in T_1, T_2 and T_3 treatments respectively.Results and findings of the present study suggested that poor salinity level and cannibalism is the potential constraints inthe growth, survival and intactness of mud crab aquaculturein the coastal areas of Bangladesh.
Keywords: Mud crab, Low salinity, Crab culture

Introduction

Theworld most valuable commercial crab species of mud crab are *Scylla serrata, S. tranquebarica, S. paramamosain* and *S. olivacea.* Among them the *S. olivacea* is focus species for aquaculture production in Asia/Bangladesh because of its availability and distributionin mangrove, coast and estuaries (Rahman *et al.* 2017). *S. olivacea* is stenohaline depending on high-salinity conditions to survive, and also physiologically well adapted to changing temperatures and salinities, conditions that typically occur in mangrove habitats/coastal ghers/estuaries. In addition, mud crab is less susceptible to disease, easier to culture, more resistant to adverse environmental conditions, and is even able to live without water for a certain time (Salam *et al.* 2012).The majorcharacteristics of *S. olivacea* in their lifecycle is a dispersing, benthic hardy in nature.They dig and inhabit burrows in mangrove swamps and shallow, soft bottom intertidal waterbodies Mud crabs spend most of their life in estuaries and coastal environments that have mud or detritus, debris of leaves, branches, roots and enough shelter materials or places to hide to avoid cannibalism or to molt (Quinitio *et al.* 2008).Compared with other types of aquaculture, mud crab culture in encircled ponds is still new in coastal districts of Bangladesh althoughcrab fattening/hardening/aquaculture is advancedstages in Thailand, Taiwan, Malaysia, Singapore, India, Indonesia (Begum *et al.* 2009).Inlast 10 years mud crab production is increasing proportionately and current annual production (fattening+hardening) is 12,084 metric tons from 9,377 ha culture area (DoF 2021). A large number of potential resources are available here, including: the diversified broodstock from the wild, as well as hatchery equipped with modern facilities; farming technology/area/facilities etc. (Mostofa *et al.* 2014).In recent years, coastal farmers have been practicing mud crab fattening/hardening/growout as a means of improving food security and alternative livelihood options mainly in traditional system in earthen ponds/gher/canal without maintaining any specific stocking density or measures to improve growth and survival

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(Islam *et al*. 2015). High mortality and poor survival are the main constraints of crab fattening/hardening/growout in existing culture systems (Shaha *et al.* 1999 and Begum *et al*. 2009). Some comprehensive work has been needed for improving existing culture system of *S. olivacea.* The present experiment was done to study the survival, intactness and production performanceby culturing mud crab juvenile in low saline earthen ponds for making crab culture system easy and cost effective.

Materials and Methods

Pond selection and preparation: The culture experiment was conducted in tide fed three earthen ponds of Betbunia village under Paikgacha upazilla at Khulna districts. The villageis situated besides the Shibsha River. These ponds had an area of 0.016 ha each with an average water depth of (1±0.05) m. The ponds were prepared bydrying, removing of unwanted sludge and repairing of embankments .Lime was applied at the rate of 250kg/ha in the ponds and left for seven days. Ponds were filled with tidal water from the Shibsha River during high tide and left for 3 days to settle down. Pond water was fertilized with 1,250kg/hacompost cow dung, 37.5kg/ha urea and 25kg/ha TSP. These ponds were left for 10 days to promote phytoplankton/zooplankton production. Thenponds area were encircling with bamboo fence for preventing escaping of crab. Thirty piece of plastic pipe, 20 pieces of earthen pots and 4 piece of bamboo bush were placed in each compartments/replication of the ponds/treatments for providing shelter of the molted crab/hiding to avoid cannibalism.

Collection and stocking of crab juvenile: The wild Juvenile or sub adult crabwithout broken legs or chelate were procured in good health conditions fromthe crab collector or fishermen.These crabs were collected from the Sibsha River of Khulna districts adjacent to the Sundarbans mangrove forest. The crab collector’s catches crab by pulling/using following devices which are locally called cast net or seine net or fine mesh net charpata jal orhorina jal or crab catching trap (locally called atton). Crab catchers use lure or bait for catching crab by using crab catching trap.Crabs are caught noticeable amount in summer,winter and rainy season in Shibsha river during new moon and full moon time.The collected crabs are irregular in size (fry,juvenile,sub-adult,adult) and have weight variations (from 2g to 300g).Net devices catches all types/sizes of crab but trap devices catches targated/grade size crab. Among the collected crab’s from the Shibsha river; the male female ratio was found more or less 1:1 ratio from the crab catcher’s information.Sub adult crab an average weight 20.11±2.58g (10g-50g) were acclimatized and stocked in 2 individual per m^2 density at 1:1 male female ratio in0.016 ha area each ponds in 1^{st}July, 2021.Aclimatization was easy because the ponds were filled with Shibsha river water.

Feed and feeding management: The Crab was fed with fresh tilapia fish. Initially feed was provided at 13% of biomass of Juvenile and subsequently decreased to 2.5%. Feeding regime was adjusted periodically in accordance with the growth performance, total biomass and assuming 100% survival of mud crab. Feeding schedule was once in every2days interval for total culture period (Rodriguez *et al.* 2007). Feed was provided on 5 plastic made feeding trays in every pond having an area of 0.01 haarea each. The feed trays were hanged to the bamboo poles and allowed to submerge in the water column. Limed with calcium carbonate was applied at the rate of 65kg/ha in the pond water at 15 days intervals to kill germs, toxic gases, suspend unwanted particle and supply Ca^{2++}.In water for helping molting/shell formation.

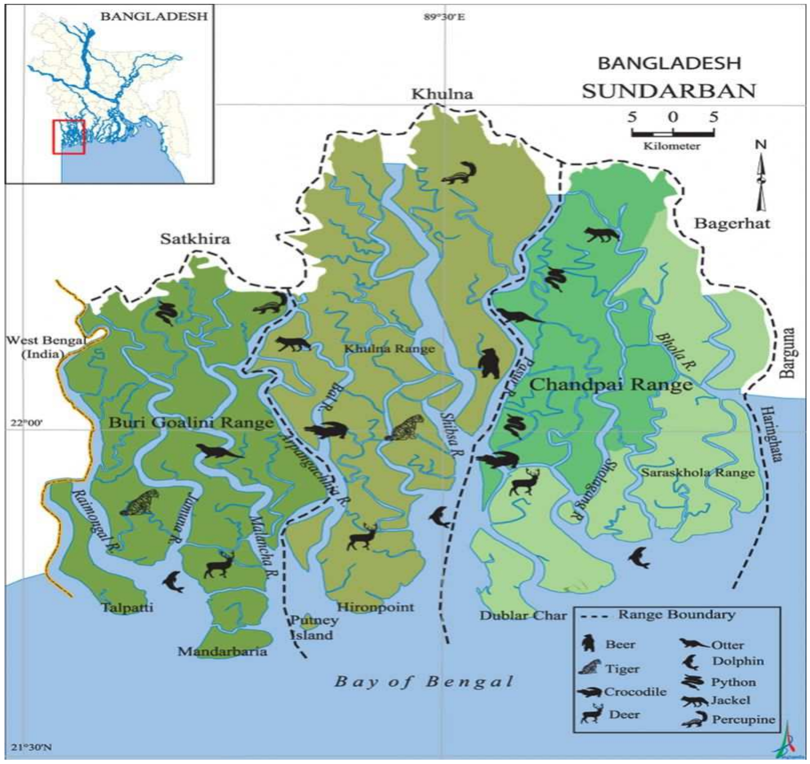

Fig 1. Image of Shibsha river of Sundarbans which go through/flow over the middle of Khulna region.

Monitoring of physico-chemical water parameters: The physico-chemical parameters of pond water were monitored at 9:00to 10:00AMin every 15 days. Water quality parameters like water temperature (^oC), DO (mg/l), CO_2 (mg/l), total alkalinity (mg/l), pH, iron (mg/l),ammonia (mg/l) was monitored using (HACH,Made in USA) Kit Box. Salinity (ppt) was measured by photo refractometer (Atago, Japan).Transparency (cm) was measured by using secchi disk and water depth (cm) was measured manually by using meter scale.

Monitoring of growth and estimation of production: Health condition and growth of crab was monitored fortnightly during the full and new moontime. At least 5% of crab was collected by angling device by using lure or bait in the early morning. Length was measured by using a centimeter scale and theweight by a portable weighing balance. After 120 days of rearing, all crabs were harvested in 30th October,2021 by drying the ponds and the following parameters were calculated:

Average weight gain (g) = Mean final weight (b) – mean initial weight (a);
SGR (%body wt. gain/day) = [(Ln Final wt.- Ln Initial wt.)/ Time interval] × 100);
Survival (%) = (Number of fish harvested/Number of fish stocked) × 100;
Production/Yield (kg/ha) = [{Number harvested × average final wt. (g)/1000] × pond area (ha);
Food conversion ratio (FCR) = Supplied feed (kg)/harvested total biomass (kg).

Data analysis : Comparison of treatment mean was carried out using one-way analysis of variance (ANOVA), followed by Duncan's Multiple Range Test. Significance at the 5% level ($p<0.05$) using the SPSS (Statistical Package for Social Science) version-20.

Results

Growth performance, survival, and intactness of mud crab culture under low saline ponds

Growth increment of *Scylla olivacea* has been shown in Table I and Fig. 1. Initially the growth (length and weight) was optimum then suddenly jumped after one month of culture and slowed down to the moderate state and followed a gradual increment for the entire culture period (Table IIand Fig. 1).

Table I. Growth, survival and intactness of mud crab under low saline ponds

Particulars	T_1	T_2	T_3
Stocking Density No/m^2	1 ^{a}	2 ^{a}	3 ^{a}
Mean weight at stocking(g)	21.5±4.35^a	24.25±1.92^a	14.6±1.48^a
Survival rate* (%)	38±8.0^a	46±6.0^b	32±10.0^a
Production rate (kg/ha)	371.56^a	433.12^b	376.56^a
Mean weight at harvest(g)	97.8±13.86^a	94.22±9.25^a	117.77±14.34^a
Average weight gain (g)	76^a	69.97^a	103^b
SGR(%day)	1.26^a	1.13^a	1.73^a
Total feed given(kg)	14.98^a	15.66^a	20.84^a
Total biomass produced (kg)	11.89^a	13.86^a	12.05^a
Feed conversion ratio	1.06^b	1.16^a	1.29^a

*Different superscript letters within the same row indicate a significant difference ($p<.05$)

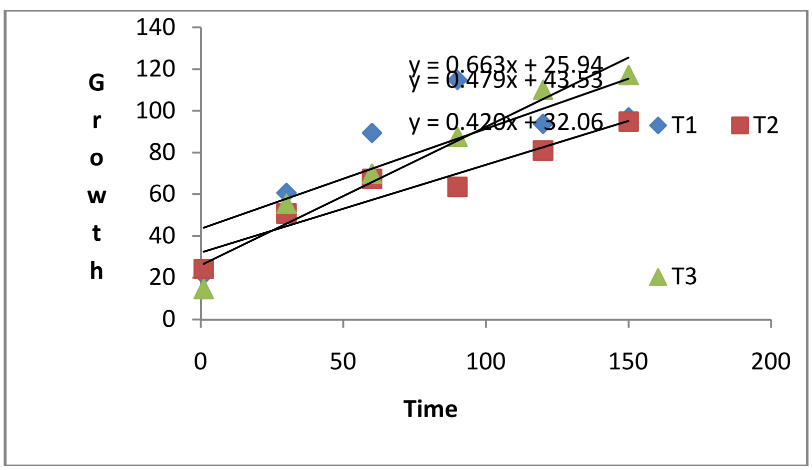

Fig. 1. Growth increment of mud crab under low saline earthenponds in rainy season.

After 120 days of culture, average body weight (117.77±14.34g) was highest in T_3followed by T_1 (97.8±13.86 g) and T_2(94.22±9.25g) with a daily weight increment (SGR) of 1.26%,1.13% and 1.73in T_1,T_2 and T_3. Survival was 38%,46% and32% in T_1,$T_2$and T_3whereas, FCR (food conversion ratio) value was 1.06,1.16,1.29 (Table III). Total production for the pond T_1,T_2 and T_3 was 11.89 kg,13.86 kgand12.05 kgthat ultimately augmented the production of 371.56 kg/ha, 433.12kg/ha and 376.56 kg/hain T_1,T_2,T_3 treatments respectively(Table III). The experiment was conducted during extremely low temperature and low salinity period.

Table II. Recorded water quality variables of experimental ponds mud crabunder low saline ponds

Particulars	T_1 (Mean±SD)	T_2 (Mean±SD)	T_3 (Mean±SD)
Temperature(°C)	28.24 ± 1.83^a	28.59 ± 1.51^a	28.00 ± 2.00^a
DO(mg/l)	4.59 ± 0.53^a	5.00 ± 1.00^a	4.81 ± 0.27^a
pH	7.85 ± 0.67^a	7.48 ± 1.23^a	8.05 ± 0.24^a
Salinity(ppt)	0.66 ± 0.81^b	0.68 ± 0.79^b	0.53 ± 0.93^b
Alkalinity(mg/l)	117 ± 8.46^a	124 ± 13.99^a	109 ± 19.21^a
Ammonia(mg/l)	0.41 ± 0.22^a	0.31 ± 0.58^a	0.36 ± 0.27^a
Nitrite(mg/l)	0.01 ± 0.01^a	$0.040\pm.02^a$	$0.020\pm.01^a$
Iron(mg/l)	0.01 ± 0.01^a	0.03 ± 0.01^a	0.03 ± 0.01^a
Transparency (cm)	20.44 ± 1.23^a	18.91 ± 1.45^a	25.11 ± 1.22^a

*Different superscript letters within the same row indicate a significant difference (p<.05).All the values wear reported mean standard deviation.

Discussions

In Bangladesh, crab fattening in ponds started in the early 1990s while culture of mud crab in bamboo cages, pens and pots started in the early 2000s at an experimental level (Khatun 2007, Begum *et al.* 2009) but nowpracticing is accelerated among coastal fishers/gher owners. Fattening/hardening/growout culture of crab is profitable because of the fast turnover, low operating cost, high survival rate and good market demand for the end products (Liong 1992). Crabfarmers generally collect small, undersized, underweight male juveniles with average individual size of about 100 g (SM grade), any sized female crab with undeveloped gonad, and both male and female soft-shell crabs for fattening/hardening/grow-out. Most crabfarmers purchase seed crabs from depots, while some collect directly from crabbers exploiting wild stocks.Seed crabs are stocked in ponds and ghers in monoculture or polyculture with other finfish (mostly tilapia) and shrimp for a certain period to attain market size (Islam *et al.* 2015). The stocking density varies from 4,000-10,000/ha depending on productivity, economic benefit in earthen ponds and culture intensity. The suitable sex ratio for stocking is 2 females for every male. Usually with low-value fresh fish and snails once in every 2 days interval is used for crab feeding (Islam *et al.* 2015). Ponds are fertilized with organic fertilizers (cattle manure, molasses) and inorganic fertilizers (Urea, TSP, Ammonium phosphate). Also, liming and water exchange are done as pond management practices. Crabs grow by molting its exoskeleton. In winter season crab culture is not profitable at all.About 8-10 days after stocking, farmers start to check the stock and harvest if the desired grade or size is attained.The duration of the culture period varies and depends on the sized stocked, amount of supplied feeds and market price. From 15 to 45 days are required to complete the production cycle, allowing 8-10 production cycles per year(Islam *et al.* 2015). One of the common features of mud crab fattening in ponds/ghers is selective or progressive harvesting and restocking (Santos 2014). The average annual production in the fattening system is about 3000 kg/ha with only 60-65 percent survival. Furthermore, 15 percent extra incomes can be added by finfish (especially tilapia) and shrimp production in a polyculture system. Monthly income of crab fatteners has increased by 39 percent (Rahman *et al*. 2017). Mortality at/after stocking because of poor quality and handling of crab seeds and lack of knowledge on best management practices hampers production and income in crab farming systems. Nevertheless, the system has a demonstrated reputation to vulnerable impoverished households and small-scale farmers. Crab fattening offers comparatively higher returns than other aquaculture practices in coastal areas. The short production time reduces the risk of losing crabs to disease. There is a higher survival rate for fattening (>90 percent) than grow-out systems (40 percent). Most crab fatteners in coastal zones are Hindu (73.7 percent) and the balance are Muslim (26.3 percent) (Rahman *et al.* 2017). Some farmers practice grow-out by stocking small (1-50 g) crab seed in ponds and ghers to grow to market size. Some independent coastal marginalized men and women crab fishermen collect crab seeds with a push net in the marshes of the Sundarbans mangrove forest, estuaries, canals, and tidal rivers during January to late March and sell to grow-out farmers at the low price. Firstly, the farmers stock the small seed in an area of confined water enclosed by bamboo or netting. There is no improved pond management techniques developed for grow-out crab culture. Farmers follow traditional process without maintaining any specific stocking density or measures to improve growth and survival. In the first half of the year, they stock crablets in ponds for culture for 3-4 months and provide low amounts of feeds on an irregular basis. In the second half, they start fattening crabs in the same ponds. Absence of separate nursery and grow-out ponds increases predation through cannibalism due to large size variation, resulting in lower production (Rahman *et al.* 2017).

Fromtheexperiment resultsthe grow-out culture of mud crab production in earthen ponds found 376.56 kg/ha in T_3which was higher than other two treatments T_1 and T_2afterculturing 120 days but not statistically significant comparing T_2treatments in whichproduction, survivaland food conversion ratio is433.12 kg/ha, 46% and 1.16.T_2treatments found comparatively better; the probable factor/catalyst is survival of Sub-adult crab after stocking. Survival increases when Juvenile faces less stress in transportation or catching in river. The difference of weight gain was not statistically (p>0.05) significant in three treatments. But production rate of crab was found 433.12 kg/ha in T_2 treatments , which was significantly (p>0.05) difference from T_1 and T_3.Saha*et al.*1991conducted 10-weeks culture trial of mud crab, *Scylla serrata* in brackishwater earthen pond in three stocking densities 5000 crablings/ha, 10000 crablings/ha and 15000 crablings/ha. In terms of production, survival, growth and carapace width, the author found the best performance from the stocking density 10000/ha followed by 500/ha and 1000/ha. Begum *et al.* (2009) also conducted research in earthen ponds and cages. In encircled earthen ponds, fattened crab found after 16 days of stocking and in cages after 12 days of stocking. In grow out system fattening/hardening time is longer than cage culture. In terms of production the present study reveals, that having stocking density 20000/ha found highest survival which is supported by the finding of Balio *et al.* (1981) where author showed relation between production and percentage of survival, so positive impact of low stocking density. At the end of the experiment survival of mud crab was found38%, 46% and 32% in T_1,T_2 and T_3 treatments which are lower than Begum *et al.*2009 who found survival rate of crab was 93.75 ± 6.25% in cages, 86.12 ± 2.16% in earthen ponds. Mwaluma and Kaunda-Arara (2021)conducted crab grow out practice in bottom and floating cages in Mida creek for a period of 120 days.They found final weight 466.2±137gm and survival 63.8% in floating cages but542.2±109 gm and 44.9% in bottom cages (James *et al.* 2021). Rattanachote and Dangwatanakul (1992) observed the mud crab fattening practice in earthen pond in Surat Thani province of Thailand and reported survival rate 85.20 %.The lower survival rate in encircled earthen pond could be due to the poor salinity level and cannibalistic nature of mud crab. An adequate supply of feeds and provision of three-dimensional shelters, including PVC pipes, straw-sheafs, leaf fronds, bamboo pieces, unused nets, coconut leaves and mangrove twigs, provided for reducing cannibalism. Cannibalism is a big problem for crab aquaculture.Mortality due to cannibalism has been widely documented (Iversen 1986). Escritor (1972) concluded that cannibalism and the burrowing habitat of *S. serrata* can be controlled to minimize losses and to make the crab culture profitable. Survival in pond culture is generally lower as a result of cannibalism and escape (Liong 1992). Dept. of Agriculture (1988) used bamboo cage battery (with several small compartments or cubicles to accommodate a single crab per compartment) for mud crab fattening and recorded a survival of 87% which was higher 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. In Vietnamese intensive farming of mud crab, the stocking density was 1-1.5/m^2, achieving 1.5t/ha for each crop. After 4-6 months, the crabs achieved an average weight of 300-450g and fed with trash fish and mollusks. (Thach 2004). Cholik and Hanafi (1992) also studied the relation among the stocking density, survival rate and production of mud crab. They found survival rate of 57% with a yield of 171.68 kg/ha while stocked with 1 individual/m^2, the survival rate was found low (30%) with increase in yield (224.16 kg per ha). However, the overall total production of crabs in all treatments were found lower than recorded by Bensam (1980), Lapie and Librero (1979) which may be due to poor salinity level,cannibalism and adverse weather(unexpected storm with raining,cold shock for sudden temperature fall). The fluaction of salinity and temperature causes stress, mortality (Quinitio *et al.* 2008).According to APHA (2005) and Boyd and Fast (1992) recorded all physico-chemical variables like dissolved oxygen, pH, alkalinity, ammonia, nitrite, iron and transparency; were found within the acceptable ranges for crustacean aquaculture except the lower salinity levels inT_1, T_2, and T_3 treatments respectively during the entire culture period (Table II) The ranges of water quality parameters recorded in the experiment were: salinity: 0-4 ppt; temperature: 26-31º C; pH: 7.5-8.7 and dissolved oxygen: 4.0 - 7.9 mg/l. These ranges were generally within acceptable levels except salinity for mud crab fattening (Cholik and Hanafi 1992).

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