

*Short Communication*

## **Improving the Livelihood for Marginalized Women's Households in Southwest Bangladesh through Aquaculture**

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### **Abstract**

Mud crab (*Scylla serrata* (Forsskål 1775)) fattening and culture is an emerging industry in Bangladesh that directly benefits households in the coastal region of Bangladesh. Currently, 37.8 % of crab fattening and culturing facilities are owned and operated by women whose households are generally poor. The study was conducted to promote the integration of tilapia (*Oreochromis niloticus* (Linnaeus 1758)) into mud crab culture, thus diversifying the crops and potentially improving household income and nutrition. First, a baseline survey of 150 mud crab farmers in the Satkhira, Khulna, and Bagerhat regions was conducted, focusing on household food consumption, dietary nutrition and earned incomes, plus household demographic and socio-economic information. The survey revealed that the majority of mud crab farmers are poorly educated (5 years average schooling) and consumed low dietary nutrients, particularly from animal protein sources. Second, tilapias were integrated into mud crab culture by 45 farmers, 15 from each surveyed region. 5 farmers from each region continued with the traditional mud crab fattening procedures and 10 were instructed in methods of mud crab and tilapia stocking and culture, using mixed sex tilapia for continuous breeding. 5 of the 10 farmers sold their tilapia to market while the other 5 kept the tilapia for direct household consumption. In both groups small tilapia were fed to mud crabs to reduce reliance on wild-caught trash fish as feed. Including tilapia in mud crab fattening and culture increased growth and production of mud crabs, albeit not to a level that differed significantly from the group

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where mud crab alone were produced. Adding tilapia into mud crab culture increased the nutrient-rich foods available for the farmer's households. A follow up survey found that the women and their household members improved their incomes and consumption of high quality protein. Overall, the integration of tilapia provides a more sustainable method for growing mud crab while also enhancing the livelihoods of farmers.

## Introduction

The people of coastal (southwest) Bangladesh are highly vulnerable to the impacts of global climate change that include increased seawater incursion into fresh water systems and lands and more frequent and powerful storms. Three districts (Satkhira, Khulna and Bagerhat) that surround the Sundarban mangrove forest are considered the most threatened, suffering repeatedly from the effects of calamitous storms (e.g., cyclone Sidr in 2007 and Aila in 2009). During periods of high flooding, the average consumption of staple rice falls to 33 % of the minimum nutritional requirement, resulting in acute malnutrition and chronic energy deficiency, particularly in women and children (World Food Programme 2011). While men in this region commonly engage in day labor or have migrated to urban areas to obtain low-income work, the majority of women in this population rely directly on subsistence farming of natural wetland resources. The prevalence of impoverished women-led farming households in coastal Bangladesh, traditionally underrepresented in the economic market chain, make this demographic particularly susceptible to exploitation and thus a key target for improving dietary nutrition and earned incomes of the impoverished Southwest. As fish commonly contribute 63 % of dietary animal protein intake for Bangladeshis (Belton et al., 2011), this investigation focused on 2 key aquaculture species, Nile tilapia (*Oreochromis niloticus* (Linnaeus 1758)) and the mud crab (*Scylla serrata* (Forsskål 1775)), the latter primarily cultured alone, but may be integrated with tilapia. Integrative culture of these species could improve the nutritional and economic well-being of female-led households as well as the environmental impact associated with crab-fattening where feed inputs are significant and water exchanges are common. A key component of this study is to promote the culture of both species by women to foster better food security through diversification of dietary resources. A secondary benefit of this strategy is that tilapia can also be used as feeds for mud crab fattening, which are traditionally reliant on fisheries by-catch. The co-production of both species, combined with on-going research into crab hatchery development will go a long way towards

securing an environmentally sustainable industry and promote better food security for impoverished women aquaculturists in coastal Bangladesh.

The large-clawed mud crabs are high-value seafood commodities due to their delicacy, medicinal value and demand in international markets (Ali et al. 2004; Keenan et al. 1997). The culturing or fattening of mud crab is an important industry directly benefiting women-led households in coastal Bangladesh (Azam et al. 1998; Khan et al. 1991; Ferdoushi and Xiang-Guo 2010). Of the 2,428 crab farms in the severely impacted regions (Satkhira, Khulna and Bagerhat), 37.8 % are currently owned and operated by women 26-41 % by region; Even farms not directly owned by women commonly rely on this demographic for stock collection of juveniles from shrimp ponds or other wetlands. While women aqua-farmers likely obtain economic benefits from crab fattening, this is solely marketed as an export crop, and thus may not directly benefit the dietary needs of women and children. To more directly improve the dietary nutrition of women and children, and create a more sustainable method of mud crab fattening, our objective was to promote integration of Nile tilapia into traditional mud crab culture, thus providing greater crop diversification. The live mud crab industry holds promise for improving economic opportunities in regions sensitive to global climate change (e.g., seawater incursion, storms), with current annual production estimates at 10,000-15,000 MT (Zafar and Siddique 2000). Despite economic benefits, the dietary conditions for many women-led households in these regions are extremely poor, and diets may constitute only staple rice, supplemented periodically with local vegetables and fish. As tilapia farming continues to grow in Bangladesh (Ahmed 2007), including in the Southwest region (Hussein 2009), the integration of tilapia into mud crab culture may enhance the incomes of women-led households through sales in domestic markets, and improve their food security by direct household consumption. The growing number of Bangladesh tilapia hatcheries and the availability of seed stock readily allow for integration of tilapia into mud crab farming.

This study was designed to foster greater participation of women in aquaculture in the impoverished coastal regions of Bangladesh. To this end, we determined the present socio-economic and nutrition status of households through surveys to understand the contribution of aquaculture to the livelihood of women-led households. Additionally, the studies were aimed at evaluating

the utility of integrating tilapia into mud crab fattening and culture. These investigations could promote better food security and dietary nutrition for women-led households through greater crop diversification and training in best management practices for tilapia–mud crab culture. Currently, the production systems for mud crab fattening are less advanced relative to other aquaculture sectors (Begum et al. 2009). This study provided on-site training along with current research into mud crab farming (e.g., captive breeding of seed stock, water quality, cage culture), to achieve sustainable development for this industry.

## **Materials and Method**

Baseline surveys were conducted with existing crab farmers to determine their socio-economic and dietary nutrition status. Surveys were conducted in 150 households in total, 50 from the Khulna, Bagerhata, and Satkhira districts of the coast Southwest region of Bangladesh. These surveys were filled out by the head of the household. They included questions relevant to the income and dietary intake of each member of the household. These surveys focused on food consumption (24 h recall) and how low-intensity culture species (including mud crab and tilapia) and other seafoods contribute to the dietary nutrition and earned incomes (both actual and potential) of surveyed families. Household demographic and socio-economic information was also collected. The survey data collected served as baseline indicators for the study. A second follow up survey was performed that included those families who undertook pilot studies on integrative tilapia-mud crab culture to determine if income and nutrient consumption increased within the household. Evaluation of nutritional benefits derived from families that integrated tilapia with mud crab culture/fattening were examined.

A pilot study was conducted to demonstrate the potential benefits of integrated tilapia and mud crab culture to practicing women aquaculturists who utilize mud crab-fattening as a source of income. The benefits of integrating tilapia into mud crab fattening and culture may include: 1) greater supply of nutritious foods for household consumption, 2) improved earnings by the sale of extra tilapia in domestic markets, 3) improved environmental water quality resulting in less stock mortality and environmental impacts, and 4) a decrease in the reliance of fisheries by-catch for use as crab feeds. The latter benefit,

utilized through feeding of extra juvenile tilapia to crabs, may also improve the environmental sustainability of this industry.

All participating households were given a data collection notebook to record farming activities including crab stocking, feeding, tilapia (kg) harvested, proceeds from crab and/or tilapia sales, and input costs associated with crab feeding. Evaluation of nutritional benefits derived from integrating tilapia into mud crab culture was examined through a survey questionnaire described above (24 h recall questionnaire on foods consumed).

Participating members from women-owned farms or from women-led households were included within the sample set identified in the baseline study of 150 households. Sites were selected to have a salinity range (5-20 ppt) tolerant for Nile tilapia (*Oreochromis niloticus* (Linnaeus 1758)) breeding and mud crab fattening (Popma and Masser 1999; Shelly and Lovatelli 2011). An equal number of ponds from all 3 districts (Kulna, Satkhira, and Bagerhat, 15 per district) were used. Ponds were assigned to 1 of 3 treatment groups (N = 45; n = 15): (T1) control – only traditional mud crab fattening or culture practiced, (T2) integrated tilapia-mud crab farming where the tilapia are sold to market, and (T3) tilapia-mud crab farming where the tilapia are directly consumed by the household.

Prior to stocking, a bamboo fence or *Pata* (15 m x 9 m) was put in place in the pond and covered with a net once crabs were stocked. The fence height extended 0.76-0.91 m above the water surface and 0.30 m below the soil. The pond bottom was cleaned and lime (3 kg ha<sup>-1</sup>) was applied. Fertilizer, urea (18.5 kg ha<sup>-1</sup>) and triple super phosphate (TSP; 24.7 kg ha<sup>-1</sup>) was then applied. Ponds for treatment 2 and treatment 3 were stocked with mixed-sex tilapia of breeding size (3 female: 1 male) at a density of 1 fish m<sup>-2</sup>. The crab stocking density was 3 m<sup>-2</sup>. At Rampal and Khulna crablet individual stocking weights were 0.60 to 3.2 g and at Syamnagar, juvenile crab individual stocking weights were 18 to 25 g. At stocking, crab biomass was 22 kg and tilapia was 11.2 kg at Munshugonj. At Rampan and Khulna crab biomass averaged 10.4 kg and tilapia biomass 11.2 kg. The tilapia were raised only on secondary pond productivity derived from excess crab feeds and pond fertilization (28 kg N, 7 kg P ha<sup>-1</sup> only if productivity was low (> 20 cm Secchi disk depth). Crabs were fed at 10 % body weight daily with trash fish. In the groups incorporating tilapia, around

10 % of small juveniles (~10g, produced by tilapia breeding within the ponds) were harvested weekly for use as supplemental crab feeds. The study was conducted over a single tilapia production phase or for ~ 4 months (2 crab fattening cycles or 1 crab culture).

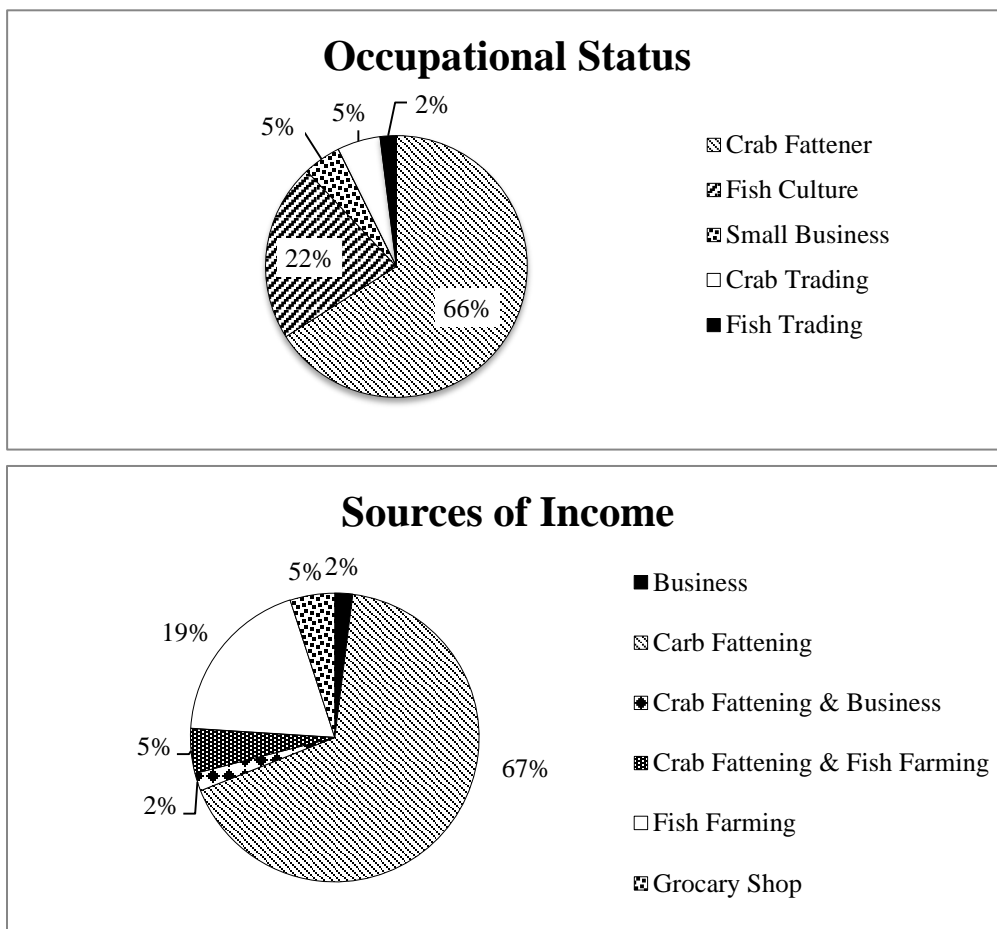
In Bangladesh, aqua-farmers have been practicing mud crab fattening mainly in earthen ponds; however, escape through burrowing is a common problem. High mortality is another production constraint, likely due in part to turbid waters, fluctuations in salinity and limits on the knowledge of farmers of water quality management. Introduction of cage culture and other innovative enclosures is new in Bangladesh though adopted in many Southeast Asian countries, e.g., bamboo and net cages (Kuntiyo 1992) in the Philippines, bamboo enclosure and cage in river and canals in Myanmar (Felix et al. 1995), and floating cage culture in Vietnam and Malaysia (Sivasubramain and Angel 1992). Training and workshops on best management practices were performed. The workshops were designed to help women aquaculturists improve their farm practices including potential integration of tilapia.

## **Results and Discussion**

The baseline analysis found that 52 % of the crab farmers had more than five years of experience in crab fattening but little experience with crab-tilapia polyculture. About 24 % of the farmers in Khulna have more than 10 years of experience while only 18 % of farmers in Bagerhat had more than ten years of experience in crab fattening. The majority of respondents were involved in crab fattening (66 %). The other respondents were involved in fish culture (22 %), crab trading (5 %), fish trading (2 %), or another type of small business (5 %) (Fig. 1).

About 37 % and 24 % of the ponds were either leased or under a multiple ownership arrangement, respectively, where the ponds were owned by more than one household. About 53 % of the farmers had taken a loan to fund their farming practices. The incomes of the respondents ranged from USD 55 to USD 243 (BDT 4,500 to 20,000). The survey also revealed that more than 78 % of the surveyed farmers did not receive any formal training related to crab farming. As for formal education, the average maximum schooling for the farmers was 5 years after which they started farming to help support the income

of their families. The surveys indicated that 49 % of the respondents had been educated to the primary school level, whereas 40 % had some high school education and 11 % had been educated beyond the high school level.



**Fig. 1.** Occupation status and income source of household members involved in mud crab fattening and culture.

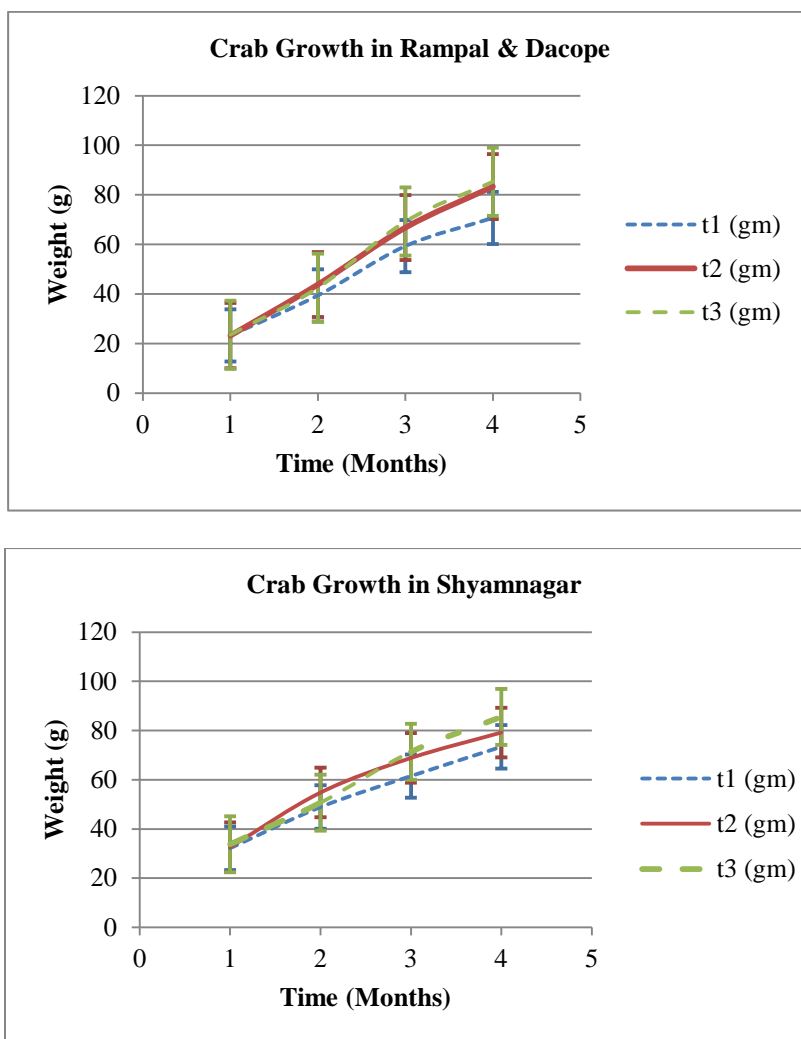
Around 64 % of the crab collectors used filtered pond water, 5 % used pond water directly, and 8 % used rainwater for drinking purpose whereas none of them had their own well. However, 23 % of the crab collectors used well water provided by the local government or those belonging to schools or neighbours.

### *Integrated tilapia-mud crab culture practices*

A pilot study was conducted to determine if introducing tilapia into mud crab culture could increase the well-being of households of women who own

farms. Groups either continued in the traditional mud crab fattening and culture practices (T1, control), cultured tilapia along with the mud crabs and sold the tilapia at market (T2), or cultured tilapia along with the mud crabs but kept the tilapia for consumption by the household members (T3). No additional feed was supplied to the ponds to support the tilapia; tilapia subsisted on biota naturally found in the ponds.

Regardless of the amount of tilapia produced in T2 and T3, mud crab growth tended to be higher in culture with tilapia although the increase did not differ statistically from control (Fig. 2). Crab production increased when grown in the presence of tilapia (Table 1).



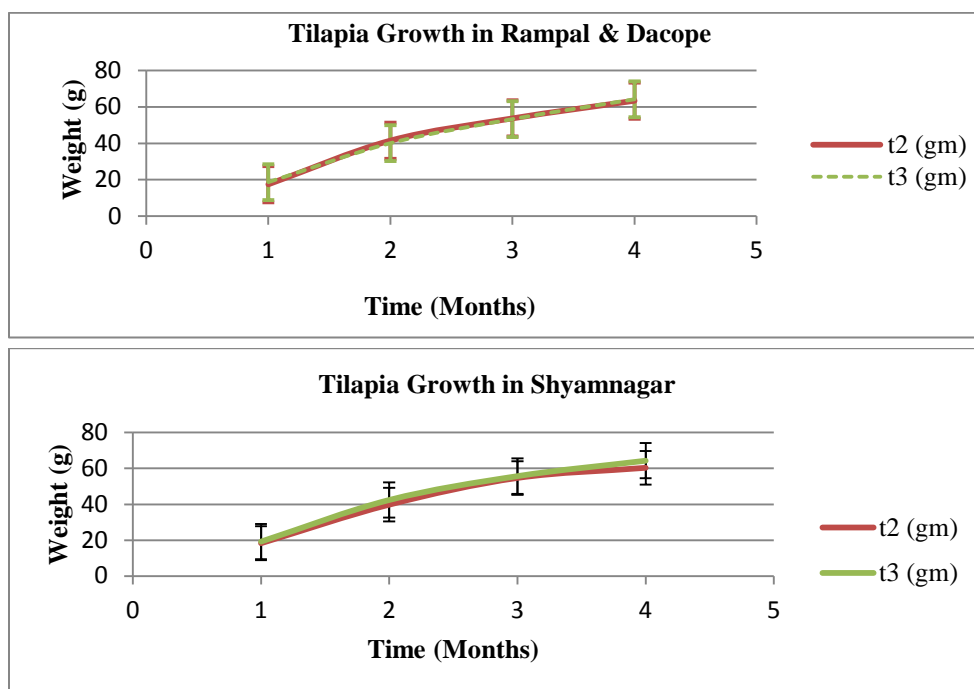
**Fig. 2.** Growth (weight) of mud crabs on integrated farms (mean  $\pm$  SD). Mud crab growth was higher when tilapia was included with mud crab.



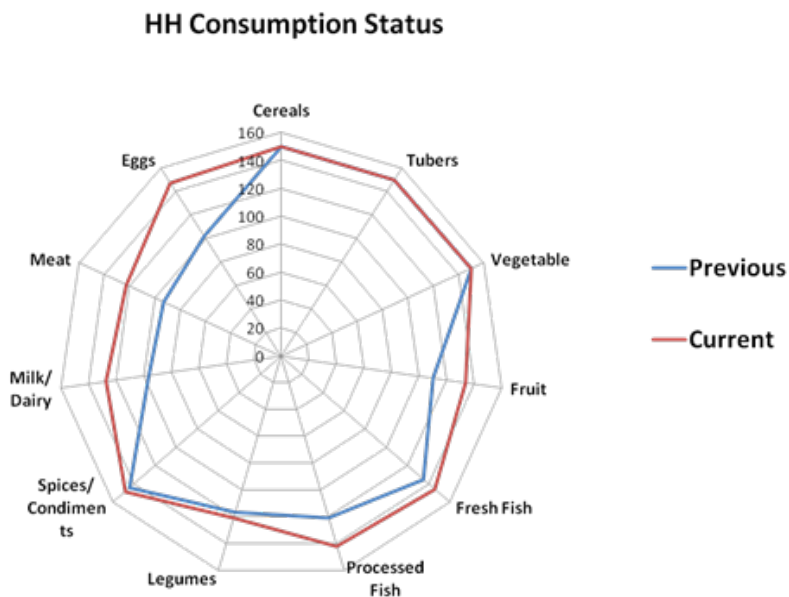
**Table 1.** Total production (weight gained) of mud crabs, including of different size classes, in the mud crab/tilapia pilot study.

Production Grade with Rate	Gained weight (kg)									Others below the size of male & female	Avg. Weight (kg) /point
	XXL +500	XL +400	Male			Female					
			L +300	M +250	SM +200	F1 +180	F2 +180	F3 +160	F4 +130		
<b>Production in Shyamnagar, Satkhira (after 3.5 to 4.0 months)</b>											
T-1	1.40	2.80	4.40	5.50	9.20	1.60	2.30	4.35	5.300	24.40	61.25
T-2	2.10	3.30	4.20	6.40	12.30	1.85	2.50	6.23	11.22	29.10	79.20
T-3	1.55	2.20	5.35	7.35	11.80	1.00	2.74	9.35	12.05	32.15	85.54
<b>Production in Rampal, Bagerhat (after 3.5 to 4.0 months)</b>											
T-1	2.05	2.34	5.15	5.50	8.86	1.80	2.50	4.75	8.45	23.75	65.15
T-2	2.21	3.40	4.60	7.10	10.25	2.75	2.30	7.30	12.02	31.20	83.31
T-3	1.61	2.33	5.15	6.05	11.50	2.10	1.94	10.15	11.45	33.01	85.29

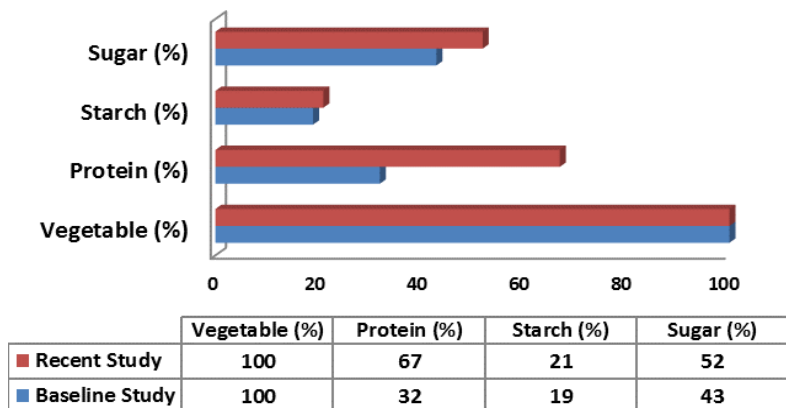
The crabs were fed 10 % of the tilapia in the ponds every week. The tilapia could be providing valuable nutrients and feed biomass to the crabs to increase their growth and production. Fig. 3 shows that growth of tilapia was similar between T2 and T3.

**Fig. 3.** Tilapia growth (weight) on integrated farms.

The addition of tilapia into mud crab culture also increased protein availability to the farmer’s households. The addition of tilapia in crab fattening and culture ponds had benefits in increasing nutrient-rich foods available to the farmer’s households. The households consumed protein-rich foods after the study with greater intensity than they did before the study (Fig. 4).



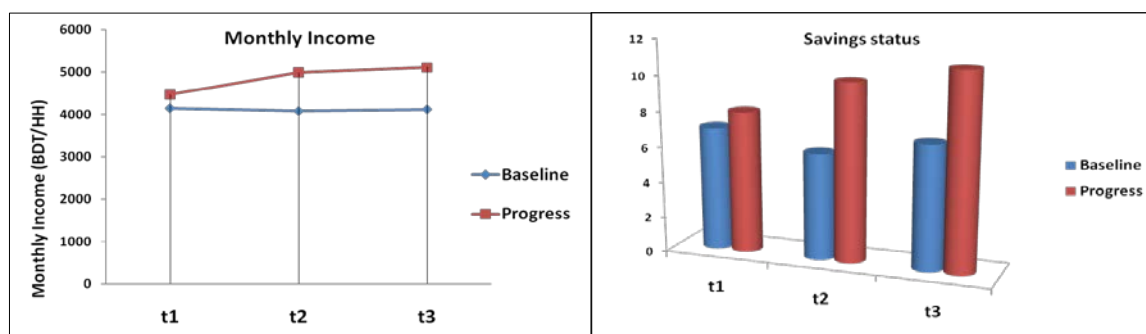
**Fig. 4.** Household consumption of food groups identified. Consumption of protein-rich foods increased after tilapia were included in mud crab fattening and culture.



**Fig. 5.** Proportion of food compositions consumed by study respondents. Respondents consumed more protein and sugar after inclusion of tilapia in mud crab fattening and culture facilities (recent versus baseline).

Respondents who consumed protein increased from 32 % in the baseline study to 67 % in the follow-up survey (Fig. 5). This is a significant increase in protein consumption for households. There was also an increase in the proportion of respondents (52 %) who consumed sugar after the pilot study compared with that observed in the baseline survey (43 %).

The other offshoot of this study was that more women were becoming income earners in each of the households. During the baseline survey farmer's lowest income was only USD 55 (BDT 4,500) and highest income was USD 243 (BDT 20,000) and the average income was USD 150 (BDT 12,250). After the integrated tilapia-crab study the average income was USD 183 (BDT 15,000) with the income pattern and savings improving from the previous baseline period. According to the baseline report only 38 % of respondents were able to maintain their savings for the betterment of the family. Afterwards nearly 48 % of respondents have the capacity to keep savings in banks and other financial institutions (Fig. 6).



**Fig. 6.** Comparison of monthly income and savings by study respondents. Income and savings of respondents increased after they incorporated tilapia into mud crab culture (recent versus baseline).

This is important because this leads to a total increase in income for the entire household, income that can be included in purchasing necessary foods for the health and well-being of all members of the household. The inclusion of tilapia in mud crab fattening and culture farms in this pilot study led to greater overall growth and production of mud crabs. This in turn could increase income to the farmers, not only through the greater production of mud crabs but also supplemental sales of tilapia not kept by the farmer's families for consumption.

On-farm training and workshops were provided to describe this new technology to the farmers and for improving mud crab fattening and culture. It mainly targeted women crab farmers in order to give them valuable information on the methods and outcomes of integrating tilapia into their crab fattening and culture operations. Items discussed were methods to include and grow tilapia along with the mud crabs and methods of proper water quality maintenance and pond preparation such as dike construction, water exchange facilities, use of fertilizer and lime, physiochemical parameters, crab and tilapia feed, stocking density, management during stocking, post-stocking management, feed utilization and feed conversion, harvesting and handling of crabs and fish, marketing, grading of crabs, and record keeping. This session also allowed the farmers to ask questions about crab and tilapia farming to members of the research and extension team. Household nutritional sessions were also given to assess and exchange nutrition information to the farmers. Changes in protein and other food nutrient uptake, and issues of malnutrition that may be resolved with these new culture methods were discussed. These sessions educated the farmers in basic concepts of food and nutrition. An extension factsheet was produced which detailed the pilot study and its potential benefits to income, nutrition, and health of the participants. This brochure was given to the participants of the training workshop and to other crab farmers in the region. The brochure included details on the methods and function of crab/tilapia polyculture with information on how these practices could lead to better seafood production and its impacts on the well-being for the women farmers and their families.

## **Conclusions**

45 mud crab farmers were trained in the new technology of integrating tilapia into mud crab fattening and culture. This polyculture system slightly enhanced the production of mud crab, and the smaller tilapia provide a source of feed for mud crab, that can reduce reliance on wild-caught trash fish. Farmers may also consume larger tilapia or sell them. The tilapia-mud crab polyculture system had the added benefits of increasing income status along with consumption of animal proteins by farmers and their families. Through outreach and extensions workshops and sessions, more farmers have been educated on tilapia-mud crab polyculture and it is anticipated as farmers become more successful, the technology will spread, particularly among impoverished women

who rely on mud crab fattening and culture for their livelihood. Accompanying nutritional education for the households could be important.

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### References

- Ahmed, N. 2007. Development of tilapia marketing systems in Bangladesh: Potential for food supply. National Food Policy Capacity Strengthening Programme. Final Report. Bangladesh. 54 pp
- Ali, M.Y., D. Kamal, S.M.M. Hossain, M.A. Azam, W. Sabbir, A. Mushida, B. Ahmed and K. Azam. 2004. Biological studies of the mud crab (*Scylla serrata* Forsskål 1775) of the Sundarbans mangrove ecosystem in Khulna region of Bangladesh. Pakistan Journal of Biological Science 1967: 1981-87.
- Azam, K., D. Kamal and M. Mostafa. 1998. Status and potential of mud crab (*Scylla serrata* Forsskål 1775) in Khulna Bangladesh. In National Seminar on integrated management ganges floodplains and sundarbans ecosystem in July 16-18, 1994. (eds. M.A. Rahman, M.S. Shah, M.G. Murtaza, and M.A. Matin ), pp. 150-160. Khulna University, Bangladesh Agricultural Research Council and Department of Agricultural Extension. Khulna University, Bangladesh.
- Begum, M., M.M.R. Shah, A. Al Mamun and M.J. Alam. 2009. Comparative study of mud crab (*Scylla serrata* Forsskål, 1775) fattening practices between two different systems in Bangladesh. Journal of the Bangladesh Agricultural University 7: 151-156.
- Belton, B., M. Karim, S. Thilstead, E. Murshed, E. Jahan, W. Collis and M. Phillips. 2011. Review of aquaculture and fish consumption in Bangladesh. Studies and Reviews 2011-53. The WorldFish Center, Penang, Malaysia. 71pp.
- Felix, S, M. Gazendran and S. Subramaniam. 1995. Aquaculture of mud Crab. Seafood Export Journal 26: 5-6.
- Ferdoushi, Z. and Z. Xiang-Guo. 2010. Role of women in mud crab (*Scylla serrata* Forsskål 1775) fattening in southwest part of Bangladesh. Marine Resource and Aquaculture 1:5-13.

- Hussain, M.G. 2009. A future for the tilapia in Bangladesh. AQUA Culture Asia Pacific Magazine 5: 38-40.
- Khan, M.G. and M.F. Alam. 1991. The mud crab (*Scylla serrata* Forsskål 1775) fishery and its bio-economics in Bangladesh. BOBP/REP 51: 29-40.
- Keenan, C.P. and A.W. Blackshaw. 1999. Mud crab aquaculture and biology in Darwin, Australia. In International Scientific Forum held in, April 21-24, 1997 on Mud crab Aquaculture and Biology. (eds. C.P. Keenan, and A.W. Blackshaw ACIAR proceedings No. 78), pp. 1-98. Watson Ferguson and Company, Brisbane, Australia.
- Kuntiyo, A. 1992. Fattening of mud crab (*Scylla serrata* Forsskål 1775) in net cages installed in the drain canal of intensive prawn ponds fed with trash fish and prawn pellet. MS Thesis. University of the Philippines in the Visayas. 60 pp.
- Sivasubramain, K and C.A. Angel. 1992. A review of the culture, marketing and resources of the mud crab. In: The mud crab (ed. C.A. Angel), pp. 5-12. Bay of Bengal Program, Madras. India.
- World Food Programme. 2011. A rapid food security assessment at satkhira in the context of recent flood and water logging. <http://documents.wfp.org/stellent/groups/public/documents/ena/wfp240049.pdf>. Accessed August 2011.
- Zafar, M. and M.Z.H. Siddiqui. 2000. Occurrence and abundance of four brachyuran crabs in the Chakaraia Sundarban of Bangladesh. The Chittagong University. Journal of Science 24: 105-110.