5th Fisheries Conference and Research Fair 2012

18 - 19 January 2012

Book of Abstracts

BFRF Bangladesh Fisheries Research Forum

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- Fish Biology, Genetics & Biotechnology
- Aquaculture, Nutrition & Diseases
- Openwater Management, Socio-economics & Policy Issues
- Coastal & Marine Fisheries
- Product Development & Quality Management

Bangladesh Fisheries Research Forum
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Foreword

Fish and fisheries are inseparable from the culture and heritage of Bangladesh and the fisheries sector plays an important role in the economy in terms of nutrition, income generation, employment and foreign exchange earning of Bangladesh. Fisheries activities has gradually emerged as an important livelihood options for over million of poorer people including full-time and part-time fisher folks, fish farmers, processors and traders. The primary need for animal protein intake for the overwhelming majority has spurred a range of initiatives among actors and institutions towards scientific fisheries management and aquaculture. To support the ongoing development of fisheries and aquaculture, the need for demand led research and generation of sustainable technologies can not be ignored. It is fact that the researchers in this country have been working in isolation in different universities, institutions and other private and NGOs; and there has been a chronic lack of coordination among the researchers as well as between researchers and the extension agencies. These have resulted repetition of research, misuse of scare resources, and thus slow progress in the sector.

In order to overcome this situation, Bangladesh Fisheries Research Forum (BFRF), a professional organization, was established in 2002 with its mission of breaking the barrier and territoriality among different organizations and bring about all the fisheries academics, researchers, extension agencies of both GO and NGOs and other relevant stakeholders under one umbrella so that we can make good use of resources, serve this important sector together, and thus make rapid development through benefiting the end-users of research outputs.

It is a great pleasure for me to extend my sincere greetings and felicitations to the members of the BFRF on the occasion of 'Fifth Fisheries Conference and Research Fair 2012' to be hold on 18-19 January 2012 for their commendable contributions to the promotion of science of aquatic natural recourses. We have received about 190 abstracts within a short time of announcement and many were obtained even after closing date. We tried our best to include all the abstracts for oral presentation but given the time available in the two days of the conference, we had to offer place for poster presentation for some abstracts. The forum has made a unique opportunity for us all to listen to the findings of the research carried out hitherto and share and exchange knowledge and ideas to decide future course of actions.

Considering the challenges facing our agriculture in general and fisheries in particular due to the environmental factors having negative impacts on fisheries development are by and large man-made intervention in hahitat destruction, disruption of ecology, intensive agriculture, and modern developments, the conference will highlight the present scenario and coping strategies through timely presentation of the keynote paper on '**Habitat and fish diversity: Bangladesh perspective'.** The editorial board has taken a lot of pains and strains in going through and editing the whole lot of abstracts. On behalf of the organizing committee, I would like to thank you all who have given their time to bring out the abstracts book in time and WorldFish Center- Bangladesh and South Asia Office for financial support.

I have very best wishes at the beginning of a new year for all the participants in the two days conference and research fair.

Prof. Dr. Md. Saifuddin Shah
President, Bangladesh Fisheries Research Forum
and
Vice-chancellor, Khulna University, Khulna

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Habitat and fish diversity: Bangladesh perspective

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The lives of Bangladeshis centre around and depend upon fish and water. The country is a transitional zone of flora and fauna, because of its geographical settings and climatic characteristics. It is natural that the water resources of the existing extent and magnitude should harbour and support populations of a large variety of vertebrate and invertebrate aquatic living organisms. Bangladesh's water bodies are known to be the habitat of 270 freshwater fishes, 475 marine fishes, 23 exotic fishes and a number of other vertebrates and invertebrates. The number of openwater species, however, is declining at an alarming rate with some species, in recent years, having become extinct due to a number of reasons. Many species are already in crisis and despite mere conservation initiatives it may already be too late to save them from extinction. Sadly, most Bangladeshis are oblivious to the diversity of species that inhabit its innumerable water bodies – how sad it is to think that a significant proportion of these splendid, vibrantly coloured fish could be lost forever – their names unknown, their beauty and value never fully appreciated.

Bangladesh is most at risk from climate change. The country will face the biggest risks from global warming in the next 30 years. Poverty and large low-lying coastal regions prone to floods and cyclones were among factors making Bangladesh the number one exposed country to climate change. Climate change impacts gradually over a wide range of livelihoods in different settings. Drought and siltation together are reducing over wintering habitat for the fish species resulting in less recruitment into the grazing field to grow open water inland fisheries. Reduced water flow in the Ganges rivers basin has resulted in a severe depletion of fisheries. Due to the decrease in groundwater and surface water, tremendous pressure has been exerted on wetlands to convert them to agricultural land, resulting in a serious decline in the numbers of fish species and the fish production as a whole. Indeed, there may be no where in the world where effects of climate change and other natural/anthropogenic activities on fish biodiversity are more apparent than Bangladesh. The floodplains of the country are now among the fastest disappearing of all ecological systems. Fishing pressure from an ever-growing population has increased dramatically and has seriously affected the abundance of nearly half of the inland fishes of Bangladesh, particularly small fishes like minor carps, loaches, barbs, minnows, catfishes, parchlets, gobies, featherbacks, snakeheads and eels.

Most of the indigenous fish are migratory and rely on seasonal flooding for spawning cues and access to larval rearing habitat (floodplain). Almost all dams and embankment interfere directly with the successful completion of the fish migration (breeding and feeding). Agriculture (excessive removal of surface water and extraction of groundwater for irrigation), pollution (domestic and industrial), and unregulated discharge of untreated industrial and farm effluents, habitat destruction also have significant impact, as does the regular over flooding and lack of flooding rain in the last few decades. Introduced species (primarily tilapia, Chinese carp, African magur, Piranha and Thai pangas) are significant contributors to aquaculture production, but also threaten the biodiversity of indigenous

fishes. In past, stocking of rivers and floodplain is carried out with both indigenous and introduced species by government and through different projects. The effectiveness of stocking activities has generally not been well assessed. Furthermore, the impacts of aquaculture (both commercial and small scale) have not been accurately assessed in this country. Capture fisheries in inland waters which are based on natural productivity generally have reached the level of overexploitation. The inland open water fisheries, where the floodplains assume an important position in the livelihoods and nutrition of the rural poor have now been under serious threat of resource depletion due to various man-made and natural causes. The majority of the waters of this type have been depleted to an alarming state and warrant urgent interventions for conservation and sustenance. Some rivers and floodplains have been modified to a level where they are only recognized as narrow ditches and paddy fields. During 1960s, the inland capture fisheries contributed about 90% of the country's total fish production. Due to the rapid increase of aquaculture production and sharp decrease of capture fishery production, in 2007-08, the aquaculture contributed almost equally (about 40 %) as inland capture fisheries in total fish production of the country. Since 1970, the annual flooding of approximately 2-3 million ha of floodplain has been either controlled or prevented altogether by means of sluice gates or pumps positioned along earth embankments or levees. This reduction in area is believed to be one of the major reasons for declining floodplain fisheries in Bangladesh.

There are serious concerns surrounding the slow decline in the condition of openwater fish stocks which have been negatively impacted upon through a series of natural and anthropogenic induced changes. These include disturbances resulting from rapid growth of population coupled with lack of proper management policy, water management programmes including the large scale abstraction of water for irrigation and the construction of water barrages and dams, human activity resulting in the overexploitation of fish including use of harmful fishing gears and system (fishing by dewatering, poisoning, using explosives), road communication, siltation of water bodies by natural process, the unregulated introduction of alien stocks and pollution from industry and agrochemicals. As a consequence, many Bangladeshi species have become critically endangered like – *Hemibagrus menoda*, *Barilius barila*, *Dermogenys brachynopterus*, *Botia dayi*, *Raiamas bola*, *Psylorhynchus sucatio*, *Scistura corica*, *Labeo pangusia*, *Labeo angra*, *Botia lohachata*, *Barilius barila*, *Chagunius chagunio*, *Gogangra viridescenes*, *Silonia silondia*, *Setipinna phasa*, *Laguvia shawi*, *Crossocheilus latius* or many more. Biodiversity status of many of the fishes have now changed from that listed in the IUCN Red Book almost a decade ago. The results of the survey conducted by FMBC (2011) found following fishes as extinct from Bangladesh water - *Neoeucirrhichthys maydelli*, *Pangio pangia*, *Salmostoma sardinella*, *Esomus* lineatus, *Garra annandalei*, *Neolissochilus hexagonolepis*, *Osteochilus hasseltii*, *Raiamas guttatus*, *Mystus armatus*, *Laguvia shawi*, *Pseudecheneis sulcata*, *Ailia punctata*, *Ambassis nalua*, *Channa barca* and *Pseudosphromenus cupanus* and a few more.

In recent years, GoB and the donors have placed major emphasis on capture fisheries, conservation, management, and development of institutional framework and need-based training. All concerned and working for the betterment of the fisheries sector of Bangladesh – the fishers, fish farmers, general people, local leaders, researchers, policy makers, GO and NGO workers should come forward to conserve the precious fish and ecosystem diversity of the country and to increase the fish production through effective coordination, long-term programme and sustainable approaches. This is the high time to care for the aquatic biodiversity – both habitat and species– the pride, heritage and livelihood of Bangladesh before they are lost forever. The national and international bodies should come forward to conserve aquatic ecosystems and organisms using both *in situ* and *ex situ* approaches.

Study of reproductive physiology of mud eel *Monopterus cuchia* for artificial propagation

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Mud eel (*Monopterus cuchia;* locally *cuchia*), native to Bangladesh, is considered to be a nutritious and tasty fish and is also a valued remedy in oriental medicine. Out of more than 800 fresh and saltwater fish and shrimp species of Bangladesh, only four are exported to foreign consumer market; *M. cuchia* is one of them. It is exported collecting from nature. Artificial breeding and fry rearing technique of mud eel in Bangladesh has not been developed yet. *M. cuchia* is also a threatened species of Bangladesh (IUCN Red List, 2000). The study of reproductive physiology and GSI of this threatened species from the haor area of Mohongonj, Netrakona will not only prevent this fish from extinction but also will help to introduce aquaculture of this exportable fish species.

Histological observation of ovary observed presence of underdeveloped oocytes (UO), early (EPNO) and late perinucleolar oocytes (LPNO), yolk vesicle (YV) and early yolk granule (EYG stage) oocytes inside the ovarian tubule (OV-T) in March. Occurrence of high proportion of early stage oocytes (UO, EPNO, LPNO, etc.) indicate developing ovary in preparatory phase; but not yet ready to spawn. In April samples, UO, EPNO, LPNO, EYG, late yolk granule (LYG) and premature (PM) stage oocytes were evident inside the OV-T. Occurrence of advanced stage oocytes (EYG, LYG, PM, etc.) indicate that mature ovary is almost ready to spawn (Fig. 3). The GSI was calculated for female mud eel during July to September, 2011. Values of GSI decreased from 1.67 ± 0.37 to 0.36 ± 0.18 during July to September. The higher values of GSI was observed during July was 1.67 ± 0.37. Gradual decrease of GSI values from July towards September indicative of end of spawning season after July. This study provides the first detailed information about breeding season of endangered *M. cuchia* that will contribute to develop artificial propagation of this species.

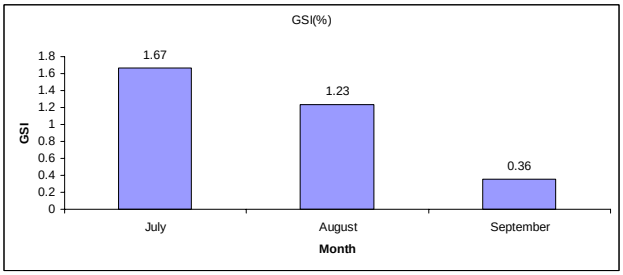

Fig. 1. Monthly mean GSI of female *Monopterus cuchia.*

Some biological aspects of *Puntius sophore*

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Puntius sophore is locally known as Punti. The species is available in all freshwater bodies of Bangladesh throughout the year. The fish is esteemed as food as an account of invigorating qualities its flesh. A seven months study was conducted to investigate some biological aspects of the fish. During the study period the length of marketed wild fish recorded from 7.2 to 10.6cm. The length-length relationships (TL/SL, TL/DL, TL/PL, TL/ PvL, TL/AL) of the fish were found isometric and highly significant irrespective of sex. The percentage composition of stomach contents of the fish were found as plant matter (29.15%), insects (8.25%), crustaceans (7.17%), debris and mud (19.65%), and unidentified (35.78%). The relationship between total length and alimentary canal length of the fish was obtained as 1 t 4.98, which indicates its herbivorous character. It is also observed that the fish changes its food habit with the change of season and degree of maturity.

Genetic structure of rohu *Labeo rohita* and catla *Catla catla* stocks under the brood bank development project of the Department of Fisheries

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Information on the genetic structure of fish species is essential for optimizing fisheries management and stock improvement programs. The genetic variation in three river populations (the Halda, the Jamuna and the Padma) of rohu (*Labeo rohita*) and catla (*Catla catla*) stocked in different hatcheries and farms of the Department of Fisheries under the Brood Bank development project were analysed by microsatellite DNA markers. Fin tissue samples of thirty fish from each of the three populations were collected. Three microsatellite loci for rohu (*Lr1*, *Llr3* and *Lr6*) and three microsatellite loci for catla (*Ccat A12*, *Ccat G1*, and *Ccat C3*) were analysed to elucidate the population genetic structure of the two important major carp species stocked under the Broood bank project of Department of Fisheries. The microsatellite markers were amplified by polymerase chain reaction (PCR) and resolved on denaturing polyacrylamide gel and visualised by silver nitrate staining. All three loci were found to be polymorphic in all populations of both species.

In rohu, the loci *Lr1* and *Lr6* had a maximum of 10 alleles while locus *Lr3* had a maximum of 8 alleles. The average number of alleles obtained in the Padma and the Halda populations was higher (8.33) than that of the Jamuna population (7.33). The observed overall heterozygosity value of the Halda population was the highest (0.8716) while that of the Jamuna population was the lowest (0.7863). All of the populations deviated from the Hardy-Weinberg proportions at three loci *(Lr1*, *Llr3* and *Lr6).* Population differentiation (F_{ST}) values between all the population pairs were found to be insignificant. Among the allele obtained in this study, the Jamuna population had a maximum number of missed alleles (6) and the Padma and the Halda populations had equal number of missed alleles (3).

In catla, the locus *Ccat C3* had the highest numbers of alleles (10), while the locus *Ccat G1* had the least (4). Differences were observed in heterozygosities and average numbers of alleles among the three populations; however, no difference was observed in proportion of polymorphic loci (P_{95}) among the populations. Between the studied populations few were deviated from Hardy–Weinberg equilibrium because of high level of heterozygosities. The population differentiation (F_{ST}) value between the Padma and the Jamuna population was the highest (0.0702), on the other hand that between the Halda and the Padma population was the lowest (0.035). The genetic distance computed by Nei between the Padma and the other two populations was higher than the genetic distances between the other two population pairs.

The study revealed a relatively high level of genetic variation in the river populations of rohu and catla. These variations indicate that there is scope to use the fish for stock improvement program through selective breeding. The variations should be maintained through proper management like imposing ban on fishing in a certain period particularly in the spawning season.

Morphological variations of freshwater giant prawn *(Macrobrachium rosenbergii)* at local markets in Batiagata, Khulna

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An experiment was conducted from June 15 to November 15, 2011 to determine morphological variations of freshwater giant prawn *(Macrobrachium rosenbergii)* at local market of Batiaghata, Khulna. Samples of prawn were collected directly from the different local markets namely Batiaghata bazar, Gollamari bazar, Mailemara bazar etc of batiaghata of Khulna region. Two types of male morphotypes were found in local markets; blue clawed male (BC) and orange clawed male (OC). They differed in cheliped morphology and some morphometric characters. OC had large orange claws on their second chilete leg. OC males later might transform into the third and final stage, the "blue claw" (BC) males. These had blue claws, and their second chilete leg might become twice as long as their body. BC males inhibit the growth of SM prawns. The total length, chilete length, body length, carapace length, weight and rostrum length were significantly different between the two morphotypes. These types of variation affect total production and market value. The prawns are graded according to their weight classes; the price which the farmer gets for the harvest depends on the quantity of higher weight group prawns which gets better price. In my present study, higher weight groups were found in blue clawed male. Ultimately the size and weight of prawn influences the economic viability. Each morphotype may play a different role in the population and in the environment in which it lives.

Table 1. Morphometric characters of BM and OM

Traits	BM	OM
TL (cm)	22.28±2.96	21.42±2.77
W(g)	132.88±53.52	146.13±57.16
BL(cm)	12.28±3.16	14.42±2.19
CL(cm)	8.96±3.92	6.21±1.03
RL(cm)	7.16±.96	6.05±1.09
CLL(cm)	21.02±5.34	22.89±3.56

Histological study of gametogenesis in captive pangasius catfish *Pangasius pangasius*

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The critically endangered pangasius catfish, *Pangasius pangasius* collected from the Meghna and reared in captivity at the BFRI Riverine station, Chandpur during May - October, 2011, was studied for determining gonado-somatic index (GSI) and stages of oocytes and testicular germ cells during spawning and the post-spawning season, and finally to identify peak breeding season. The highest GSI of female *P. pangasius* was 9.52 in July and the lowest was 0.59 in September. Histological observation of ovary identified undeveloped oocytes (UO), early perinucleolar oocytes (EPO), late perinucleolar oocytes (LPO) and previtellogenic oocyte (PVO) during the entire study period (May to October). Yolk vesicle stage (YV), granule stage (YG), vitellotenic oocyte at vesicle breakdown stage (VO-vb) and vitellotenic oocyte at hydration stage (VO-h) were particularly evident during May to August; indicating spawning season for female pangasius. High amount of mature stages oocytes were evident in July samples. UO, EPO and LPO stages of oocytes were evident during September and October samples month indicated spent ovary. Microscopic observations of testes sections identified spermatocyte (SC), spermtids (ST), spermatozoa (SZ) and empty lumen of tubules (LU). Abundant of early stages germ cells and at low density with empty LU in May and presence of ST and SZ in low quantity indicated gradually maturing testes. Mature testicular germ cells in high number inside the lumen were observed from June to August, indicating period of testicular maturity of male pangasius catfish in captivity. In September and October, the testes were found spent indicated by low density of germ cells with empty LU. The highest GSI value of female in July conceded with mature ovary in July and matures testes in July and August indicates a peak breeding season of captive *P. pangasius* in Bangladesh in July. It is expected that the findings from the present study will be helpful for better management of pangasius catfish fishery in this country towards its conservation and for introduction of this potential species into aquaculture.

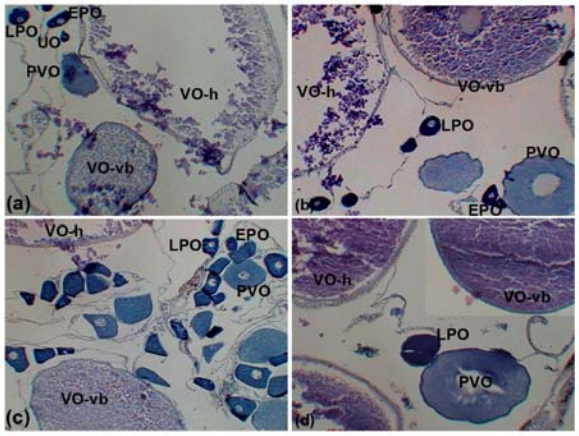

Fig. 1. Haematoxyline-eosin stained sections of *P. pangasius* ovary (a-d) at 10× magnifications. (a) Ovary from 1700 g female (BFRI ♀) sampled in May, 2011; (b) Ovary from 1600 g female (BFRI ♀) sampled in June, 2011; (c) Ovary from 5500 g female (Meghna ♀) sampled in May, 2011.

Reproductive cycle of giant river catfish *Sperata seenghala* from the Sylhet basin

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In order to conserve the biodiversity and to develop suitable techniques for the rearing and culture of *S. seenghala* it is essential to confirm the appropriateness of macroscopic staging of gonad with histological examination, study the reproductive physiology of male and female through gonadal histology and identify the peak breeding season of and finally produce an accurate and understandable descriptive guide for future macroscopic staging of ovary and testes of based on histology. During the study period, the experimental fishes were collected month-wise (March-August, 2011) from catches of Sylhet basin. Early and developing stage oocytes were mostly observed during April-May, maturing oocytes in June, and mature oocytes during July-August. Testicular germ cells stages, such as spermatocytes, spermatids and spermatozoa were observed after H-E staining of testes. Early and developing germ cells were mostly observed during April-May, gradually maturing in June, and mature germ cells during July-August sections of testes. Mature oocytes evident in ovary samples during July-August indicated mature phase of ovary ready to spawn. Again, appearance of most mature testicular germ cells in July-August samples are also supportive of the peak maturity of testes at the same time. The combination of ovarian and testicular histology summarizes that *S. seenghala* breeds during late monsoon. It is remarkable that, while many fish species from the freshwaters start to breed with the first rain in the year, *S. seenghala* breeds in the late monsoon. For maintaining biodiversity of this species in the natural waterbodies, it is necessary to take steps towards conservation of this species through detailed studies of reproductive physiology and development of seed production techniques.

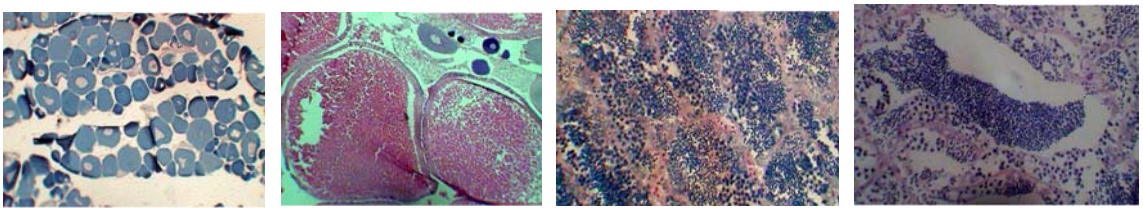

Fig. 1. Haematoxylin-eosin stained sections of *Sperata seenghala* ovary (a. March; b. July) and testes (c. May; d. July).

Reproductive biology of Gangetic hairfin anchovy *Setipinna phasa* from the Halda river

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Gangetic hairfin anchovy *Setipinna phasa* a commercially important clupeid is abundant in the lower section of the tidal river Halda. The fish is also available in the other tidal rivers of Bangladesh and established in the Kaptai reservoir after damming the River Karnaphuli. Although the fish is highly demanded with increased market value and can sustain in open lake waters, no step is taken yet for its culture development. Before selecting a species for aquaculture, its reproductive biology should be known in detail. In order to elucidate the reproductive features of the species, a one year study covering January to December 2010 was under taken on *S. phasa* of the Halda River, a famous spawning ground of major carps.

A total of 941 individuals of *S. phasa* were used for sex ratio study, 55 individuals for gonadal development study and 35 ripe fishes for fecundity study. Monthly sex ratio of male and female varied from 1.00:0.80 to 1.00:1.17 with a yearly average of 1.00:1.20 (χ^2 = 0.55, $p>0.05$, N= 941, df =1) and showed no significant difference from hypothetical ratio of 1:1. Female attained first maturity at 19.6 cm total length and 47 g body weight. No significant variation in development of ova in two lobes of ovary (χ^2 = 0.34, $p>0.05$, N= 55, df=1), (t= 1.37, $p>0.05$, N= 55, df= 22,) or in different anterio-posterior regions of ovary (F= 0.30, df= 13,70, $p>0.05$) was found. Fecundity varied from 3666 to 35607 eggs with a mean of 14845± 7004. Fecundity factors varied from 59 to 292 eggs/g of body weight with a mean of 230.8±49.6. Spawning occurred twice yearly with a prolonged duration, one during February to May with a peak in March and another one during August to December with a peak in November. Fecundity was highly correlated ($p<0.001$) with total length, body weight and ovary weight.

Fecundity, food and feeding habit and some aspects of biology of *Liza parsia*

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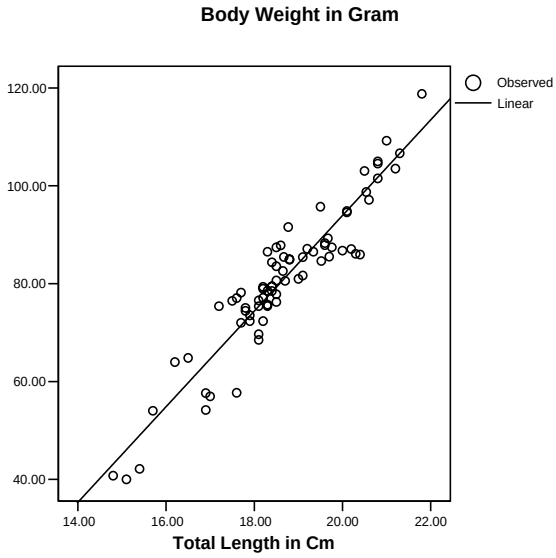
In order to estimate the fecundity, reproductive character and feeding habit of *Liza parsia* (Hamilton), 75 gravid female were collected from the local markets of Khulna District during November 2010 to January 2011. The equation for the total length-body weight and standard length-body weight relationship of the species were found to be $BW = -101.46 + 9.77 \times TL \ (r^2 = 0.88)$ and $BW = -77.19 + 9.92 \times SL \ (r^2 = 0.87)$ respectively. The condition factor ranged from $10.12 - 15.05$. The mean value of the condition factor was 12.3560 with a standard deviation of 1.0822. Fecundity of *Liza parsia* ranged between 56541 to 188860 and mean fecundity was calculated at 122999.80 ± 30035.048. Total weight of the gonad varied from 5.41 to 18.41g where the weight of left and right lobe of the ovary varied from 2.78 to 9.57g and 2.63 to 9.25g respectively. The mean weights of right and left lobe gonad were 5.942 ± 1.409g and 5.589 ± 1.381g respectively. The mean weight of gonad was found $11.532 + 2.773$ g. The regression equation for total length and fecundity, standard length and fecundity, body weight and fecundity, gonad weight and fecundity was estimated at $F = -176359 + 16034.5 \times TL \ (r^2 = 0.60)$, F=−132956+16059.9xSL($r^2$=0.57), $F = -5595.3 + 1588.79 \times BW \ (r^2 = 0.63)$ $F = 9048.16 + 9881.27 \times GW \ (r^2 = 0.83)$ respectively. The GSI values obtained in the present study varied between 7.90 to 17.61. The mean value of the GSI was 14.2045 with a standard deviation of 1.65155. The stomach contents were consisted of algae, diatoms, desmids, plant materials, annelids, crustacean, bivalves, fishes, detritus and sand grains. Food items indicated that the species is an omnivore in its feeding nature.



Genetic variation in wild and hatchery populations of two Indian major carps (*Labeo rohita and Cirhinus cirrhosus*) using allozyme marker

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To investigate genetic variation in two Indian major carps (rohu and mrigal) of three wild i.e., the Halda (P_1), the Jamuna (P_2) and the Padma (P_3) and six hatcheries of three different regions i.e., Brahmaputra (P_4) and Rahim fish hatchery (P_5), Mymensingh; Rupali-J (P_6) and Ma-fatema (P_7) fish hatchery, Jessore; Bismillah (P_8) and Rupali-C (P_9) fish hatchery, Comilla were used. For allozyme electrophoresis, muscle sample of 360 individuals with four enzymes were used (LDH, MDH, PGM and GPI) in CA 6.1 buffer system. Seven presumptive loci were screened and five of them (*Mdh-1**, *Mdh-2**, *Pgm**, *Gpi-1** and *Gpi-2**) were found to be polymorphic (P_{95}) in case of rohu populations and four loci (*Mdh-1**, *Mdh-2**, *Gpi-1** and *Gpi-2**) were found to be polymorphic (P_{95}) in case of mrigal populations. The mean proportion of polymorphic loci in rohu were 28.57%, 42.86%, 14.29%,57.14%, 28.57%, 57.14%, 57.14% and 28.57% in P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8 and P_9 respectively and in mrigal 14.29%, 14.29%, 14.29%, 28.57%, 14.29%, 14.29%, 42.86%, 42.86% and 42.86% in P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8 and P_9 respectively. The Nei's (1972) analysis of gene diversity within populations estimated the genetic differentiation (F_{ST}) over all nine populations of rohu and mrigal were 0.092 and 0.213 and the gene flow (N_m) was 5.366 and 16.181 respectively. Based on Nei's (1972) UPGMA dendrogram, 18 populations of rohu and mrigal were divided into two major clusters. Claster-I for rohu and claster-II for mrigal. In claster-I three wild populations of rohu separated from six hatcheries populations by the genetic distance of $D = 0.081$ and in mrigal populations wild populations also separated from hatchery populations by the genetic distance of $D=0.008$.

Table 1. Genetic variabilities of nine *L. rohita*

Pop.	*Na*	*Ne*	Heterozygosity		*I*
			H_o	H_e	
P_1	1.14	1.13	0.05	0.07	0.09
P_2	1.14	1.11	0.07	0.06	0.09
P_3	1.14	1.07	0.05	0.05	0.07
P_4	1.28	1.19	0.07	0.11	0.16
P_5	1.14	1.08	0.03	0.05	0.08
P_6	1.14	1.09	0.01	0.05	0.08
P_7	1.42	1.36	0.14	0.20	0.27
P_8	1.42	1.36	0.11	0.20	0.27
P_9	1.42	1.32	0.10	0.18	0.26

Table 2. Genetic variabilities of *C. cirrhosus*

Pop.	*Na*	*Ne*	Heterozygosity		*I*
			H_o	H_e	
P_1	1.42	1.27	0.07	0.11	0.18
P_2	1.71	1.34	0.09	0.12	0.23
P_3	1.42	1.23	0.09	0.09	0.15
P_4	1.57	1.24	0.07	0.15	0.24
P_5	1.71	1.32	0.14	0.19	0.30
P_6	1.42	1.31	0.14	0.15	0.22
P_7	1.71	1.31	0.12	0.17	0.28
P_8	1.57	1.30	0.14	0.18	0.26
P_9	1.28	1.24	0.07	0.13	0.18

PCR-based detection of *Pseudomonas fluorescens* isolates collected from diseased fish

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Studies were conducted for rapid detection of *Pseudomonas fluorescens* isolates associated with 'Bacterial Hemorrhagic Septicemia' disease of carp and catfish by Polymerase Chain Reaction (PCR) method. *P. fluorescens* specific and highly conserved forward and reverse primers were designed after alignment of 16S rDNA sequences available in the database. The forward primer (225F) was 18 bp in length and the reverse primer (1265R) was 17 bp in length. Percentage of Genus/Species specific conserved region of the PCR primers was calculated by base pair specific calculation. The Forward primer (225F) possess 27.78% conserved region compared with *Aeromonas* spp., 27.78% with *Edwardsiella* spp., 50% with *Flavobacterium* spp. and 38.89% with *Vibrio* spp. whereas reverse primer hold about 58.82% unique sequence with *Aeromonas* spp., 41.17% with *Edwardsiella* spp., 64.70% with *Flavobacterium* spp., and 42.12% with *Vibrio* spp. A total of seven isolates viz. $PuKL_2$, $PuKL_{22}$, PFK_{13}, Cla_1B_8, Cla_1B_{10}, Cla_1B_{18} and P_2F_2 collected from hemorrhagic septicemia infected carp and catfish and identified to be belong to *P. fluorescens* gave the expected 1040 bp PCR product. Isolates belonged to *Aeromonas* spp, *Edwardsiella* spp., *Flavobacterium* spp. and *Streptococcus* spp. did not amplify in the PCR method. Thus the PCR method was found selective for *P. fluorescens*. This PCR based detection of *P. fluorescens* could be used for rapid and specific detection of *P. fluorescens* pathogen form disease infected fish and waterbody.

Refrigerator storage of sperm of an Indian major carp, *Labeo calbasu*

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The study focused on the spermatological properties and development of a protocol for refrigerator storage (4°C) of *Labeo calbasu* sperm for artificial breeding. Sperm samples were collected from artificially induced males. Volume, motility, concentration and pH of the freshly collected sperm were 2.21±0.53 (µl g^{-1}), 95±1 (%), 1.93±0.44 ($\times 10^9$) and 7.56±0.17, respectively. Sperm activated with 0.3% NaCl (96 mOsmol kg^{-1}) retained motility for longest duration of 138 s. Sperm activation was then evaluated at different osmolalities of NaCl solution and motility was completely ceased when osmolality of the extender was ≥ 287 mOsmol kg^{-1}. Alsever's solution, formulated at osmolality of 296 mOsmol kg^{-1} was used as diluents for sperm during refrigerator storage. Sperm retained motility for 24, 72 and 108 hrs, respectively after refrigerator storage, when sperm were undiluted, suspended in Alsever's solution, and in Alsever's solution containing 5% methanol. Fertilization rate of fresh eggs with 16 hrs stored (4°C) sperm in Alsever's solution and Alsever's solution containing 5% methanol was 77% and 60% with a hatching rate of 60% and 43%, respectively. Simple storage of diluted sperm in a refrigerator for a couple of days is such an easy procedure that can be adapted to all sorts of the fish hatcheries. The fertilization and hatching success of the stored sperm signified the applicability of refrigerator storage of fish sperm to transport the genetic material to the nearby and distant hatcheries for artificial breeding of *L. calbasu* in Bangladesh.

Improvement of maturation and spontaneous spawning of threatened fish species kholisa (*Colisa fasciatus*) with polyunsaturated fatty acids

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Lipid and fatty acid composition of broodstock diet have been identified as major dietary factors that determine the reproductive success, egg quality, fecundity, fertilization success, hatching success, and survival of offspring. The present study was conducted to observe the effects of polyunsaturated fatty acids (PUFAs) enriched diets on improved maturation, spontaneous spawning, viable egg and sperm production as well as fry growth of *C. fasciatus*. The kholisa were stocked in cisterns and provided supplemental diet enriched with 1% phospholipids (PL) for three months and a control diets without PL. Sperm qualities were determined by staining with trypan blue dye. Trypan blue stains only the dead sperm and not the live ones. Sperm were counted by using a hemacytometer under microscope. The live sperm count was significantly higher (p<0.01) in treated group compared to control group (98.86±0.87 % live sperm for treated group and 92.58±0.67 % for that of control group). *C. fasciatus* bred spontaneously in the cistern in case of treated group. As they spawn spontaneously, the fertilization rates and hatching rates of fertilized eggs of the treated groups were remarkably high, about 93.45±2.62% and 98.43±3.03%, respectively. Embryonic and larval development of kholisa was observed successively. Histomorphology of ovary showed that most of the oocytes were at the stage of late yolk granule (LYG), migratory nucleus (MN), and the germinal vesicle breakdown. Afterward the oocytes ovulated into the ovarian lumen and became mature or ripe eggs (RP). Subsequently, the peripheral migration of the nucleus and the dissolution of its membrane were observed (in April PUFAs treated kholisa) which point towards the fish will spawn spontaneously. Whilst in control group mostly observed oocytes were in pre-maturation stage (oocyte growth). Histoanatomical changes in liver confirmed significant amount of lipid droplets, initially small droplets of fat and gradually the droplets increased in size and finally coalesced to form a single large droplet. The highest were in prespawning period (March in case of PUFAs treated kholisa) and it decreased as early as April or May. While, no such lipid droplets were initiated at that point in time in control group. The experiment of calcium concentration in the blood serum is an indicator of augment of estradiol-17β (E2) secretion during ovarian maturation consequence the release of Vitellogenin (Vtg) protein by the liver into the bloodstream, taken up by growing oocytes, and chemically modified to form a suite of egg yolk proteins by introducing biofunctional compounds in fish diet. The serum calcium concentration values were peak (3.699±0.014 mg/dl) in April (in PUFAs treated). Four types of PUFAs enriched diets containing 1 % Docosahexaenoic Acid (DHA), 1 % PL, 5 % Cod liver oil, and 1 % Cod liver oil were provided to observe the growth of *C. fasciatus* fry for 50 days. Control (without PUFAs) and live feed (Tubificid worm) were also used. Growth of fry were found significantly higher (p<0.05) in DHA and PL enriched diet compared to control. The result suggests that it would be possible to spawn this species spontaneously with this biofunctional lipid as an ingredient of supplemental diet. Therefore, this technology may be applicable for conservation of other threatened fish species in Bangladesh.

Development of quality broodstock of freshwater prawn *Macrobrachium rosenbergii* and assessment of breeding performance

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To develop a protocol for the production of quality broodstocks for *Macrobrachium rosenbergii*, the present study was carried out at Noakhali during September 2009 to May 2011. One hundred eighty juveniles of *M. rosenbergii* of local river origin were stocked in each of 6 ponds of size 15 decimal (12 juveniles/decimal) maintaining 1:2 male-female ratio. Three feeds - i) Mega shrimp feed (protein 37%), ii) Quality shrimp feed (protein 26%) and iii) own formulated feed (protein 32%) were considered as T_1, T_2 and T_3 respectively having two replicates each. They were reared for 5 months until maturation. Berried females reared with own formulated feed (T_3) were shifted to a private prawn hatchery, Sonapur, Noakhali for breeding purposes. To compare their performance berried females from two other sources- i) the Halda river (wild) and ii) a gher (captive reared) were also collected and bred in the same hatchery. Post-larvae (PL) of these broods were produced and their performances were studied. Fecundity, hatching rate and PL conversion rate of three broodstocks were determined. F1 PL of three broodstocks were reared for two months in six earthen ponds (15 decimal each) using supplemental feed (CP Company). F1 juveniles of three broodstocks were stocked at the rate of 40 individuals per decimal in six earthen ponds (15 decimal each). They were reared for 9 months with own formulated feed (protein 32%). F1 berried females of each source were brought to the same hatchery for breeding purposes. Fecundity, hatching rate and PL conversion rate of each source of F1 broods were determined.

Highest survival (47.78%) of broods was recorded from own formulated feed while Mega shrimp feed resulted highest SGR (1.08). Broods fed with own formulated feed showed early gonadal maturation compared to other two feeds and highest number of broods (55.83%) was obtained from it. Relative fecundity of Halda broods (971.32±26.42) and own reared broods (1081.81±26.32) were significantly ($p<0.05$) higher than those of gher broods (373.60±13.61). Relationship between weight and fecundity of Halda, own reared and gher broods were linearly positively correlated. Average hatching and PL conversion rate of Halda broods (46.64% and 23.10%) and own reared broods (42.30% and 20.10%) were significantly ($p<0.05$) higher than those of gher broods (20.23% and 12.86%). Conversion rate of F_1 PL to juveniles of Halda origin (64.94%) and own reared origin (60.88%) were also significantly ($p<0.05$) higher than those of gher origin (35.27%). Though performance of broodstocks of Halda origin was better than own reared origin, there was no significant difference ($p>0.5$) between them. F1 broods of own reared origin showed highest hatching rate (53.59%) and PL conversion rate (42%).

Ontogenic development of terminal nerve gonadotropin-releasing hormone (GnRH3) neurons in medaka, *Oryzias latipes*

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The gonadotropin-releasing hormone (GnRH) neuronal systems of vertebrates have been considered to constitute the final common pathway for the central control of reproduction. Here we report the characterization of the ontogeny of terminal nerve GnRH neurons (GnRH3) that is expressed by EGFP (enhanced green fluorescent protein) in a newly developed transgenic medaka, *Oryzias latipes*. Evidence suggests that GnRH3 neurons originate in the olfactory placode and migrate to their final destinations. We found that EGFP is specifically and robustly expressed in GnRH3 neurons and fibers. A cluster of GnRH3 expression began in the olfactory and near the trigeminal ganglion (TG) region at about 2 days after post fertilization (dpf). The axons consisted of projections extending bilaterally from both GnRH3 clusters migrate caudally at 3–4 dpf. GnRH3 cells were reached to the terminal nerve ganglion (TNG) from the olfactory region at 4-5 dpf. Fluorescence GnRH3 cells were also seen in the retina, optic nerve, sympathetic ganglion (SG) and in the preoptic area/anterior mesencephalon by 5-6 dpf. Novel data regarding the early development of the GnRH3 fiber network in the central nervous system and beyond are described.

Assessment of genetic variability of golda (*Macrobrachium rosenbergii*) post larvae from the broods stocked under different sex ratios

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The giant freshwater prawn, *Macrobrachium rosenbergii* is an important species, both as a food item for local consumption as well as a commercially exportable product. *M. rosenbergii* culturists in Bangladesh have been facing a severe problem of slower growth performance in culture condition. The aim of the present study was to assay the impact of sex ratio on the genetic variability of larvae produced from the broods stocked under different sex ratios by analyzing Randomly Amplified Polymorphic DNA (RAPD) of *M. rosenbergii*. Broods were stocked under 3 different sex ratios viz., 1♂: 1♀, 1♂: 2♀ and 2♂: 1♀. A control population was also kept that involved the broods of natural source. The RAPD analysis generated 84 distinct bands of which 52 bands were polymorphic. In case of all the experimental groups 100% polymorphism was observed. Intra-population genetic similarity indices (SI) were 37.6%, 43.3%, 57% and 62.8% for 1♂: 1♀, 1♂: 2♀, 2♂: 1♀ and control groups respectively. Inter-population genetic similarity indices (SI_{ij}) were 72.4%, 65.3%, 63.8%, 59.2%, 58% and 56% for 1♂: 2♀ vs. 1♂: 1♀, 1♂: 1♀ vs. Control, 1♂: 1♀ vs. 2♂: 1♀, 1♂: 2♀ vs. Control, 2♂: 1♀ vs. Control and 1♂: 2♀ vs. 2♂: 1♀ respectively. The pair wise genetic distances were 0.75, 0.143, 0.5, 0.143, 0.0 and 0.75 for 1♂: 1♀ vs. 2♂: 1♀, 1♂: 2♀ vs. 1♂: 1♀, 1♂: 2♀ vs. 2♂: 1♀, 1♂: 2♀ vs. Control, 1♂: 1♀ vs. Control and 2♂: 1♀ vs. Control respectively. The result of the present study showed that RAPD based DNA variability analysis is a useful tool to assess the genetic variability of giant fresh water prawn, *M. rosenbergii.* The results further revealed that 1♂: 1♀ sex ratio is appropriate for maintaining genetic variation in the offspring, to establish the brood banks of this species in order to supply good quality broods for producing high yielding post larvae for culture.

PCR based DNA variability assay of different stocks of *Labeo rohita*

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The level of genetic variation provides the raw material for selective improvement of a stock. Randomly amplified polymorphic DNA (RAPD) assay was used to assess the genetic variation of seven different populations (one natural population of the Halda River and six different hatchery populations) of Indian Major Carp, *Labeo rohita* (Rohu). Five fish samples were collected from each population. Genomic DNA was isolated from the muscle tissue of the collected fish samples. Five different oligonucleotide primers were used and found to be scorable on agarose gel of which 80% DNA bands were polymorphic. The polymorphic loci proportions were 0.8, 0.706, 0.583, 0.773, 1.00, 1.00 and 0.857 for Kapotakkha Hatchery, Ma-Fatema Hatchery, Halda River, Sonali Hatchery, Chowdhuri Hatchery, Niribili Hatchery and Baluhar Baor Hatchery, respectively. A total of 175 bands were generated of which 140 were polymorphic. The pairwise population's similarity indices and interpopulation dissimilarity values indicated a high level of genetic differentiation between the population pairs. From the Unweighted Pair Group Method of Arithmetic Mean (UPGMA) dendogram based on Nei's genetic distances, a correlation between genetic affinities and geographical area was found. The dendogram revealed high interpopulation genetic variation among the different stocks of *L. rohita*. The populations were segregated into two groups: the Halda River and Baluhar Baor Hatchery in one group and Kapotakkha, Ma-Fatema, Chowdhuri, Niribili and Sonali hatcheries in another group. Study confirmed the RAPD technique to be an effective tool in the population genetic studies of the rohu to provide information on genetic stock structure. It was suggested that high level of genetic variation and RAPD assay might have potential use for establishing genetic relationship, genome specificity and phylogeny among wild and hatchery stocks of *L. rohita.*

Reproductive biology of the pool barb *Puntius sophore* in the Padma river, north-western Bangladesh

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The reproductive process of fish involves attaining maturity, mating and spawning. Sustainable fisheries management relies on understanding the regenerative ability of fish populations and having an accurate assessment of biological parameters, including reproductive traits such as ovarian maturation, size at sexual maturity, spawning season and fecundity. However, the pool barb *Puntius sophore* mainly inhabits rivers, streams and ponds in plains and submontane region .It also found in *beels*, floodplains, *baors*, *haors* and everywhere in Bangladesh. It is surface dweller fish and takes small insects, algae and planktons, and in culture pond, it takes rice bran, oil cake, rice polish and other supplementary feed. This species matures by one year and releases eggs in the beginning of the rainy season. A total of 682 female specimens of *P. sophore* were collected during July 2010 through June 2011. Ovarian maturity stages were divided into four categories (Immature, Maturing, Ripe and Spent) based on the visual observation of ovaries fixed with 10% formalin and oöcyte diameter. The stages of gonadal maturation and spawning type were determined through macro- and microscopic analysis of the gonads as well as by variation in the gonadosomatic indices. The gonadosomatic index (GSI) for females were calculated by the equation, GSI (%) = (GW/BW) × 100. The size at first sexual maturity of females was estimated by the relationship between their gonadosomatic index and standard length, and sexual maturity of male and female were respectively estimated to be 4.60 cm and 5.00 cm in total length. The spawning season was estimated from July to September and February to June. The progression gonadal cycles of *P. sophore* collectively revealed that the maturation of males coincided with the maturation of females during the spawning period. The sex ratio showed a predominance of females, representing 60 % of the total sample. This study may be useful for fisheries biologist to impose adequate regulations for sustainable-fishery management in the Padma River and elsewhere in Bangladesh.

Application of DNA markers in genetically male tilapia (GMT) production

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All-male fry are preferred to prevent uncontrolled reproduction before harvest in intensive aquaculture of Nile tilapia (*Oreochromis niloticus*). Males also grow faster than females. The most commonly used method for male production is direct hormonal treatment of fry during sexual development. An alternative approach is to produce fry that are genetically male (GMT). However, the sex determination system in tilapia is fairly complex. Recent developments have resulted in a linkage map and genetic markers that can be used to analyse the sex determination system (the XY locus is in linkage group 1). The present research is aimed at developing marker-assisted selection to improve the process of developing lines of fish which produce progeny with close to 100% male offspring. Three types of families were screened with microsatellite markers: XY x XX crosses (producing 1:1 sex ratios), YY x XX crosses (producing near to 100% males), and putative YY males x XX crosses that produced intermediate sex ratios (60-80% males: these have been observed in YY breeding programmes but never explained). Initial screens were with markers from LG1, which were very strongly associated with sex in the first two types of cross. In the third group, one LG1 allele from the putative YY male parent was associated only with male progeny, while the other LG1 allele was associated with both male and female progeny. This suggests that some alleles of the XY system are intermediate (ambivalent) in effect, either directly or by interaction with other sex determiners. Screening of progeny with markers from LG3 and LG23 (both known to influence sex determination in tilapias) was carried out to test this hypothesis. Marker Assisted Selection (MAS) was also used to separate supermales (YY) from normal males (XY) to reduce the effort spent on progeny testing, and to screen normal crosses (XY x XX) to identify suitable Y alleles for transfer into the YY gene pool. This MAS approach helped us investigate the complex mode of sex determination of Nile tilapia and improve GMT production in aquaculture production system.

Genetic variation of three different broodstocks and their F_1 progeny of freshwater prawn *Macrobrachium rosenbergii* revealed by allozyme markers

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To analyze genetic variation of different sources of broodstocks and their progeny, the present study was carried out with three different broodstocks- i) wild broodstocks collected from the Halda river (P_1), ii) broodstocks developed by rearing wild juveniles collected from rivers in Noakhali region by own management practices (P_2) and iii) gher reared broodstocks (P_3) and their progenies (P_4, P_5 and P_6 respectively). Genetic variation of all populations was studied with muscle tissues through starch gel electrophoresis using seven enzymes (LDH, MDH, PGM, GPI, G3PDH, IDH and EST) in CA 6.1 buffer system. Nine presumptive loci were encoded and among them four loci (*Mdh-1**, *Est-1**, *G3pdh** and *Idh-1**) were found to be polymorphic (P_{95}). The mean proportion of polymorphic loci were 44.44%, 55.56%, 55.56%, 22.22%, 33.33% and 22.22% in P_1, P_2, P_3, P_4, P_5 and P_6 respectively. Highest genetic variability was observed in P_2 (own reared broods) (Table 1). Among the three broodstocks used, the lowest pair-wise population differentiation (F_{ST}) (0.03) and highest gene flow (*Nm*) (9.13) were found in P_1 and P_2 indicating close relationship among them as both were originated from river. Based on Nei's (1972) UPGMA dendrogram, six populations were divided into two major clusters separated from each other by the highest genetic distance of *D*= 0.08. Cluster-1 consisted of P_1, P_2 and P_5 while cluster-2 contained P_3, P_4 and P_6. As both P_1 and P_2 were originated from river, genetic distance between these two populations was low (*D* = 0.01) compared to genetic distance between P_3 and either of P_1 (*D*= 0.04) or P_2 (*D*= 0.07). What do the results imply? Some conclusions are expected.

Table 1. Genetic variabilities at 4 polymorphic loci of six *M. rosenbergii* populations

Pop.	*Na*	*Ne*	Heterozygosity		*I*
			H_o	H_e	
P_1	1.44	1.18	0.12	0.13	0.20
P_2	1.56	1.23	0.14	0.14	0.22
P_3	1.56	1.15	0.12	0.11	0.18
P_4	1.22	1.14	0.07	0.09	0.13
P_5	1.33	1.18	0.10	0.12	0.18
P_6	1.22	1.13	0.07	0.08	0.12

Pop.: Populations; *Na*: Observed number of alleles; *Ne*: Effective number of alleles;
Ho: Mean heterozygosity observed; *He*: Mean heterozygosity expected; *I*: Shannon's information index.

Genetic study of frog population of Bangladesh

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Frogs are very important part of our ecosystem and playing very important role in agriculture by controlling the insects. Frogs are least concerned in Bangladesh even though we don't know scientifically how many species available in our country. A Frog Research collaborative project with Hiroshima University, Japan was established since 2000 from where we are getting scientifically authentic information about Bangladesh herpetofauna. During the last decade frog samples were collected from more than 30 districts including all peripheral region of Bangladesh and their morphology, allozyme electrophoresis, histology, spermatogenesis observations and mitochondrial gene sequence analyses of Cyt*b,* 16S and 12S rRNA genes were conducted. The study revealed that collected specimens comprised 19 distinct species of 5 families (9 species of Dicroglossidae, 5 species of Microhylidae, 3 species of Ranidae, 1 species of Rhacophoridae, and 1 species of Bufonidae). Inter-familial relationships and generic relationships in each family (including paraphyly of the genus *Fejervarya*) were largely congruent with recent molecular phylogenetic studies. Following the addition of 16S sequence information from public DNA databases to present study, phylogenetic trees for three frog families: Dicroglossidae, Ranidae, and Microhylidae were reconstructed. The resultant trees and nucleotide divergences of 16S sequences suggested that collected frog specimens consisted of at least 20 species, among which 10 species were previously known, while the remaining 10 species were not well identified, including *Hoplobatrachus* cf. *tigerinus*, *H*. cf. *taipehensis* and *H*. spp. represent possibly undescribed and/or newly recorded species from Bangladesh. Furthermore, morphometric, molecular studies have suggested the underestimation of anuran species diversity and the existence of several undescribed species in Bangladesh. Many neighboring countries of South and Southeast Asia have established frog farming which is playing important role in their economy.

Taxonomy, food and feeding habits and some other biological aspects of *Mugil cephalus*

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In the coastal areas of Bangladesh *Mugil cephalus* are harvested, in general, along with shrimp. It is not a deliberate policy to stock the ponds with mullet fry. The young mullet usually enter the ponds whilst they are being flooded and therefore constitute an accidental or secondary crop. Full-scale commercial production of the species is not common. But the species is considered as demandable food fish for its taste, mineral and iodine contents. Thus to bring the species under modern aquaculture system, knowledge about its taxonomy and biology is prerequisites and hence the present experiment was carried out. A total of 30 specimens were collected for morphometric measurements and meristic counts. Average total length of this species was found to be 33.7833±6.75089 cm (min. 24.00cm and max. 45.00cm) and standard length was found at 28.56±5.6547cm (min. 21.00cm and max. 38.00cm). All the relationships among length-body weight, length-condition factor, length-gonad weight, body weight-gonad weight were positive and linear. Among the different relationships, standard length- body weight relationship was the strongest (r^2= 0.958). Relationship between total length and condition factor was the weakest (r^2= 0.587). The mean HSI value in the species was 0.93561 and the relationship found between HSI and body weight was not significantly positive (r^2=0.047). The line graph showing the relationship between HSI and body weight was irregular since the fishes were collected from market at random. The mean GSI value in the species was 0.18327 and the relationship found between GSI and body weight was moderately strong (r^2=0.627). The line graph showing the relationship between GSI and body weight was irregular also since the present experiment was conducted with fishes of different age and size. The food organisms found in the stomach contents of 20 specimens were blue green algae, unicellular and filamentous algae, diatoms, plant materials, annelids, crustacean, bivalves, fishes, planktons, detritus and sand grains. The food items in the stomach were *Nostoc, Anabaena, Spirogyra*, *Oscillatoria* sp., *Coscinodiscus* sp. *Cosmarium* sp., *Thalassionema sp., Chlorophyceae* and *Myxophyceae group sp.*

Chromosomal studies and quantitative karyotypic analysis of rohu *Labeo rohita*

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The research consisted of chromosomal studies and quantitative karyotypic analysis of *Labeo rohita.* Larvae of *L. rohita* were collected from the hatchery of "Fisheries Field Laboratory Complex", Bangladesh Agricultural University, Mymensingh, and "Brahmaputra Fish Seed Complex", Shambugonj, Mymensingh. Colchicine (0.05%) treated (2 h, 2.5 h and 3 h) tissues of one, two and three day-old larvae were observed under microscope after hydrolysis, mordanting and staining with 10% HCl, 2% aqueous solution of iron alum, 0.5% haematoxylin and 8 min respectively for chromosomal and karyotypic analysis. Colchicine (0.05%) treatment for 2 h and two day-old larvae gave satisfactory results in respect of degree of contraction. Photomicrographs were taken from selected plates and then enlarged. From enlarged prints chromosome number 2n=50 was counted. Late prophase, exclusively contracted and metaphase stage of chromosomes were observed. In the late prophase stage chromosomes were condensed, thicker and shorter. Chromosomes at exclusively contracted stage were unsuitable for measurement of karyotype study. Chromosomes of metaphase stages were observed and clearly identified in four plates used for karyotype study and the chromosomes were considerably shorter, 0.75 µ to 3.48 µ. Standard haploid karyotype was formulated following the combined scattered diagram technique. From combined scattered diagram 6 identified chromosomes of the haploid sets were distinguished and consisted of 2m+3sm+1st based on morphological measurements. The remaining 19 unidentified chromosomes of the haploid sets were classified into various morphological classes using probabilistic inferences based on frequency of chromosomes in a given class interval range of arm ratio. These 19 unidentified chromosomes consisted of 16m+3sm. Thus the standard haploid karyotype from four haploid complements was consisted of 18m+6sm+1st (Fig. 1.).

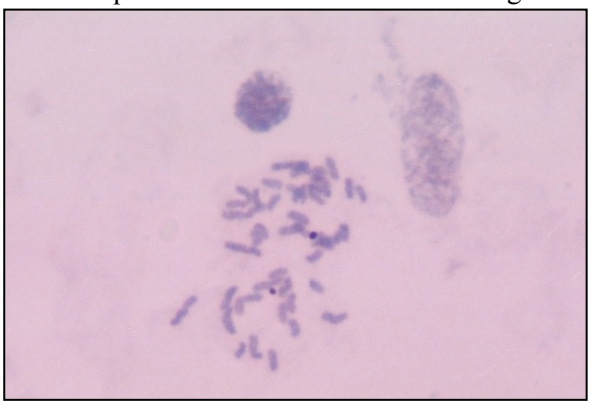

Fig. 1. Representative complement of rohu (*Labeo rohita*) larvae tissue included for karyotype analysis.

Histological study of gametogenesis in threatened *Mystus cavasius* from Mymensingh region

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In order to identify the processes of gametogenesis in a threatened fish species, *Mystus cavasius*, an investigation was conducted during monsoon and post-monsoon seasons. The investigations included the observation of month-wise gonado-somatic index (GSI), identification of breeding frequency of male and female fishes, determination of the peak breeding season, identification of the process of gametogenesis and furnish guideline for conservation of this threatened fish species. Fish samples were collected from Masuabazar, Mymensingh where fish catches from neighboring parts of the Sylhet basin are received. The highest value of GSI for male was identified to be 3.41 in early July and the lowest was 0.05 in late September and for female it was highest (24.54) in late July and lowest (0.19) in October. The mature stages of oocytes (premature, PM and mature, M) were observed from early July to August samples and developing oocytes (oogonia, OG, previtellogenic oocyte, PVO and perinucleolar oocyte, PNO) were mostly observed in the September samples. It was also observed that oocytes did not develop synchronously. Testicular germ cells identified during July to October samples were spermatocytes (SPC), spermatids (SPT) and spermatozoa (SPZ). High proportions of mature germ cells (SPT and SPZ) were observed from July to August samples of testes where SPC was in low proportions. In post-monsoon samples (September to October), high abundance of early stage germ cells (mainly SPC) were observed indicating spent phase of testes. The peak breeding season was identified to be in July from occurrence of high GSI and appearance of mature oocytes and mature testicular germ cells in this month. It is expected that the preliminary information generated on the gametogenesis of *M. cavasius* can serve as the base for further research on this fish with an aim of establishing the package of induced breeding and to management and conserve from the threatened condition. This study provides the first detailed information about oogenesis and spermatogenesis of *M. cavasius* from the Sylhet basin of Bangladesh.

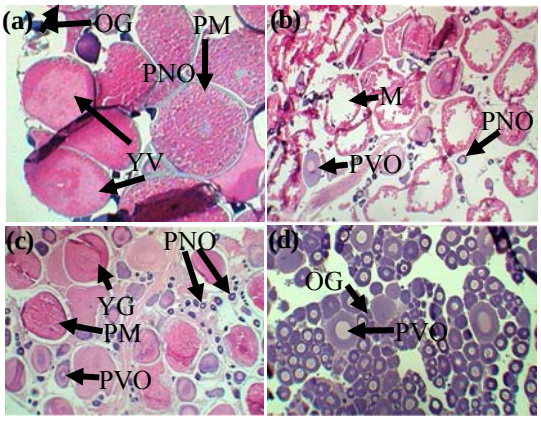

Fig.1. Haematoxylin-eosin stained sections of *Mystus cavasius* ovary sampled in (a) Early July, (b) Late July, (c) August & (d) Early September. OG, oogonia; PNO, perinucleolar oocyte; PVO, previtellogenic oocyte; YG, yolk granule and PM, premature; M, Mature oocytes.

Histological study of gametogenesis in endangered catfish *Ompok pabo* from the Sylhet basin, Bangladesh

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The endangered pabo catfish, from the Sylhet basin in the North-East Bangladesh, was studied for determining gonado-somatic index (GSI) and stages of oocytes and testicular germ cells during the post-spawning season, from September to December 2010. The highest average GSI value in female was observed in September (4.06) and lowest in November (1.55). For male it was highest in December (0.76) and the lowest in October (0.43). GSI values suggested spent condition of ovary and testes during the study period (Fig. 1). Histological observation of ovary and testes of *O. pabo* was done during the post-spawning season. Oogonia (O) perinucleolar oocyte (PNO), previtellogenic oocyte (PVO) and yolk granule (YG) stage were observed in developing ovary during the successive months (October to December). It was observed that oocytes did not develop synchronously (Fig. 2). The testicular germ cell stages of spermatocytes (SC), spermatids (ST) and spermatozoa (SZ) were gradually evident in the maturing testes (Fig. 3). Empty lumen of tubules (LU) in testes samples during October indicates spent phase just of peak breeding season. The GSI values in female were in agreement with that of histological observations of ovary indicated by yolk granule formation in December and increased GSI values in December. Again, gradual increase in GSI value of male is in agreement with the histological observations of testicular tissues, indicated by filling-up of empty LU with ST and SZ. The current study will provided important information on spent and maturing female and male which will ultimately help better understand reproductive physiology of *O. pabo* towards designing conservation plans and captive maturation.

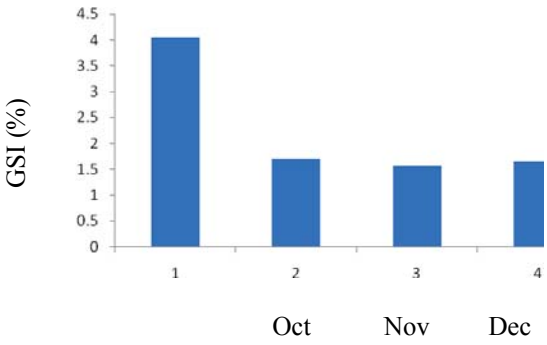

Fig. 1. Monthly mean GSI value of female *O. pab*

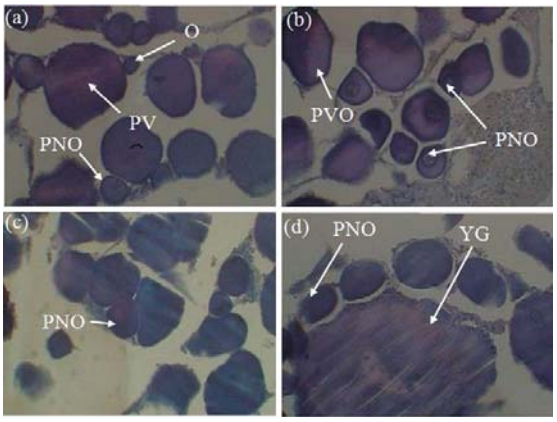

Fig. 2. H-E sections of *O. pabo* ovary sampled in September (a), October (b), November (c) and December (d), 2010.

Sperm cryopreservation of the Indian major carp, *Labeo calbasu*: effects of cryoprotectants, cooling rates and thawing rates on egg fertilization

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A sperm cryopreservation protocol for the Indian major carp, *Labeo calbasu* was developed for long-term preservation and artificial fertilization. Milt collected from mature male fish were placed in Alsever's solution (296 mOsmol kg^{-1}) to immobilize the sperm. Cryoprotectant toxicity was evaluated by motility assessment with dimethyl sulfoxide (DMSO) and methanol at 5, 10 and 15% concentrations. DMSO was more toxic at higher concentrations than methanol, and consequently 15% DMSO was excluded from further study. A one-step cooling protocol (from 5 °C to –80 °C) with two cooling rates (5 and 10 °C/min) was carried out in a computer-controlled freezer (FREEZE CONTROL® CL-3300; Australia). Based on post-thaw motility, the 10 ºC/min cooling rate with either 10% DMSO or 10% methanol yielded significantly higher (P = 0.011) post-thaw motility than the other rate and cryoprotectant concentrations. Sperm thawed at 40 °C for 15 s and fresh sperm were used to fertilize freshly collected *L. calbasu* eggs and significant differences were observed (P = 0.001) in percent fertilization between cryopreserved and fresh sperm as well as among different sperm-to-egg ratios (P = 0.001). The highest fertilization and hatching rates were observed for thawed sperm at a sperm-to-egg ratio of 4.1×10^5: 1 (Table 1). The cryopreservation protocol developed can facilitate hatchery operations and long-term conservation of genetic resources of *L. calbasu*.

Table 1. The effect of sperm-to-egg ratio on fertilization in *L. calbasu.* Eggs were fertilized at room temperature (27 ºC) using fresh and cryopreserved spermatozoa. The cryopreserved and fresh spermatozoa were activated with 0.3% NaCl (96 mOsmol kg^{-1}). Values with different superscripts within a column are significantly different.

Attributes	Sperm-to-egg ratio	Fertilization (%) Mean ± SD (min.-max.)	Hatching (%) Mean ± SD (min.-max.)
10% DMSO	1.4×10^5:1	47 ± 4^d (43-52)	33 ± 3^c (28-36)
	2.3×10^5:1	55 ± 3^c (50-60)	42 ± 3^b (38-46)
	4.1×10^5:1	65 ± 3^b (60-71)	45 ± 2^b (42-49)
10% methanol	1.4×10^5:1	45 ± 4^d (40-53)	30 ± 2^c (27-37)
	2.3×10^5:1	55 ± 3^c (50-59)	43 ± 4^b (37-49)
	4.1×10^5:1	63 ± 4^b (59-69)	45 ± 3^b (40-49)
Fresh	1.4×10^5:1	62 ± 4^b (57-70)	45 ± 3^b (41-49)
	2.3×10^5:1	75 ± 4^a (70-81)	64 ± 4^a (60-70)
	4.1×10^5:1	79 ± 3^a (74-83)	66 ± 3^a (61-71)

Morphological variability of the 11th generation strain of Nile tilapia *Oreochromis niloticus* and traditional GIFT

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To investigate the morphological variations 12 morphometric and 11 meristic characters were studied for 100 individuals of the same age of traditional strain GIFT (5th generation) and recently developed 11th generation strain (GIFU) of Nile tilapia, *Oreochromis niloticus*. No significant difference was found between total length and other body measurements at 5% level. However, GIFU showed faster linear growth on body depth, maximum body circumference and minimum body circumference where GIFT showed faster linear growth on standard length and head length. On meristic characters, notable variations were observed in case of scale above and below the lateral line, where GIFU individuals showed greater number of scales in both cases. The total length and body weight relationship of both the strains were found to be straight line in logarithmic scales. The mean values of condition factor (K) have been found to be 1.671 for GIFT and 1.711 for GIFU and the mean values of relative condition factor (Kn) were 1.001 and 1.002 for GIFT and GIFU, respectively.

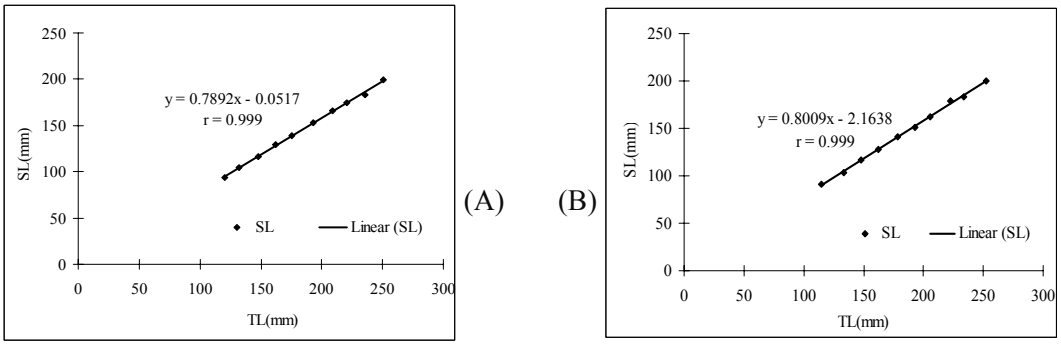

Fig. 1. Relationship between standard length (SL) and the total length (TL) of (A) GIFT and (B) GIFU.

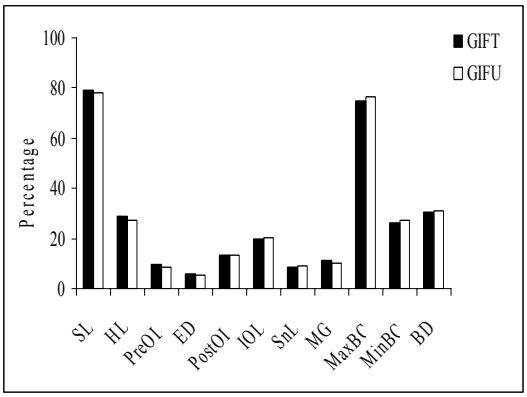

Fig.2. Growth of different morphometric body parts of GIFT & GIFU when considering the total length (TL) as 100%.

Development of sperm cryopreservation protocol of koi *Anabas testudineus*

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For long-term storage of genetic materials specially the germ cells, cryopreservation technique is thought to be a potential tool. This study was dealt with the development of sperm cryopreservation protocol of koi (*Anabas testudineus*) and a series of experiments were conducted. Sperm was collected by sacrificing males and suspended in extenders. Activation of sperm motility was evaluated in different osmolalities and found that sperm motility decreased with the increase of osmolality of the extending media and it was completely inhibited above 319mOsmol/kg. The toxicity of cryoprotectant (DMSO, methanol and ethanol) to sperm was tested at different concentrations (5%, 10%, 15%) and incubation time (5-40 min) and found that cryoprotectants with 5% and 10% concentrations produced better motility during 5 and 10 min incubation. 15% concentration seemed toxic to sperm. Three extenders Alsever's solution, egg-yolk citrate and urea egg-yolk and three cryoprotectants, DMSO, methanol and ethanol were used for preservation of sperm. Alsever's solution with 10% DMSO showed highest performance, produced 67.5±5.45% and 50±6.12% equilibration and post-thaw motility respectively. The fertilization and hatching rates were 51.04±2.44% and 33.38±3.82%, respectively, for Alsever's solution plus DMSO which was higher than that of Alsever's solution plus methanol (40.96±3.85% fertilization and 20.54±0.81% hatching). In contrast, fresh sperm produced 77.96±4.05% fertilization and 60.92±5.33% hatching which were significantly higher than those of cryopreserved sperm. Significant differences were also obtained for both fertilization and hatching between two cryopreserved groups.

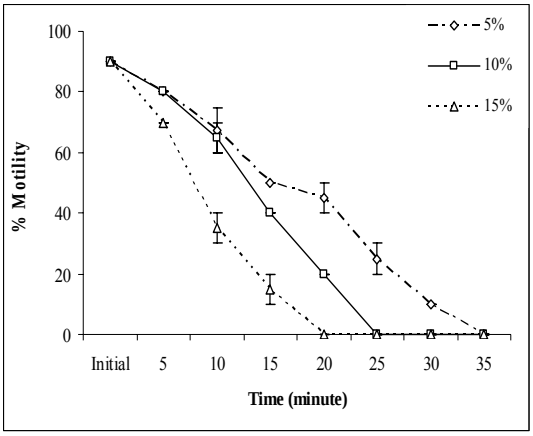

Fig. 1. Motility of sperm incubated with DMSO at its final concentration of 5, 10 and 15% in Alsever's

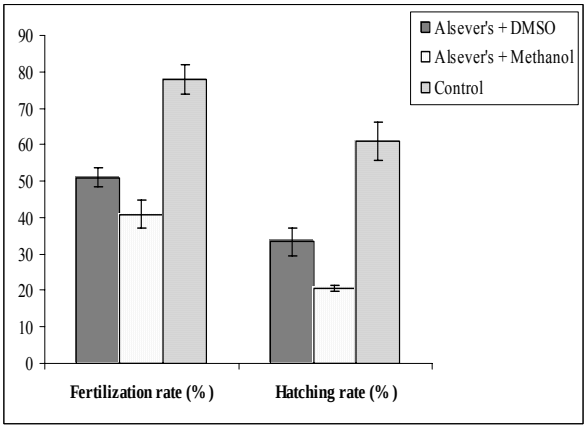

Fig. 2. Fertilization and hatching rates of eggs produced from cryopreserved and fresh sperm.

solution.

Genetic variability analysis of different hatchery stocks of mrigal, *Cirrhinus cirrhosus*

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Status of genetic diversity provides the understanding on fitness of a population and helps for the production of improved lines for better production. Random amplified polymorphic DNA (RAPD) analysis was used to test the genetic variability of six different populations (one natural population of the Halda River and 5 different hatchery populations) of Indian Major Carp, *Cirrhinus cirrhosus* (Mrigal). Ten individuals were sampled from each population and 10 trials were given. Genomic DNA was isolated from the muscle tissue of the collected fish samples using Genomic DNA Extraction Kit. Five different commercially available oligonucleotide primers were used and in total 128 distinct bands were obtained on agarose gel electrophoresis of which 78.23% DNA bands were polymorphic. The polymorphic band proportions were 100%, 77.27%, 62.5%, 100%, 100% and 100% for Kapotakkha Hatchery, Ma-Fatema Hatchery, Halda River, Sonali Hatchery, Chowdhuri Hatchery and Niribili Hatchery, respectively. Inter-population genetic similarity indices provided lower proportions of similarity between Halda-Hatchery populations whereas hatchery-hatchery populations provided higher percentages of similarity. The pair wise inter-population distances values indicated a high level of genetic difference between Halda to hatchery population pairs and comparatively lower genetic distance values between hatchery to hatchery populations. The Unweighted Pair Group Method of Arithmetic Mean (UPGMA) dendrogram based on Nei's genetic distances showed a correlation between genetic affinities and geographical area. The populations were segregated into two groups: the Halda River population in one group and Kapotakkha, Ma-Fatema, Chowdhuri, Niribili and Sonali hatcheries in another group. Thus RAPD technique could be introduced as an effective tool in the population genetic studies of Mrigal to provide information on their genetic stock structure.

Reproduction of inbred lines of *Labeo rohita* and *Cirrhinus cirrhosus* by gynogenetic technique

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The present study was aimed at the identification of treatment optima to induce gynogenesis in two different stocks of *Labeo rohita* (rohu) and *Cirrhinus cirrhosus* (mrigal) by UV irradiation and heat shock treatment. The sperm was exposed under UV lamp (254 nm wave length emitting capacity) from 3 different distances viz., 10cm, 15cm and 20cm. Two different sperm dilutions were tested viz., sperm: cortland salt solution = 1:5 and 1:10. For each dilution rate and distance, sperm solution was exposed under UV lamp for 2, 5 and 10 minutes duration. To induce meiotic gynogenesis, heat shock was applied 4 minutes after fertilizing the eggs with UV irradiated sperm for both species. Heat shock treatment was applied 15 minutes after fertilization to induce mitotic gynogenesis. In both the cases, heat shock treatment was applied at 40^{o}C for 1 minute duration to induce meiotic gynogenesis and 10 minutes duration for mitotic gynogenesis. Among the various treatment combinations tested, UV irradiation from 15cm distance at 1:10 sperm dilution rate with different durations for meiotic and mitotic gynogenesis was considered to be the best combination. This treatment combination revealed 28% and 27% hatching rates in rohu and mrigal, 80% and 90% gynogenesis induction rates in rohu and mrigal in case of meiotic gynogens. In case of mitotic gynogenesis, 15% and 18% hatching rates were obtained in rohu and mrigal whereas 85% and 80% gynogenesis induction rates were obtained in case of mitotic gynogens. Chromosome counting revealed that the haploids have 25 chromosomes and diploids have 50 chromosomes in both the species. Haploid gynogenesis was also induced but the haploids did not survive after 3 days. Survivability of the gynogens was tested with the normal diploids for a period of 30 days. Survivability rates of the meiotic gynogens, mitotic gynogens and normal diploids were 18%, 15% and 64% respectively for rohu; and these rates for mrigal were 14%, 11% and 65% respectively. As gynogenesis was induced successfully in this experiment, this technique can effectively be introduced in Bangladesh to produce inbred lines in different stocks of fishes for the production of faster growing seeds by performing intra-specific hybridization between two inbred stocks.

Random amplified polymorphic dna fingerprinting of endangered butter catfish *Ompok bimaculatus*

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Random amplified polymorphic DNA (RAPD) fingerprinting method was used to assess the genetic variation in *Ompok bimaculatus*, an endangered catfish of Bangladesh, collected from two wild populations and one hatchery population. A total of 34 RAPD bands were amplified in *O. bimaculatus* using five single decamer random primers (Fig 1), among which 24 bands were polymorphic. The percentage of polymorphic loci, similarity indices and Nei's (1973) gene diversity values were 64.71%, 77.57 and 0.24±0.21 for Chalan *beel* population, 58.82%, 75.45 and 0.21±0.21 for Tola *haor* population and 52.94%, 86.49 and 0.21±0.21 for Brahmaputra hatchery population, respectively (Table 1). The highest inter-similarity (S_{ij}) was found between Chalan *beel* - Brahmaputra hatchery populations. Among the three populations, the highest genetic distance (0.157) was found between Tola *haor* and the Brahmaputra hatchery population. The unweighted pair group method with averages (UPGMA) dendrogram based on Nei's (1972) genetic distance resulted in two distinct clusters: Brahmaputra hatchery population was alone in one cluster whereas the Chalan *beel* and the Tola *haor* populations made another cluster (Fig. 2). The results of the present study would be useful for the selection of the parents for quality seed production to have potential genetic gains in breeding programme.

Table 1. Number and proportion of polymorphic loci, gene diversity and similarity indices in 3 populations of *O. bimaculatus*

Populations	Gene diversity (Mean±SD)	Similarity Index
Chalan *beel*	0.24±0.21	77.57
Tola *haor*	0.21±0.21	75.65
Hatchery	0.21±0.21	86.49

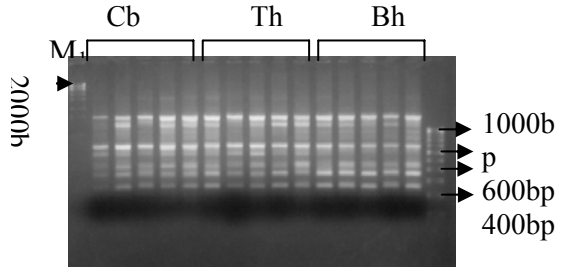

Fig. 1. RAPD profile of *O. bimaculatus* for primer OPB08; M: Molecular weight marker (100bp DNA ladder); M_1: Molecular weight marker (Lambda DNA/*EcoRI/HindIII* digest ladder); (Cb:Chalan *beel*, Th: Tola *haor* and Bh: Brahmmaputra hatchery).

Enhancement of reproductive performances of Gangetic leaf fish, *Nandus nandus* with the dietary supplementation of polyunsaturated fatty acids

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Incorporation of biofunctional compounds (polyunsaturated fatty acids-PUFAs) with feed is an effective way for gonadal maturation, which would enhance spawning of fish without any hazardous effects on health and thus it is possible to save the vulnerable fish species from the danger of extinction. In the present study sperm quality, histological structure of the liver and developmental stages of ovary, level of Ca^{2+} concentration, embryonic development and larval growth were investigated for the confirmation of the positive effects of PUFAs in reproduction and gonadal maturation of *Nandus nandus*. Treated group was fed 1% squid extracted phospholipid supplemented diet whereas controlled group was fed the same except phospholipid. In comparison to the control group, treated group exhibited higher gonadal maturation which resulted in spontaneous spawning. In the present study 98.95% and 91.43% live sperm for treated and control group were found respectively. During the pick breeding (April) season in case of treated group most of the oocytes were found at nuclear migration and tertiary yolk oocyte stage while in case of control group most of them were found in primary and secondary yolk oocyte stage. During spawning season lipid granules and normal morphological structures of hepatocytes with enlarged nucleus and considerable amount of vacuoles were observed in case of phospholipid treated fish liver whereas less lipid granules with scattered necrosis and large vacuoles in cytoplasm with polarized nucleus were observed in control group. Increasing trend of Ca^{2+} concentration in treated female 5.46±0.68 mg/dl (p<0.05) in contrast to the controlled female of 2.68±0.29 mg/dl during the breeding season was an indicator of the augment of estrogen secretion during ovarian maturation. Therefore, level of Ca^{2+} concentration in the blood serum was used as a biomarker for monitoring developing estrogens and gonadal maturation by introducing biofunctional compounds in fish diet. Consequently 15±0.30 h hatching period of embryos and 98.5% hatching rate of fertilized eggs of treated fish indicated better quality eggs and sperm. During 50 days trial of larvae rearing of *Nandus nandus* they were fed live tubificid worm, 1% DHA supplemented dry tubificid worm, 1% phospholipid supplemented dry tubificid worm and only dry tubificid worm. Larvae fed with DHA supplemented dry tubificid worm showed significantly (p<0.05) higher growth of 3.18±0.13 cm length and 411.8±36.94 mg weight which was comparable to that of live feed which showed highest growth performance of 3.4±0.1 cm length and 466.6±27.30 mg weight. The experiment suggests that supplementation of dietary PUFAs eventually improve the spawning performances of fish.

Morphological characterization of two cuchia- *Monopterus cuchia* (Hamilton, 1822) and *Ophisternon bengalense* (McClelland, 1844) found in inland water of Bangladesh

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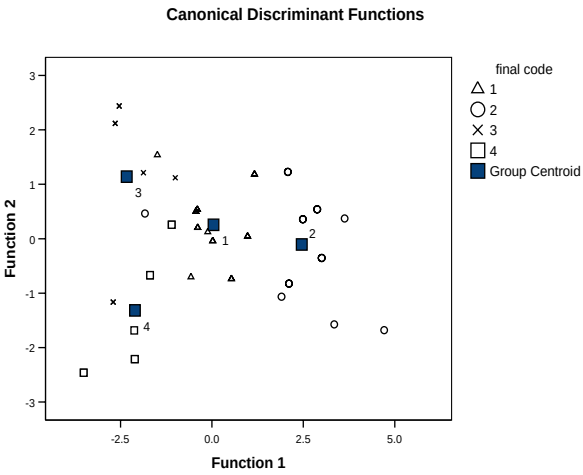
Morphometric comparison was carried out to evaluate the population status of two eels-*Monopterus cuchia* and *Ophisternon bengalense* collected from four different stocks. Morphometric, truss measurements and meristic characters from thirty two *M. cuchia* (collected from Mymensingh and Dinajpur), seventeen *O. bengalense* (from Bagerhat and Satkhira) were analyzed. The mean number of line below head were significantly (Mann-Whitney U test; z= -6.091; $p<0.001$) different between two species out of five meristic characters. Significant differences were observed in eleven morphometric characters: Pre dorsal length (PDL), Post dorsal length (PoDL), Post anal length (PoAL), Head length (HL), Snout length (SnL), Upper jaw length (UJL), Lower jaw length (LJL), Head width (HW), Pre orbital length (PrOrL), Least body diameter (LBD) and Highest body diameter (HBD) and one truss measurement (3-5) between two species in varying degrees. Plotting discriminant function DF1 and DF2 showed a clear differentiation between the species as well as between the stocks for both morphometric and landmark measurements. For both morphometric and landmark measurements, the first and second DF accounted 64.8% and 33.2% of among group variability, explaining 98% of total group variability. A dendrogram based on morphometric and landmark distance data shows the populations of both the species constructed one cluster and further divided into two distinct sub-clusters. *M. cuchia* collected from Mymensingh and from Dinajpur constructed one sub-cluster and *O. bengalense* collected from Satkhira and from Bagerhat constructed another sub-cluster based on the Distance of squared Euclidean dissimilarity. A correct classification of individuals into their original population from leave-one-out-classification varied between 93.3% and 94.1% by discriminant analysis and 95.9% of individuals could be classified in their correct priori grouping. Morphological characterization could be used effectively to know the population structure and taxonomic status. Both eels have high commercial value with domestic and overseas demand and their biodiversity should be conserved and should be brought under aquaculture to save them from extinction.



Cryopreservation of sperm of an endangered fish pabda, *Ompok pabda*

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Cryopreservation of sperm is considered as an effective tool for conservation of endangered fish species. The present research was focused on development and standardization of the protocol for cryopreservation of sperm of the endangered fish species pabda (*Ompok pabda*) and a number of experiments were carried out in this regard. The activation of motility of sperm at various osmolalities of NaCl was tested and found that the activation of sperm motility decreased with the increase of osmolality and the motility of sperm was completely ceased at 319 mOsmol/kg. Toxicity of cryoprotectants to sperm was evaluated using dimethyl sulfoxide (DMSO), methanol and ethanol at 5, 10, and 15% concentrations and incubation time (5-35 min) and found that cryoprotectants with 5 and 10% produced better motility during 5 and 10 min incubation. Sperm exposed to 15% cryoprotectants seemed toxic. For cryopreservation of sperm three extenders, Alsever's solution, egg-yolk citrate and urea egg-yolk and three cryoprotectants, DMSO, methanol and ethanol were employed. Alsever's solution with DMSO showed best performance and produced highest post-thaw motility, 71.67±4.41% followed by 51.67±1.67% with Alsever's solution plus methanol and 50.0±2.89% with egg-yolk citrate plus DMSO. Sperm preserved with Alsever's solution plus DMSO responded positively and produced 79.33% fertilization and 42.38% hatching while fresh sperm yielded 82% and 53.49% fertilization and hatching respectively. Fry produced by cryopreserved and fresh sperm were reared for six weeks and grew well. No significant differences (P>0.05) in survival and growth in terms of length and weight were observed between them.

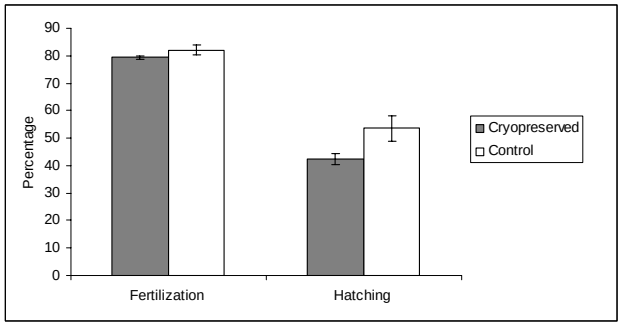

Fig. 1. Fertilization and hatching of eggs of *O. pabda* obtained from cryopreserved and fresh sperm.

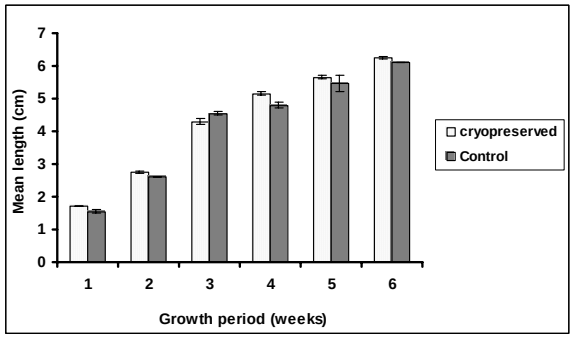

Fig. 2. Length (cm) of *O. pabda* fry derived from artificial fertilization with fresh and cryopreserved sperm.

Assessment of genetic diversity of five wild populations of freshwater striped dwarf catfish, *Mystus vittatus* using allozyme markers

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Knowledge of genetic variation is a useful tool for developing a good management strategy for maintaining genetic quality of the species. Genetic analysis in five tengra (*Mystus vittatus*) populations was investigated to know the variation among them using allozyme markers. Fish samples were collected from five wild populations namely the Brahmaputra river (P_1), the Kangsha river (P_2), the Bulla river (P_3), the Boluhor *baor* (P_4) and the Mithamoin *haor* (P_5). The genetic variation was interpreted in muscle tissue with starch gel electrophoresis and five enzymes (LDH, MDH, PGM, GPI and EST) were used in CA 6.1 buffer system. Among the seven presumptive loci, six (*Ldh-1**, *Mdh-1**, *Mdh-2**, *Pgm**, *Gpi-1** and *Gpi-2**) were found to be polymorphic (P_{95}) where as the mean proportion of polymorphic loci were observed 66.67, 100, 50, 50 and 66.67% in all the populations respectively. The mean proportion of heterozygous loci per individual, the average observed heterozygosity (H_o) and expected heterozygosity (H_e) were 16.667%, 0.167 and 0.197 respectively for all populations. The lowest pair-wise population differentiation (F_{ST}) (0.015) and highest gene flow (*Nm*) (16.942) were found between the Brahmaputra river and the Kangsha river indicating close relationship among them. Based on Nei's (1972) UPGMA dendrogram, five populations divided into two major clusters: cluster-1 consisted of the Boluhor *baor* only and separated from other cluster by the highest genetic distance, *D*= 0.139. The cluster-2 consisted of four populations and divided into two sub-clusters and separated from each other by the genetic distance, *D*= 0.009. The sub-cluster-1 consisted of the Brahmaputra river and the Kangsha river populations and separated from each other by the genetic distance, *D*= 0.008. The sub-cluster-2 was made by the Mithamoin *haor* and the Bulla river populations and separated from each other by the smallest *D*-value 0.007 (Fig. 1.).

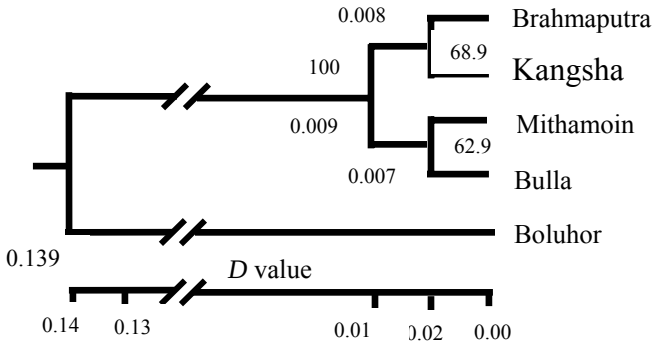

Fig. 1. Unweighted pair-group method with arithmetic averages (UPGMA) dendrogram based on Nei's (1972) genetic distance (*D*), summarizing the data on differentiation among five populations of *M. vittatus*, according to the allozyme analysis.

Taxonomy and some biological aspects of *Rhinomugil corsula*

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Rhinomugil corsula, locally called *'Khalla'* is a common and valuable species of Bangladesh. Very little work has been reported on the taxonomy and other biological aspects of this species. Present study was conducted to obtain an idea on the taxonomy and other biological aspects like fecundity, gonadosomatic index, food and feeding habit, alimentosomatic index and hepatosomatic index of *R. corsula.* The study was carried out during December 2010 to March 2011. Total 150 specimens were assayed. Of them, 50 female broods were subjected to fecundity estimation and gonadosomatic index determination, 50 were used for taxonomic study and 50 for food and feeding habit determination. The body of the fish was sub-cylindrical at the anterior region and moderately compressed at the posterior. The dorsal profile is nearly straight. First dorsal fin had spines and others had soft rays. The head was flat in above and compressed at sides. Mouth position was ventral and eyes were elevated. The taxonomical study showed that the total length (cm), standard length (cm), head length (cm), length of upper jaw (cm), body depth (cm) and body weight (g) ranged from 19-24, 15-20, 3.1-4.6, 0.90-1.10, 3.20-4.50 and 64-124. The taxonomic formula for the species appeared like; D1. 4, D2. 7, P1. 13-14, P2. 5-6, A. 9/11, C. 18, RC. 4. Number of scales on, above and below the lateral line ranged from 46 - 49, 7-9 and 10-12. The biological investigation revealed that the fish weight (g), gonad weight (g), fecundity, GSI, liver weight(g), gut weight (g), alimentosomatic and hepatosomatic index and condition factor ranged from 100-202, 8.13-27.64, 8924-82642, 8.13- 13.99, 0.96-2.00, 3.81-6.57, 2.78-5.06, 0.83-1.14 and 0.57-0.93. The relationships between the various weights and indices of the fish body were found to be linear. Different types of phytoplankton, zooplankton, microscopic organisms, sand, mud, detritus, decayed organic matter and miscellaneous matter etc. were found as the main food items of *R. corsula*, indicating that the species was omnivorous in its feeding habits. The mean values of hepatosomatic and alimentosomatic indices indicated greater liver activity and feeding intensity in *R. corsula* during the investigation period.

Improved hatchery management through identification of peak breeding season and sexual maturity stages of native, Thai, and hybrid (Thai♂ × native♀) koi (*Anabas testudineus*)

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In order for the improved management of koi (*Anabas testudineus*) hatchery, the peak breeding season and gonadal maturity stages of native, Thai, and hybrid (Thai♂ × native♀) koi were studied during the breeding season (April-June, 2010). During the study period, the highest value of GSI for native male was 1.43±0.68 in June and the lowest was 0.97±0.16 in May and for female it was highest in May 9.16±12.23 and lowest in June 3.01±0.3. The highest GSI of male Thai koi was 7.54±9.1 in May and the lowest was 0.64±0.07 in April and for female it was highest 9.71±5.07 in June and lowest 2.54±0.18 in April. The GSI of male hybrid was highest 1.57±0.59 in June and lowest 0.56±0.06 in May and for female it was highest 19.45±0.71 in May and lowest 1.13±1.21 in June. GSI values indicate that native male koi gets highest maturity of testis in June, Thai koi in May and hybrid koi in June. On the other hand, female native koi gets highest maturity of ovary in May, Thai koi in June and hybrid koi in May. Histological observation of ovary and testes of native, Thai, and hybrid koi were done during the breeding season of koi, from April to June. Seven oocyte maturation stages *viz.*, early perinucleolus (EP), late perinucleolus (LP), yolk vesicle (YV), early yolk granule (EYG), late yolk granule (LYG), premature (PM) and maturature (M) stages were observed in ovary of native, Thai and hybrid koi. It was observed that oocytes did not develop synchronously and oocyte at various maturation stages were observed in paired ovaries in native, Thai and hybrid koi. The testicular germ cell stages observed were spermatocytes (SPC), spermatids (SPT), spermatozoa (SPZ). From the histological study of testes it was found that testes of all native, Thai and hybrid koi were rich in SPT and SPZ during the breeding season from April to June although there were SPC stage cells in some. This finding is indicative of the fact that male of native, Thai and hybrid koi get mature and ready to spawn during the entire breeding season. The GSI value and the ovarian and testicular maturity stages that were observed from the histological study of gonads were found in agreement with each other. For native female, the highest GSI value (9.16±12.23) and most oocytes with mature stage were observed in May indicating its peak breeding season. For Thai female, the highest GSI value (9.71±5.07) and most oocytes with mature stage were observed in June indicating its peak breeding season. For hybrid female, the highest GSI value (19.45±0.71) and most oocytes with stage were observed in May indicating its peak breeding season. These observations indicate that maturity in native and hybrid koi ovary starts earlier compared to that of Thai koi. The present studies also revealed that male were remained mature almost throughout the breeding season. Hence, the peak breeding season in native, Thai and hybrid koi were identified to be May, June and May.

Stock variability analysis of *Glossogobius giuris* through morphometric and meristic characteristics

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The stock variability of pond, haor and estuary populations of *bele G. giuris* were studied through landmark based morphometric and meristic analysis to find out desired stock for establishment of induced breeding technique. Samples were collected from three different regions such as pond of Mymensingh, haor of Kishoreganj and estuary of Barisal. In this regard, 13 general morphometric characters, 23 landmark-based morphometric measurements and 11 meristic characters were recorded from each of the three stocks of *G. giuris*. Significant differences (p<0.01) were observed in 13 general morphometric measurements among three stocks. Similarly, all 23 size adjusted landmark based morphometric measurements were also significantly different (p<0.01) from each other. Among the 10 meristic counts the first dorsal fin rays (D1FR), transverse scale above lateral line (TSALL), branchiostegal rays and number of vertebrae were same among fishes from these stocks. However, in case of pectoral fin rays (PcFR) and transverse scale on lateral line (TSOLL) the haor stock of Kishoreganj was significantly higher than other stocks. In discriminant space, pond stock was isolated from other stocks (Fig. 1). This suggested that pond stock was morphologically dissimilar to other stocks of *G. giuris*. On the other hand, haor Kishoreganj and estuary stocks showed very close relationship due to their natural habitats.

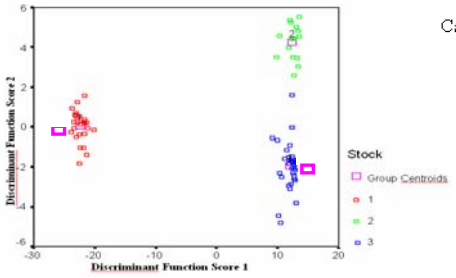

Fig.1. Group centroids of discriminant function scores refer to-1. Pond stock, 2. Haor stock and 3. Estuary stock.

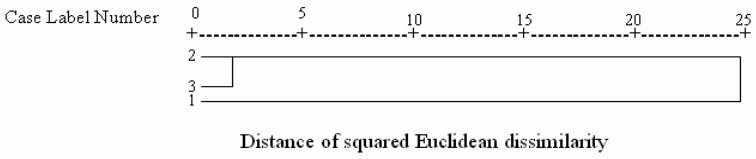

Fig. 2. Dendrogram based on average linkage (between groups) of Mymensingh (1), Kishoreganj (2) and Barisal stock (3) of *G. giuris*.

A dendrogram based on the hierarchial cluster analysis using size adjusted general morphometric and landmark measurements for *G. giuris* are shown in Fig. 2. The dendrogram formed two main clusters- pond stock in one cluster and other two stocks (haor and estuary) remained in another cluster. This indicates that pond stock was separated. The 2nd cluster of dendrogram explained that haor and estuary stocks had very close relationship. However, in consideration of most of the morphometric and meristic characteristics the haor stock performed better than the estuarine stock of Barisal because of which the haor stock has been selected for domestication and induced breeding purposes.

Detection of White Spot Syndrome Virus (WSSV) in brackishwater cultured shrimp (*Penaeus monodon*) in Khulna district using PCR with different primer

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White spot is a common symptom and is frequently reported from the shrimp *Penaeus monodon* farms in Bangladesh especially in Khulna region which is caused by a DNA virus of White Spot Syndrome Virus (WSSV). This virus causes a serious economic losses of shrimp and the incidence of the disease is prevalent in the farms. To find out the intensity of the infection, a field survey was performed during the month between June and December, 2010 and depending on the extensiveness of farming 4 ghers in the unions of Batiaghata, Dumuria and Paikgacha were selected. Four samples from each gher were randomly collected and examined for the presence of WSSV by Polymerase Chain Reaction (PCR) technique. The PCR, using three different pairs of primers (Lo 1–2 (1447 bp), 146 F2-R2 (941 bp), Lo 3-4 (298 bp)), yielded amplicons of 298, 941 and 1447 bp. Out of 48 cultured shrimp tested, 66% were positive for WSSV. Only three shrimp samples showed positive bands for WSSV with all the three primer pairs, 21 showed positive bands with primer pair Lo 1–2 (1447 bp), 15 samples showed positive bands with primer pair 146 F2-R2 (941 bp), and 15 samples showed positive bands with primer pair Lo 3-4 (298 bp). Out of the samples showing positive results with all types of primers, two contained mild symptom of WSSV and one was found apparently healthy. From Batiaghata region out of 16 samples, 7 samples were positive, while from Dumuria and Paikgacha, 13 and 12 samples were positive for WSSV, respectively. Sensitivity of PCR detection of WSSV depended on the size of amplicon. From our detection result using PCR reaction it was understood that Dumuria was more vulnerable to WSSV than Batiaghata and Paikgacha.

Impact of aqua drugs and chemicals on health of fish

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The present study was conducted in farmer ponds and experimental ponds at BAU to find out the impact of aqua drugs and chemicals on health and production of fish. In aqua drug shop of investigated areas, 50 aqua drugs and chemicals were recorded. Among those, 15 were widely used by the farmers such as Renamycin, Amoxifish, Ossi-C, Timsen, Aquamysine, Aquamycine, Virex, Aquakleen, Geolite gold, Oxy Dox F, Polgard plus, Charger gel, Seaweed, Bactisal and Deletix. In farmers ponds of Gouripur, production of Thai Pangus in chemical treated ponds was 8100 kg/acre whereas in non treated ponds was 4800 kg/acre. Production of Thai koi were 14000 kg/acre in chemical treated ponds and 10000 kg/acre in non treated ponds in Muktagacha. In Fulpur, Muktahacha and Fulbaria EUS, Dropsy, Edwardsiellosis diseases were recorded with pangus and tilapia. Shing had 90-100% mortalities within very short period from unknown diseases with no obvious symptoms (except swollen abdomen and spots) provided 30-100% recovery after application of drugs. For EUS affected tilapia in Fulpur (20%) and Muktagacha (30%) and farmers used Renamycin, Polgard plus and Ossi-C with 80-95% recovery. In Edwardsiellosis affected pangus in Fulpur (80%) and Fulbariaa (50%), farmers used Renamycin, Timsen, Polgard plus and Ossi-C in Fulpur and Geolite and Timsen in Fulbaria having 80% recovery in both upazillas. Farmers used Aquamycin and Ossi-C against dropsy in Fulpur with a result of 95% recovery. Zoothamnium and various spots on skin, scale loss in Thai koi, where farmers used Renamycin, Aquamycine, Ossi-C and Polgard plus and achieved 70-80% recovery. It was thus observed that aqua drugs played excellent role in recovery of fish diseases and maintenance of health. In experimental ponds, food conversion ratio (FCR) was 1.27 and 1.13 in the treatments I and II in for Pangus. However, in case of Thai koi, FCR in the T_I was significantly reduced that of T_{II}. Production of Pangus in the non treated ponds was higher which was 7328.16 kg per acre than in the treated ponds (6400.08 kg per acre). Histopathology in the control ponds, skin-muscle, liver, kidney and gill of fish had almost normal structure. However, in the chemical treated ponds, the above mentioned investigated organs of fishes had remarkable pathological changes like necrosis, hemorrhage, vacuum, melanocytes and partial loss of organs.

Anabaena sp. bloom and the occurrence of microcystins from a eutrophic pond in Bangladesh

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Eutrophication of freshwaters and appearance of cyanobacteria blooms have become a serious problem in Bangladesh. A bloom of *Anabaena* sp. occurred in a freshwater pond in Brahmanbaria. Bloom sample was collected and filtered through a glass fiber filter. Methanol-water extract of filtered cells were analyzed by high performance liquid chromatography (HPLC) with UV, MS and MS-MS detection detected three types of microcystins *viz,* [D-Asp^3, Dha^7] Microcystin-LR, [Dha^7] Microcystin-LR and Microcystin-LR. The total concentration of microcystins was 4.0 $\mu g l^{-1}$, well above the WHO provisional guideline value for drinking water. Cyanotoxin risk assessment is important to protect public health in Bangladesh where surface water is used as drinking-water source.

Striped catfish (*Pangasianodon hypophthalmus*) aquaculture in Bangladesh: an overview

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Farming of the striped catfish, *Pangasianodon hypophthalmus,* is one of the major aquaculture activities in Bangladesh. This article redresses this balance by providing an overview of the present status and characteristics of pangasius farming in Bangladesh. This is achieved with reference to a study conducted using questionnaire interviews and PRA tools in Muktagacha, Trishal and Bhaluka upazila of Mymensingh district during 2009. Mean farm size and water surface area were significantly different ($p<0.05$) between the three sub-districts. Pond size ranged from 0.08 to 24.29 ha (1.13±2.13), and number of ponds per farm ranged from 1 to 22 (5.14±4.45). The water depth of individual ponds in rainy season ranged from 1.07 to 3.05 m (1.64±0.41) where mean water depths in Bhaluka were significantly different ($p<0.05$) to those in Muktagacha and Trishal. The mean stocking densities of pangasius fingerling was significantly ($p<0.05$) lower in Bhaluka but carps stocking was higher than in the other two upazilas, reflecting the different balance of polyculture practiced there. The mean productivity of pangasius was 36.9 MT ha^{-1}, where 87.9% of the farms produced between 15 to 65 MT ha^{-1} of pangasius, with an additional 10-20% of Indian major and Chinese carps, and Nile tilapia. Although no statistically significant difference was identified in the average production (MT/ha^{-1}) of farms using farm-made (37.41±20.30) and commercial pellet feeds (36.57±21.75), food conversion ratio (FCR) differed significantly ($p<0.05$). The production cost of a kg of pangasius using commercially milled (US$ 0.76±0.03) and farm-made feed (US$ 0.70±0.05) was significantly different ($p<0.05$). More than 80% of surveyed farms used groundwater pumped from shallow tube-wells or submerged pumps and 71% exchanged pond water at infrequent intervals ranging from 1-10 (mean 2.11) days and the total rate of exchange varied from 5 to 70% (mean 43.40%). The direct water consumption required per MT of fish was 0.65 Mega Liters (ML) and the frequency distribution shows water consumption to be highly skewed (skewness = 2.98). Almost all of the pangasius produced in Bangladesh is consumed domestically. However, in recent years a few processors have started exporting frozen pangasius in the export market. Pangasius aquaculture in Bangladesh has developed a vibrant domestic value chain which has impacted positively on the economic and social development of various stakeholders of wider social classes.

Effect of feeding regime and dietary protein on growth, feed conversion, protein utilisatin and body composition in stinging catfish *Heteropneustes fossilis*

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The stinging catfish, *Heteropneustes fossilis* is a newly introduced species in aquaculture of Bangladesh.; Lack of information on its nutrition and appropriate feeding regime is a major constraint in the development of intensive culture of this fish. In fish feeding, an inverse relationship between optimal dietary protein level (as a percentage of the diet) and feeding regime (ration size) has been suggested. On the contrary, investigations into the manipulation of dietary protein levels and feeding regimes in stinging catfish, *Heteropneustes fossilis* have been limited and inconclusive. An 8-week feeding trial was conducted in indoor rearing system with 18 cylindrical fiber glass tanks (80 cm diameter, 75 cm deep, 70-L each) to examine the interactions between dietary protein level and feeding regime on growth, feed conversion, protein utilization and body composition, leading to optimization of feeding regime and dietary protein for *Heteropneustes fossilis* (3.44 ± 0.05 g). Three fishmeal based practical diets were used: protein at 25, 30 and 35%, gross energy (GE) at 12.12, 14.62 and 17.07 kJ g^{-1}, protein to energy (P/E) ratios of 20.53-mg protein kJ^{-1} GE were fed to triplicate groups of 50 fish (per 70-L tank). Fish were fed either to satiation or according to a restricted feeding regime. In restricted feeding, the fish were offered diets at fixed rates of 5.0, 4.1 and 3.6% of their body weight daily to provide approximately the same amounts of protein and energy for the 25, 30 and 35% protein diets. Diet supply was adjusted after fortnightly weighing. Satiation feeding was also performed three times daily, by giving a small quantity of feed every 2 to 3 minutes and allowing the fish to eat until they stopped (each meal spanned about 20-minutes). Feed intake was recorded daily in all treatments. There were no significant differences ($P > 0.05$) on growth rates, feed efficiency and protein utilization in either restricted or satiation feeding for a particular protein diet. Growth rates and feed efficiency did not differ significantly ($P > 0.05$) between fish fed diets containing 30 or 35% protein, but was lower ($P < 0.05$) for diet containing 25% protein. Whilst non- significant ($p > 0.05$) values of protein utilization were found between feeding regimes and protein diets. Whole body compositions did not differ significantly ($P > 0.05$) on dietary protein level or feeding regime. This indicated that the change in dietary protein levels was not influenced by feeding regimes. This study revealed that satiation-feeding of a diet containing 30% protein was suitable for stinging catfish, *Heteropneustes fossilis* under these conditions.

Maximize growth and minimize production cost of tilapia *Oreochromis niloticus* with alternate feeding schedule in farmers pond

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A 5-month feeding trials was conducted in field conditions using 6 farmers' ponds (400-600m^2) to investigate the suitability of alternate feeding schedules for maximizing production and minimizing cost of production of tilapia (*Oreochromis niloticus*). Same aged and uniform sized (10.15 ± 0.04 g) fingerlings of mono-sex tilapia were stocked at the rate of 62,500/ha. Two experimental diets consisting of low protein (14% CP, LP) and high protein (26% CP, HP) were prepared using locally available fish feed ingredients such as meat & bone meal, mustard oil cake, maize meal, rice bran and wheat flour (*atta*) in different combinations. There are 2 treatments and the following feeding schedules were used: (1) continuously feeding with high protein (HP) diet (control, T_1); (2) 1-day low protein diet followed by 1-day high protein diet (1LP/1HP) (T_2). Each feeding schedule had two replicate and the demonstration (each feeding trial) was conducted 5 months. The fish were fed twice daily at the rate of 5% of their body weight.

The results showed that feeding with low protein and high protein diet on alternate day (1LP/1HP) resulted higher growth performance in term of final weight, mean weight gain, % weight gain, specific growth rate (SGR, % per day) in comparison to treatment-1 (fish fed continuously high protein diet). The total production (kg/ha.) of tilapia for 5 months culture period in both treatments are 13,219 and 14,528 kg/ha. With1LP/ schedule resulting the higher production of 14,528 kg/ha. Feeding schedule 1L/1H resulted in the higher net profit of Tk.8,01,390/ha./ 5 months. The fish fed continuously with high protein i.e. HP feeding schedule resulted in the net profit of Tk.5,58,703/ha./ 5 months. Such feeding schedule (1LP/1HP) generate about 1.43 times higher profit and 30% higher net profit that is obtain with fish maintained continuously on a high protein diet (HP) by saving dietary protein as well as feed cost. Feeding of fish with alternate day of low protein and high protein diet saved Tk.7.10 and 6.70 for every 2 kg of feed consumed and the production (kg/ha) was also higher in 1L/1H, that is why the net profit was higher in 1LP/1HP. The results demonstrated that it is possible to save 24.50% protein by adopting 1LP/1HP feeding schedule. Because of significant improvement of feed utilization and net profit with higher growth performance and production, fed with low and high protein diet in alternate day (1LP/1HP) proved to be more efficient in economic terms. The overall results of the feeding trials provide evidence of the potential applicability of alternate feeding schedule in reducing the feed cost under a semi intensive pond culture system. This demonstration also supports the refinement of suitability of the alternate feeding schedules for maximizing production and minimizing cost of production. Furthermore, it is economically beneficial and biologically more productive to provide the fish alternately with low and high protein diets instead of feeding only with the high protein diet. This demonstration in farmers ponds also clearly demonstrated that alternate feeding schedule of low and high protein diet is a possible way of reducing feed cost in tilapia farming.

Is stocking of mola *(Amblypharyngodon mola*) and darkina (*Esomus danrika*) brood fish in ditches of the wetlands useful to get increased production?

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Of different fish rich with micronutrients mola (*Amblypharyngodon mola*) and darkina (*Esomus danrika*) are the import ones in Bangladesh. Although in the past, the fish were abundantly available in the wetland, presently for various reasons it has been gradually decreasing and almost disappeared from fisherman's catch. As important techniques to increase production of mola and darkina in the wetlands, initiatives were taken to stock broodfish. A total of 269 kg broodfish of mola and 11 kg darkina were stocked during dry months in two ditches (locally known as pockets) - Sumer Agar area - 150 dec and Bazar Duba - 55 dec inside a wetland called 'Suma Nodi Jalmahal' in Sunamgonj Haor Basin. During monsoon the ditches including the surrounding areas became inundated and the fish spreaded throughout the areas where they bred and the new recruits started to grow. The stocking of the mola broodfish increased the mola production in the wetlands which was not observed in previous years.

During harvesting of fish in the shallower part of the wetland (lKhara) in November 2011, the amount of mola was 56.16kg (~7%) in the total fish harvest of 841kg and in December harvest mola was 80.23kg (>10%) out of the total fish of 783kg. For harvesting small fishes, fishers used large lift net (vesel jal) and set bag (gur jal) fixed in outlet although such gears were useful to catch different types of fish species it was found to be less effective to get higher harvest of mola. Outside the Kharas, total fish harvest from deeper part of the wetland 'Suma Nodi' by seine net in December 2012 was 7422.46 kg and the amount of mola was 946.18 kg (~13%). The result presented here are based on the partial harvest of fish from the wetlands. As it is expected both total and mola catch will increase in the next years. However, though 11 kg darkina was stockedalong with mola, no darkina was found during fish harvesting. The outcomes of the studies showed a positive impact on stocking of mola broodfish in the ditches of the wetlands during the dry months to get significantly increased level of mola during harvest.

Freshwater snail (*Viviparus* sp.) culture techniques at the farmers level and its potential to use in fish feed

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The traditional aquaculture systems of Bangladesh is dominated by piscine species however, there is a potential scope to culture non-piscine aquatic animals. The present study concerned with emerging culture systems of freshwater snail (*Viviparus sp.*) at the farmer's pond highlighting its potential to be used in fish feed ingredients. The study was conducted in Rupal Integrated Farm at Chothrasia, under Muktagachha Upazila of Mymensingh district. The culture systems of freshwater snail, its collection methods, proximate composition of snail mixed feed and comparative economic efficiency of snail mixed feed versus commercial fish feed were the main focus of this study. The pond for freshwater snail culture was rectangular in shape with an area 120 decimals. After liming at the rate of 1-1.5 kg/decimal, pond was filled up with water and compost manure was spread throughout the pond. After stocking of snails, compost was provided to the pond at 15 days of interval during the culture period for growth and breeding of snails. The culture of snail and its collection in the culture ponds were carried out using different substrates. The production cycle of snail was completed by 40-45 days and its productivity was about 4,117 kg/ha in a cycle. Snail culture was carried out in fry rearing ponds of carps (*Labeo rohita*, *Catla catla*, *Cirhinus cirrhosus*, *Hypophthalmichthys molitrix* etc.), and catfish (*Pangasianodon hypophthalmus*).

Two types of snail mixed feeds; one commercial feed; and only rice bran were analyzed to determine the proximate composition of snail to fish feed. The crude protein content, lipid content was higher in snail mixed feeds compared to commercial feed. The crude fibre content was lower in snail mixed feeds than commercial feed. Average cost for the production of a kg of snail was about BDT 5.00. In farm, per kg snail mixed feed price was BDT 10.00 which was used as fish feed for Tilapia (*Oreochromis niloticus)*, Shing (*Heteropneustes fossilis)* and Magur (*Clarias batrachus*). For preparing *Pangasius* feed, per kg feed price was BDT 18.50 where only meat and bone was used as a source of protein. Per kg feed price was BDT 16.15 when snail was mixed for preparing *Pangasius* feed. Using snail in fish feed reduced BDT 2.34 for a kg of *Pangasius* feed production. In terms of growth of fish, there was no significant difference between the feeds.

Design and construction of a low-cost mobile hatchery: an understanding on technical and economic efficiency

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Hatchery based seed production developed fish seed supply networks in Bangladesh over the last three decades. The majority of fish hatcheries are centralized which often undermine the needs of seed of the people living in the remote places. In this context, the mobile small-scale hatchery based seed production could be an alternative for those people interested in aquaculture. The purpose of this study was to understand design and construction of a low cost mobile hatchery (LCMH) that was developed and examined with technical and economic efficiency. The efficiency based on technical and economic aspects using mathematical formula was assessed. Design facilities of LCMH were simple for which locally available materials such as iron rod, plastic bowl, porous plastic bowl, child bathtub, soybean oil bottle, electric pump (1 hp), hosepipe and pipe setting materials were collected from hardware shops and variety stores. All the facilities as a whole of LCMH were more or less resembled of a typical large hatchery facility however, it was constructed with some extra facilities of re-circulatory system. Average water flows were recorded at 2.43 l/m in each bottle jars (BJ), 7.90 l/m in circular chamber (CC) and 4.131/m in larvae rearing chamber. Total water requirement was 15 l/m in whole LCMH operating system. Testing a fish species, silver barb *(Barbodes gonionotus)* in the hatchery, the fertilization rate of eggs was found at 90.29% in BJ and 89.74% in CC. The total hatchling production per month (i.e. per cycle of the hatchery) was estimated at 13,86,000 individuals. The average survival of hatchling was 75.53% in BJ and 76.56% in CC. Water quality parameters recorded were at an average temperature of 30°C, pH of 7.4, dissolved oxygen of 6 mg/l and ammonium/ammonia (NH_4/NH_3) of 0.5/0.008 mg/l during the whole experimental period. According to cost-benefit analysis, the capital cost was BDT 26,756 with depreciation cost of BDT 140 for materials and the operating cast of BDT 830. The revenue, net profit and BCR were 10,350, 6,060 and 2.41 respectively for a cycle of operation. LCMH could play an important role to supplying fish seed for the poor people interested in aquaculture who are living in remote places in the country. It may enhance fish production through stocking locally produced fish seed in under or unutilized water bodies like rice-fields, *beel* (natural depression), fellow ponds etc. However, to test LCMH's efficiently at the field level, further farmers based action research is required.

Review of aquaculture and fish consumption in Bangladesh

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This review examines the aquaculture sector and fish consumption in Bangladesh. Collection of fisheries statistics in Bangladesh is based on a design which has not been able to fully account for recent developments in aquaculture. This review attempts to make alternative estimates using data drawn from numerous sources, including the Household Income and Expenditure Survey 2005. This approach suggests that aquaculture (in particular intensified commercially-oriented forms) are likely to play a much more important role in meeting national fish consumption needs and alleviating poverty than previously understood.

Inland pond culture represents the mainstay of aquaculture in Bangladesh, accounting for almost 86% of total recorded aquaculture production and is dominated by production of carps. Our analysis suggests that combined tilapia and pangasius production exceeds 335,000t. We estimate that around 399,000t of fish are produced from homestead ponds; 390,000t from commercial semi-intensive carp culture; 395,000t from pellet fed intensive systems, along with 98,000t of shrimp and prawn, for a total of 1.35 million tonnes (325,000t or 27% greater than the 1.06 million tonnes of aquaculture production officially reported). We calculate that 4.27 million households (20% of rural inhabitants) operate a homestead pond, covering a combined area of 265,000 ha. Commercial semi-intensive carp culture covers an estimated 110,000 ha, and intensive forms of entrepreneurial pond culture cover just 15,000 ha. Forty major feed mills produced 0.67 million tonnes of formulated feeds, worth around $220 million in 2010. Whilst seed and feed supply has grown rapidly in recent years, quality remains a major concern for both inputs.

Fish consumption trended strongly upward during the period 2000–2005, but the gap in consumption between rural and urban areas widened over this period. Per capita fish consumption in urban areas increased by 17.5% to 18.1kg from 2000-2005 against a national average of 15.4kg, while consumption in rural areas climbed 4.8% to 14.5kg. Expenditure on fish among upper income quartiles in major cities is almost twice those in rural areas. There appears to be a growing division between rural and urban fish consumption patterns. Low value wild fish and cultured carps remain the most common fish consumed in rural areas, whereas species produced by entrepreneurial aquaculture (i.e., pangasius, tilapia and climbing perch) are increasingly dominant in Dhaka and other urban markets. Excluding shrimp and prawn, Bangladesh is a net importer of fish, receiving 44,000t of mainly Indian major carps from Myanmar and India in 2010. However, imported fish is destined primarily for the restaurant trade, and net imports account for only 1.1% of total fish consumed.

Toxicity of diazinon in embryonic and larval stages of stinging catfish, *Heteropneustes fossilis*

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In order to determine the toxicity of diazinon, an organophosphorus pesticide used in the paddy fields, on embryonic and larval stages of stinging catfish *Heteropneustes fossilis,* were exposed to 3 concentrations (145, T1; 230, T2; 314, T3; 0 µg/L, C) of this pesticide. The experiment, in three replicates, was carried out in glass aquaria at the backyard hatchery of Faculty of Fisheries, Bangladesh Agricultural University at Mymensingh during late monsoon 2011. This exposure experiment was designed to elucidate sensitivity of embryonic and larval stages of *H. fossilis* to diazinon-induced toxicity, to the degree of toxicity in particular. Embryo samples were collected at six hours interval and larvae samples were collected at twelve hours and twenty four hours interval. Faster embryonic development and degeneration of eggs due to diazinon exposure was evident compared to unexposed ones (Fig. 1). Diazinon exposure during larval stage resulted in different deformities like edema, deformed body structure, curved notochord, deformed mouth, jaw, and caudal fin, damaged caudal fin etc. (Fig. 2). Moreover, mouth, jaw and burble development were slow in diazinon-exposed larvae. Movements of larvae exposed to diazinon were decreased gradually compared to control. The mortality rates of larvae gradually increased (29, 59, 62 and 71% in control, 145, 230 and 314 µg/L diazinon, respectively) in response to increased diazinon concentrations. The finding of current research highlights that exposure of *H. fossilis* at the critical and sensitive stages in the life cycle may significantly reduce the number of adults and compromise the spawning biomass of many populations.

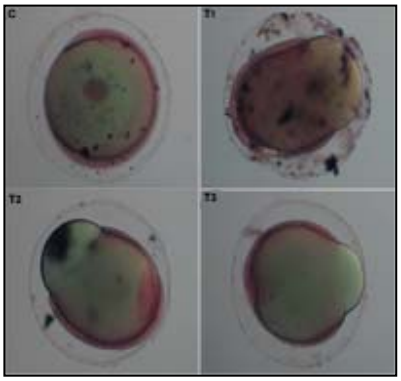

Fig 1. Faster embryonic development of *Heteropneustes fossilis* embryo exposed T1, T2 and T3 concentrations of diazinon compared to C (at 6-hours after fertilization). C. shield stage; T1. 70% epiboly stage; T2. 70% epiboly stage; T3. 75% epiboly stage.

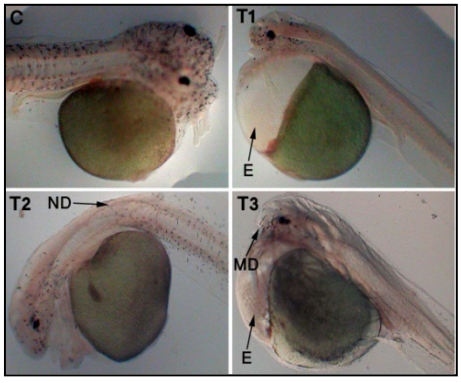

Fig. 2. Developmental deformities of *Heteropneustes fossilis* larvae exposed to diazinon at 32-hours after hatching. C. eye, heart, burble formed; T1. edema (E); T2. notochord deformity (ND); T3. edema (E) and mouth deformity (MD) on larvae.

Techniques for improving quality carp seed production in Bangladesh

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One of the major constraints to increase fish production in Bangladesh is the non-availability of improve quality fish seed. Poor quality fish seed production is largely related to poor management of broodstock, inbreeding, hybridization and negative selection. Keeping all other management same, use of improve quality fish seed could increase production even >30%. Considering the importance and to achieve the purpose of improving quality fish seed the WorldFish Center with support from RFLDC Danida has been implementing a project. Other than situational appraisal on fish seed production, measures were taken to develop technical and business plan for improve quality fish seed for specific carp hatcheries called 'Contact Hatcheries' selected from the private sector in RFLDC areas. Total 8 hatcheries (4 in RFLDC Barisal and 4 in RFLDC Noakhali) were selected for the purpose. In the technical and business plan, both short and medium/long term measures were suggested to carry out for improving quality fish seed production in the hatcheries in 2011 production season. The major short term measures included - improvement in management of broodstock, avoid inbreeding, ban on interspecies hybridization and avoid negative selection. In addition, measures related to improvement in water quality management were also taken. The maintenance of records was given high importance. In order to reach the impacts of improve quality fish seed up to end users, initiatives were taken in to work on value chain in which CBOs of RFLDC were tried to involve actively .

It showed good success in improvement of practices by the contact hatcheries suggested in their plans such as more than 90% of hatcheries prepared their ponds timely for stocking of broodfish, most maintained optimum stocking densities of broodfish following priority in species selection and quality of broodfish based on appearance. There was a significant level of improvement in the water uses in the hatcheries and in ponds. Such improvement on management of broodfish was found to be helpful to optimize breeding protocols. The practice of inter species hybridization stopped and more awareness were build up to avoid negative selection and control of control inbreeding. All of these measures even within short showed increased level of efficiency in broodfish uses for spawn production (kg of spawn/kg of broodfish) by the contact hatcheries. As mid/long term initiatives the project is going to establish Nucleus Hatchery (selecting one of the contact hatchery with needed facilities) and few Satellite Hatcheries for development of broodfish using genetic measures not only for the contacted hatcheries but also for other hatcheries to get improve quality broodfish in near future. It is expected that a model can be developed through this initiatives for promotion that will be useful for overall improvident of quality fish seed in the country.

Major approaches on improving quality fish seed production in Asia

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This synthesis paper describes three major approaches on improving quality fish seed production and distribution in Asia. One of the approaches is on improving fish seed production largely by the private sector hatcheries and nurseries located in clusters. The other approach is 'decentralised (fish) seed production (DSP)' on production and dissemination of improve quality seeds in rice fields, cages and seasonal ponds of farming households. There are strong evidences describing technologies, outcomes, impacts of the approaches developed based on activities implemented in Bangladesh, Nepal and India. In most cases one of the approaches is found to be complementary to others and useful to add value in improve quality fish seed production. It was found that irrespective of quality, the seed produce in hatcheries through nursing in rice fields, cages or seasonal ponds were able to provide large size fingerlings with minimum effort by using the resources normally not used for aquaculture production. However, development of systems for production of improve quality broodfish by setting up 'Nucleus Hatcheries' and 'Satellites Hatcheries' are of use to get quality seed which further add value in production though DSP approach and ultimately to the end users 'grow-out farmers' to get increased productivity in fish production.

In addition, another approach found to be essential for sustainable development of improve quality fish seed production is the 'Market and Value Chain' the promotion of which is useful to get premium price by those involved in improve quality fish seed production influencing the success of two other approaches. The activities linked to establishment of effective seed production networks and markets are found to be useful. Finally, the significance of improve quality fish seed for development of sustainable aquaculture in Asia has been described.

Aquaculture feasibility of water bodies along the Barisal-Faridpur road based on pre-monsoon water quality

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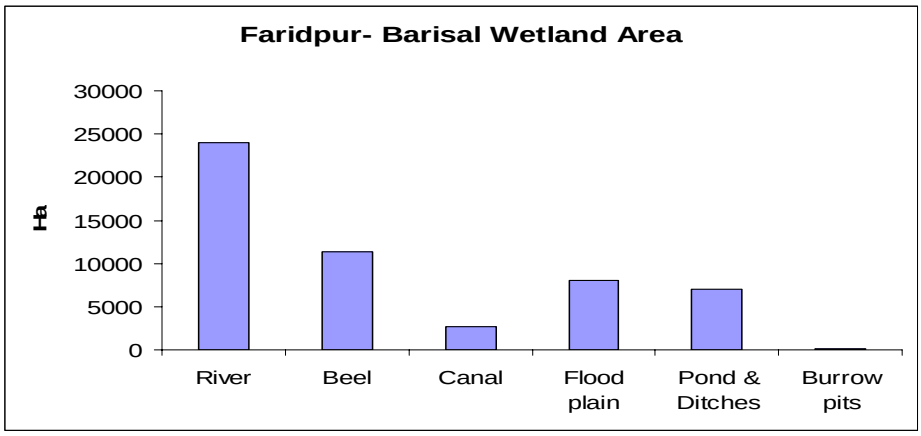
Rural populations in Bangladesh often are heavily dependent on small reservoirs for their water supply not only for drinking and domestic purposes but also for fish culture. The study was carried out to assess surface water quality of waterbodies along the Barisal-Faridpur road (N8) which is of 128 km in length, touching 4 districts namely-Barishal, Madaripur, Gopalngonj and Faridpur. The distribution of wetland is as follows -



Water quality parameters - pH, conductivity, total dissolved solids, dissolved oxygen and transparency were assessed before the monsoon as the unsuitable season of year for aquatic life. The results were compared with standard values of aquaculture prescribed by Water Quality Guidelines developed in AFRL. The samples were collected form 34 points along the road. From data analysis it was found that several water quality parameters - temperature, dissolved oxygen, BOD, conductivity, salinity, TDS showed variability but were mostly within the acceptable range for most sampling points with a few exceptions. In total, water of three closed waterbodies (P-11, BP-1, and P-12) were tested and found that the water quality was not suitable for aquatic organisms as the DO, pH and depth were not suitable enough. Proper treatment of water is necessary there before aquaculture is commenced. To obtain more production of fish from aquaculture in the surface water it is necessary to have all information on the resources namely-physico-graphic, chemical and biological characteristic of these water bodies of an area.

Antibacterial activity of some soil bacterial isolates against fish pathogenic bacteria

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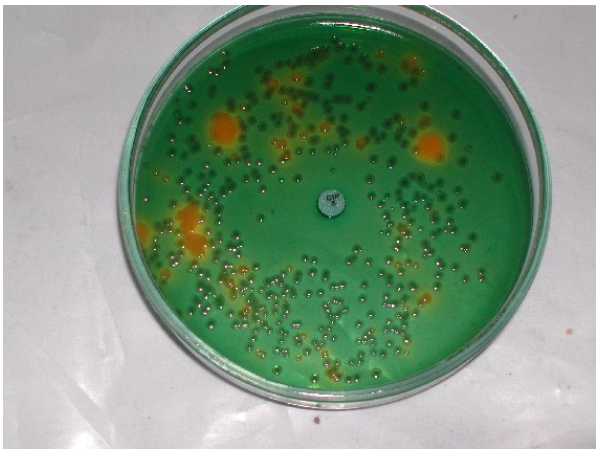
Studies were conducted to isolate and identify soil microbes possessing antibacterial activity against fish pathogenic *Aeromonas* sp., *Pseudomonas* sp., *Flavobacterium* sp. and *Edwardsiella* sp. isolates. A total of fifteeen isolates were collected from soil samples of different hills and graveyards of Sylhet districts through primary screening. The isolates were identified as from *Streptomyces* sp., *Bacillus* sp. and *Pseudomonas* sp. through morphological, physiological and biochemical tests. All the isolates were tested for their antibacterial activity against different fish pathogenic isolates. Among these isolate no. B2/3 inhibited the growth of three fish pathogenic bacteria - *Aeromonas* sp., *Pseudomonas* sp. and *Edwardsiella* sp. isolates, whereas, isolate no. B15/1 repressed the growth of 100% of *Flavobacterium* sp. and *Edwardsiella* sp. isolates. The soil isolates S2/1 and S2/6 inhibited the growth of all *Aeromonas* sp. isolates, B1/2 suppressed the growth of all *Pseudomonas* sp. isolates, and B10/1 restricted the growth of all *Flavobacterium* sp. isolates. Isolate no. B2/3, B1/2, S2/1, S2/6 and S5/1 also exhibited antimicrobial activity against all four fish pathogenic bacterial genera tested. Purified active components of the isolates could be used as new antibiotics to control bacterial fish diseases.



Effects of temperature on egg production and growth of monosex tilapia *Oreochromis niloticus* fry

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In order to know the effect of temperature on egg production and growth of monosex Nile tilapia (*Oreochromis niloticus*) fry, present study was conducted in a private fish hatchery at Trishal upazilla of Mymensingh district for a period of nine months from January to September 2011. Water temperature during experimental period fluctuated from 25°C to 33°C in the broodstock pond and nursery hapas in treatment pond. Eggs were collected from the mouth of female tilapia and were subsequently incubated for hatching in tray where incubation temperature was maintained at 28±1°C. Monosex male tilapia was produced by feeding 17α–methyl testosterone hormone mixed feed in transitory tank and nursery hapas in the treatment pond. Growth of fry was observed at 7, 14 and 21 days at different water temperature and was determined in terms of number of fry/10 g. Results of the present study showed that water temperature had significant ($p<0.01$) effect on egg production. Egg production decreased with the increase of water temperature. Maximum numbers of eggs were found at 25°C and lowest numbers of eggs were produced at 33°C. The most suitable period for egg production was observed in March and the optimum temperature was between 25 and 28°C. At temperature ranged from 29-33°C, the egg production was found very low. Water temperature also found to have a significant ($p<0.01$) effect on the growth of monosex tilapia fry. Negative correlation was observed with temperature and growth of fry i.e, growth of fry decreased with the increase of water temperature. The optimum temperature for fry growth ranged from 25-29°C and at temperature ranged from 30-33°C the growth of fry was found very low. These results of the present study thus indicated that temperature played an important role on promoting the egg production and growth of Nile tilapia fry.

Cultured and ornamental exotic fish diversity in Bangladesh

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This study was conducted in Dhaka, Jessore, Khulna, Mymensingh, Natore, Rajshahi and Thakurgaon districts to figure out the diversity of cultured and ornamental exotic fishes in Bangladesh for a period of 18 months from July 2008 to December 2009. A total of 92 varieties (including 2 cross breeds) of exotic fish species were identified under 53 species and 48 genera (excluding 2 cross breeds), 17 fish families and 5 orders. Perciformes was found as the most abundant fish order in terms of fish family (47.06%), genus (35.42%), species (39.62%), cross breed (100%) and fish variety (45.65%) diversity. Next to Perciformes, Cypriniformes was the most diversified fish order consisting of 3 families (17.65%), 33.33% genera, 34.78% species and 33.33% varieties of exotic fishes. Whereas, Osteoglossiformes was found as the less diversified group in terms of genus (2.08%), species (1.89%) and variety (1.09%) diversity of exotic fishes.

Majority 33.96% exotic fish species in Bangladesh were originated in Southeast Asia followed by South America (32.08%), Northeast Asia (13.21%), Central America (11.32%) and Africa (9.43%). Source countries of exotic fishes were recorded as Australia, China, India, Nepal, Philippine, Thailand, and Vietnam. Commercial breeding of at least 20 exotic fishes was recorded in Bangladesh. Maximum 82.61% exotic fishes were found to be used as ornamental fish followed by food fish (14.13%) and both food and aquarium fishes (3.26%). Top three highly priced exotic fishes were Silver Arowana, *Osteoglossum bicirrhosum* (BDT 30,000/pair), Koi Carp, *Cyprinus carpio carpio* (BDT 12,000/pair) and Tiger Shovelnose Catfish, *Pseudoplatystoma tigrinum* (BDT 4,000/pair).
Entrance pathway of exotic fishes was also studied and poor quarantine system during import of exotic fishes was recorded. The study concluded with the recommendations- improvement of legislation to regulate the introduction of exotic fishes, especially quarantine and record keeping system development are required, culture and entry of predatory fish and other potential threats should be controlled, breeding and business of ornamental fishes should be encouraged, and finally further researches - on impact of exotic fishes are needed to be undertaken.

The diversified use of *Pangasius* pond sediment through integrated aquaculture-agriculture: potential for food security

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Catfish (*Pangasianodon hypophthalmus*) production in Mymensingh, Bangladesh is intensive, resulting in huge sediment deposit in the pond due to regular supplies of artificial feeds. Regular removal of pond sediment is time consuming and incurs high labour costs. Conversely, Mymensingh is an important region for dairying lacking of quality green fodder linked to the cost of N fertilization (urea). The vegetable production also needs regular supply of nitrogen fertilizers. The use of N fertilizers is cost-intensive; the manufacture and distribution of oil-based urea is a major part of the energy cost of agricultural production and is highly sensitive to volatility in energy prices. In this context, the objective of the present study was to examine the potential of using catfish pond sediments to substitute for conventional N fertilizers used in green fodder grass and vegetable production. For fodder grass production, an experiment was conducted in *Pangasius* farm in Dhanikhola village under Trisal upazila focusing the effects of *Pangasius* pond sediment on the growth and production of para grass (*Brachiaria mutica)*. According to soil chemistry, the major soil nutrients such as nitrogen (N), Phosphorus (P) and Potassium (K) were very high in *Pangasius* pond sediment compared to virgin soil. The total nitrogen content of the sediment was 0.30% which was double than that in the sediment of carp polyculture pond, and traditional compost (0.4-0.5%) made of animal waste and crop residues. The organic carbon in *Pangasius* pond sediment (3.15±0.04) was more than double than that of virgin soil (1.31±0.1). The fodder was cultivated with various levels of *Pangasius* pond sediment in a completely randomized designed on-farm experiment in 6 treatments, each with three replications. The size of each replication plot was 25 m^2 (5m × 5m) which was organized in the rice-field closed to *Pangasius* farm. The doses of the treatments 1-6 were of control (only virgin soil), 100% inorganic N, 75% inorganic N + 25% sediment N, 50% inorganic N + 50% sediment N, 25% inorganic N + 75% sediment N, and 100% sediment N, respectively. Following transplantation of cutting (25 cm in length), the fodder was harvested at the pre-flowering stage (45 days after transplantation). The highest average length of para grass was 85.57 cm in T_6 at first cutting where 100% N was supplied from pond sediment. After first cutting, a mechanized floating irrigation system was developed to irrigate *Pangasius* pond sediment into the plot that increased the nutrient content of the soil and resulting in higher growth (108.49 cm) of grass in T_6. Accordingly, the yield of fodder grass in an individual cutting was high ranging from 4.52 - 6.20 t/ha. The yield of fodder grass was almost similar in three cutting stages for the corresponding treatments. The harvested grass was instantly purchased by the local dairy farm owners showing their positive interest to cultivation of folder grass. The use of *Pangasius* pond sediments for vegetable production, particularly for a variety of summer tomato (BARI-14), was tested using bag gardening system in the rooftop of the Faculty of Fisheries Building, BAU. In bag gardening experiment, filling the bags with dried sediment, three treatments were set, each with three replications. Treatment T_1 was set with 100% dried sediment, T_2 with 50% sediment and 50% virgin soil, and T_3 with 60% virgin soil, 40% cowdung, 50g of TSP and 50g of MP fertilizers. In the bags of T_1 and T_2, the growth of tomato plants was very faster compared to T_3. Within a month, tomato became matured which was highest in the bags of 100% *Pangasius* pond sediment. After one and half month, the tomato got ripened with a total production of 3kg/bag in T_3. These studies clearly indicate the potential for the use of *Pangasius* pond sediment to integrate aquaculture – agriculture for environmental improvement and food security.

Comparison between growth performances of Thai pangus *pangasius hypophthalmus* and native pangus *Pangasius pangasius* cultured in earthen ponds

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Yellowtail catfish (*Pangasius pangasius*), is the native pangus which is listed as critically endangered species in IUCN red list. On the other hand, exotic Thai pangus, sutchi catfish (*Pangasius hypophthalmus*), is being intensively cultured by local farmers, although the culture of native pangus in ponds is not yet possible for commercial production. Thai pangus farmers often face a huge loss due to very low margin profit as the market price is Tk.60-70/kg in contrast to the farm rate price of Tk.60-65/kg whereas native pangus deserves very market price of Tk.300-350/kg with production cost of Tk.200-230/kg. During breeding season seeds of yellow catfish are available in the Meghna and Bakkhali estuary near Chandpur and Cox's Bazar respectively which are mostly destroyed and exploited by the farmers for local consumption. If these natural seeds are collected or appropriate artificial propagation technique is developed the culture of sutchi catfish is supposed to be replaced by yellowtail catfish will contribute a new dimension to Bangladesh aquaculture.

Based on the above perspective an experiment on rearing of sutchi catfish and yellowtail catfish at stocking density of 3fish/m^2 in 88m^2 earthen ponds was conducted at two experimental ponds situated at Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh during May 2011-November 2011. Both were fed with commercial pellet diet twice daily for 6 months at 6% body weight. Growth parameters in terms of body weight, body length, specific growth rate and water quality were analyzed monthly. In addition, feed conversion ratio, yield and production were also analyzed. The economic analysis reveals that the culture of yellowtail catfish is profitable for the farmers.

Table 1. Growth rate of Sutchi catfish and Yellowtail catfish

Parameters	Sutchi catfish	Yellowtail catfish
Survival rate (%)	100	94.66
Food conversion ratio	2	2.5
Yield (kg/pond)	91.53	24.99

Effects of partial replacement of fishmeal by fermented soybean meal and squid by-product blend in the practical diet of climbing perch *Anabas testudineus*

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Fishmeal (FM) is a major ingredient in commercial fish feeds because of its high quality of protein, lipid and other macro and micro nutrients. The continuous increasing demand for FM in different agro-industrial sectors and limited supply make this product very expensive. Therefore, cost-effective, nutritionally balanced, environmentally sound and available alternative protein feedstuff is necessary for sustainable aquaculture. A blend of plant and animal proteins eg. fermented soybean meal and squid by-product mix (7:3) (FSSB) might be a good approach for this purpose. So, in the present research effects of partial replacement of dietary FM with FSSB on growth performances, feed utilization and whole body composition of climbing perch, (*A. testudineus,*) were investigated.

Three isonitrogenous and isolipidic diets were prepared by replacing 0 (control), 25 and 50 percent brown FM protein with FSSB (Diet-1, Diet-2 and Diet-3 respectively). The feed were tested using juvenile fish of 1.013 g initial weight held in triplicate groups (stocking density 40000 ha^{-1}) in 30 m^2 earthen pond for 10 weeks. The test diets were hand delivered twice a day at the rate of 10% of their body weight in the beginning and gradually decreased to 5% at the end. At the end of trail, the highest final weight (31.81g) was observed with Diet-2 followed by Diet-1 (31.33g) and Diet-3 (24.35g). Significantly higher SGR was found in fish fed diet-2 (4.99%day^{-1}) over Diet-1 (4.93%day^{-1}) and Diet-3(4.47%day^{-1}). Though no significant differences were detected in AFCR and APER in different treatments, the best feed utilization was observed in fish fed diet-2. Significantly higher AFI was found in fish fed diet-2 (60.40g $fish^{-1}$ $70days^{-1}$) and Diet-1(59.73g $fish^{-1}$ $70days^{-1}$) over and Diet-3(46.40g $fish^{-1}$ $70days^{-1}$). The highest fish production was found in Diet-1 (996.5 kg ha^{-1}) followed by Diet-1 (991.5 kg ha^{-1}) and Diet-3 (751.5 kg ha^{-1}). Survival rate and whole body proximate composition were not varying significantly among different treatments. Based on the present experimental condition, it could be recommended that up to 25% FM protein can easily be replaced with FSSB in the diet for *A. testudineus* without any negative effects on growth performances, feed utilization, survival and whole body proximate composition.

Evaluation of rice bran, wheat bran and maize as supplemental feed compared with commercial feed for the monoculture of monosex tilapia (*Oreochromis niloticus*) in ponds

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Tilapia (*Oreochromis niloticus*) is widely recognized as one of the most important species for farming in a wide range of aquaculture systems. All male fry circumvent these problems and due to having better growth, culture of monosex (male) tilapia has been increasing day by day. Feed cost generally constitutes the highest single operating cost in semi-intensive and intensive farming operation. It is therefore, very important for low income or rural poor farmers to utilize their investment in feeding management as optimal as possible. If the agricultural product and by products such as wheat bran and rice bran and maize could be effectively utilized in tilapia feed, it would be possible to minimize the production cost.

To evaluate the effects of rice bran, wheat bran and maize as supplementary feed in comparison to a commercial feed for monoculture of monosex tilapia (*O. niloticus*) a four months feeding trial was conducted. Five supplemental diets such as commercial tilapia diet, rice bran, wheat bran, maize and a mixture of rice bran, wheat bran and maize (33.33 : 33.33 : 33.33) were assigned to five treatments designated as T_1, T_2, T_3 T_4 and T_5 respectively. Triplicate groups of fish (initial mean weight 2.80 g) were delivered the test diets in 15 experimental ponds. Water quality parameters measured were within the acceptable range of fish culture. Result of the study showed that fish fed with commercial diet (T_1) resulted significantly ($P < 0.05$) highest weight gain (147.8g) followed by fish in T_2 (124.0g), T_4 (120.6g), T_5 (119.5g) and T_3 (118.5g). Feed conversion ratio followed the similar trend as with weight gain and ranged between 1.84 and 2.23. Survival of fish was not affected by the dietary treatments and ranged between 78.67 and 83.33%. The highest fish production (kg ha^{-1}) was found in treatment T_1 (4173), followed by treatments T_2 (3435 kg), T_4 (3190 kg), T_3 (3180 kg) and T_5 (3301 kg). A simple economic analysis of the culture operation showed that treatment T_2 receiving rice bran generated the maximum net profit of Tk.207524.5/ha/4 months followed by treatments T_5, T_1, T_4 and T_3. It was concluded that the use of rice bran as supplementary feed was more economical and beneficial than wheat bran, maize and even commercial tilapia feed for monoculture of monosex tilapia in ponds.

Table 1. Growth, feed utilization and production of GIFT strain (*O. niloticus*) in different treatments.

Parameters	T_1	T_2	T_3	T_4	T_5
Mean initial weight(g)	$2.80^{a1} \pm 0.00$	$2.80^{a} \pm 0.00$	$2.80^{a} \pm 0.00$	$2.80^{a} \pm 0.00$	$2.80^{a} \pm 0.00$
Mean final weight (g)	$150.61^{a} \pm 7.47$	$126.80^{b} \pm 2.84$	$121.34^{b} \pm 3.71$	123.42 ± 2.58	$122.35^{b} \pm 1.84$
SGR (% day)	$3.32^{a} \pm 0.05$	$3.18^{b} \pm 0.02$	$3.14^{b} \pm 0.03$	3.15 ± 0.04	$3.15^{b} \pm 0.02$
FCR	$1.84^{c} \pm 0.04$	$2.07^{b} \pm 0.04$	$2.23^{a} \pm 0.07$	$2.18^{a} \pm 0.06$	$2.09^{b} \pm 0.04$
Survival (%)	$83.33^{a} \pm 6.51$	$81.33^{a} \pm 3.21$	$78.67^{a} \pm 3.06$	$77.56^{a} \pm 3.10$	$81.00^{a} \pm 3.00$
Production (Kg/ha)	$4173^{a} \pm 139$	$3435^{b} \pm 101$	$3180^{b} \pm 117$	$3190^{b} \pm 119$	$3301^{b} \pm 72$

Egg production performance of tilapia of different size in fluctuating temperature

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In order to estimate egg and fry production performance of Nile tilapia (*Oreochromis niloticus*) related to fluctuating temperature and size variation an experiment was conducted at Sharnalata Agro-fisheries Ltd., Radhakanai, Fulbaria, Mymensingh for a period of eight months. Water temperature during experimental period fluctuated from 31°C to 36°C in the broodstock ponds. Incubator temperature was 29±0.5°C. Six body weight categories of tilapia (200, 250, 300, 350, 400 and 450 g) were selected for this experiment. Eggs were collected from each female at 15 days interval for four months and were subsequently incubated for hatching. Histological observation of ovary for each weight category of female was also performed to identify different stages of ovarian cells according to size variation. Results showed that water temperature has significant effect on egg production ($p<0.01$). Egg production decreased with the increase in water temperature. Maximum number of eggs (1342±10.54) was found at 32°C. Relative fecundity decreased significantly with the increase in body weight of female ($p<0.01$). Highest number of eggs (1377.33±48.27) was produced by 250 g female. Histological sections of ovaries from 250 g and 300 g females showed high proportion of mature eggs compared to other weight categories. Effects of broodstock pond water temperature and body weight of female on hatching rate were not significant ($p>0.10$). Reproductive performance in *O. niloticus* can be improved by selecting 250 to 350 g brood and rearing them near 32°C temperature.

Table 1. Number of eggs produced per female tilapia (~ 250 g weight)
At different temperature and different size

Water temperature (°C)	Number of eggs/female	Weight of female (g)	Number of eggs/female
31.5	1218.66±15.50	~ 200	1201±27.62
32	1342±10.54	~ 250	1377.33±48.27
33	1305±8.89	~ 300	1298.66±23.81
33.5	801.66±22.55	~ 350	1216.33±49.37
34	636.33±39.27	~ 400	989.67±40.00
35	0	~ 450	820.67±9.02

Growth-dependent survival during the early life of a temperate fish: field test of the 'growth-mortality' hypothesis

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The functional mechanisms contained in the general 'growth–mortality' hypothesis have been considerably discussed; three concepts based on body size, time and growth rate are widely known as the 'bigger is better', 'stage duration' and the 'growth-selective predation' hypothesis respectively. Although these hypotheses suggest that the faster growing and bigger larvae selectively survive and are now supported by sufficient evidence, relative contributions of these three components have received little attention.

In this study, we have tested the components of the 'growth-mortality' hypothesis based on the growth characteristics of the original larval population (OP) and the survivors (SV) of four cohorts of Japanese sea bass (JSB) *Lateolabrax japonicus*, a coastal marine fish with very high commercial importance. Larval and juvenile JSB were repeatedly sampled from the Sea of Japan coast in January–March 2007 and 2008. Otoliths from larvae and juveniles were analyzed to produce back-calculated daily records of size-at-age and growth rate, and were compared between OP and SV.
Selective survival for fast-growing and bigger larvae was evident as the SV consistently had significantly faster growth rate and bigger body size than OP. Length-at-age and growth rate were also significantly different among the major developmental stages (preflexion, flexion, postflexion and juvenile). Larvae that had higher growth rate and bigger size at a particular stage survived to the next stage. Our data strongly support the 'bigger is better' hypothesis; further, assuming predation as the main source of mortality, our data also support the 'growth-selective predation' hypothesis.

Individuals that metamorphosed into juveniles grew at significantly higher rates than non-metamorphosing larvae older than 48 d, the minimum age for metamorphosis, suggesting clear relationship between growth rates and the timing of metamorphosis. On average, SV completed the larval stage 16 days earlier than those of OP, supporting the 'stage duration' hypothesis. Thus, SV of JSB exhibited traits consistent with all aspects of the 'growth–mortality' hypothesis: faster growth, bigger size-at-age, and shorter larval stage duration (LSD), i.e., larvae with faster growth, bigger size-at-age and a shorter LSD selectively survived the larval period.

A major part of the materials responsible for growth and size variation between OP and SV might have been incorporated from maternal sources at the time of hatching and was propagated through the life history stages. Selective survival has important implications for recruitment, although the detailed mechanisms are yet to be explored.

Species suitability for fish farming in irrigated rice field of drought prone barrind area of Rajshahi, Bangladesh

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Species suitability in terms of production and economics for fish farming in irrigated rice field ecosystem were studied from March to June 2009 at Godagari upazila of Rajshahi district, a drought prone Barind area of Bangladesh. three most popular fish species (Tilapia *Oreochromis niloticus,* Thai sarputi *Barbodes gonionotus* and Common carp *Cyprinus carpio*), which are widely cultured in rice fields weree selected and tested in monoculture systems in irrigated rice field. The experiment was conducted with three treatments (T_1: Rice + 4940 individuals ha^{-1} of Tilapia; T_2: Rice + 4940 individuals ha^{-1} of Thai sarpunti; and T_3: Rice + 4940 individuals ha^{-1} of Common carp) each with three replications. Treatment T_1 varied more significantly than others incase of increasing organic matter and total nitrogen content. Average rice yield significantly varied from 3.82±0.02 mt ha^{-1} in T_2 to 4.03±0.03 mt ha^{-1} in T_1 (in 4 months). Mean final weight (85.0 g in T_2 to 109.83 g in T_1), weight gain (16.25 g in T_2 to 22.50 g in T_1), SGR (1.21 in T_2 to 1.43 in T_1) and survival rate (65% in T_2 to 85% in T_1) of fishes were varied significantly among the different treatments. Mean fish yield (kg ha^{-1} 4 $months^{-1}$) varied from 208.72 in T_2 to 377.91 in T_1 with significant difference among the treatments. Total return (Tk. 63,833.00 ha^{-1} in T_2 to Tk. 76,868.80 ha^{-1} in T_1), net benefit (Tk. 22,305.33 ha^{-1} in T_2 to Tk. 35,202.00 ha^{-1} in T_1), net profit margin (52.35% in T_2 to 81.04 % in T_1) and CBR (0.54 in T_2 to 0.85 in T_1) varied significantly among the different treatments. This study indicated that Tilapia is the most suitable fish species among the three species studied in terms of production and economics in irrigated rice fields under drought prone Barind area, which can potentially be used for fish farming.

Effects of sumithion on larval development in *Heteropneustes fossilis*

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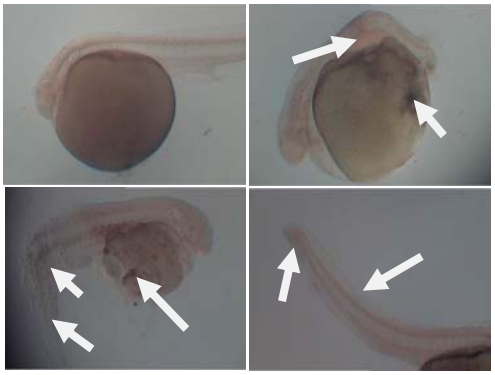
Sumithion, a synthetic organophosphate is used widely as insecticide for crop protection and eradication of tiger bug from larval ponds in Bangladesh. An experiment was conducted during late monsoon of 2011 to determine the effects of sumithion on larval development, to observe the developmental deformities and to determine the mortality rates of *H. fossilis* larvae. The *H. fossilis* larvae were exposed to three different concentrations of sumithion (T1 - 145µg/L; T2 - 230µg/L and T3-314µg/L) and one control (C - 0µg/L) in glass aquaria. Exposure experiment was continued upto the absorption of yolk sack and the developmental deformities were investigated under microscope.

Different forms of developmental deformities, *viz.* edema, notochord deformity (ND), caudal fin damage (CD), atretic yolk sack (AY), damaged yolk sack (YD), posterior region damage (PD), tissue degeneration (DT) and deformed body (BD) were evident in the sumithion-exposed larvae (Fig. 1 & 2). The mortality rates (%) of the larvae were found 32.0, 52.9, 57.9 and 65.7 for C, T1, T2 and T3, respectively. Moreover, around 30% of the total *H. fossilis*, reared in sumithion-treated ponds were found with irreversable deformity (Fig. 2). The results of the current study denote that sumithion exerts developmental toxicity to *H. fossilis* larvae and results in irreversible deformities in larvae together with significant increase in mortality. It is expected that the results of the present research will make the people aware about the toxic effect of sumithion, as well as other insecticides and pesticides on *H. fossilis* and other fish species. The use of insecticides and pesticides in crop field is needed to be carefully considered and alternatives are required to be developed for controlling aquatic insects in ponds.



Potential of integrated multi-trophic aquaculture (IMTA) in the ponds of *adivasi* households: preliminary observation

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Integrated multi-trophic aquaculture (IMTA) is the farming of aquatic organisms, which provides the by-products including waste, from one aquatic species as inputs (e.g. nutrients, food) for another. In this system, fed-aquaculture (e.g., fish, shrimp) is combined with inorganic extractive (e.g., aquatic plants) and organic extractive (e.g., snail) aquaculture to create balanced systems for environment remediation, economic stability and social acceptability. In freshwater aquaculture systems in Bangladesh, there is a potential of IMTA. This is because, in freshwater ponds, fish (e.g. carps), shellfish (e.g. snail) and aquatic plants (e.g. water spinach) are traditionally grown. This potential could be brought under culture system to maximize the impacts of traditional pond farming. For this, *Adivasi* households' ponds were considered in Sherpur district under the Northeast region of Bangladesh.

Adivasi people are traditionally poor and disadvantaged due to their cultural practices, who mainly depend on wild food collections however, due to scarcity of wild food sources they started adopting agricultural practices. Among different agricultural activities, some of *Adivasi* households adopted small-scale pond farming in the recent years. In this context, how IMTA will fit into their exiting agrarian structure- was a thrust of preliminary understanding under this study. A number of participatory community appraisal (PCA) tools such as focus group discussion, well-being ranking, seasonality analysis, and food consumption matrix were used to analyze the agrarian context of *Adivasi* households in a community namely, Andharupara in Nalitabari, Sherpur. In this community, out of 68 *Adivasi* households, 95% were poor without any richer households. However, about 20% of households were characterized by having small and medium ponds (mostly perennial) with some formal experience in pond aquaculture. Seasonally during the rainy season (April – August), *Adivasi* households do not have the intensity of farm or non-farm activities. In this time, the availability of vegetables in their own farm (mainly homestead) and market become less available. In terms of access to food fish, except *Pangasius,* other fishes were reported high priced and less available. Meat items from own farm and market origin are highly expensive. On the other hand, the wild meat animals were reported least available which traditionally are highly tasty to them. Vegetables in market became expensive and less available in the recent years. Moreover, now-a-days the wild vegetables became least available. Considering this context, the follow-on research is focusing to develop IMTA with *Adivasi* households to provide different food items from their limited pond resources.

Reproductive biology of feather back, chital (*Notopterus chitala*)

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Studies on Gonadosomatic index (GSI), ova diameter and histology of gonads were performed to determine reproductive biology of Feather back, chital (*Notopterus chitala*) for a period of 6 months from January to June 2010. Thirty live chital fish were used in this study. The mean GSI values for female chital were found to range between 0.20±0.013 to 4.63±0.50. The highest GSI value was found in the month in June, which indicates the period of peak gonadal maturity. The smallest diameter of ovum was recorded 0.04 mm and the largest was 4.00 mm. From the observation it was found that fecundity was ranged from 8,238 to 18,569 (mean 13,052±4607), in fish samples having body weight of 1,296g to 2,360g (mean 1,742.50±474.44g) while the relative fecundities were 5.65 to 14.33. Histological study revealed that the percentage of late perinucleolus (LPN) stage was attained at highest in April. Cortical alveoli (CA) stage appeared from April and became the maximum in May. Vitellogenic stage (VG) appeared in the month of May and chronologically increased through June. The variations in the gonad weight and gonado somatic index (GSI) of the female fish showed peak during June indicating maturity of ovary and definite spawning season. While Vitellogenic stage (VG) of oocyte as well as highest ova diameter was appeared at peak in the month of June also.

The chemical composition of fish feed ingredients available in Luxmipur region

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The present study was conducted to investigate the availability of fish feed ingredients and to determine their nutritive value in Luxmipur region in southern Bangladesh those were Alexander, Hazirhat and Luxmipur city during the period from March to August, 2011 considering the presence of large number of fish farms in those areas. For nutritional investigation the ingredients were collected from the markets of Luxmipur region and then transported to the Fish Nutrition Laboratory, Bangladesh Agricultural University, Mymensingh. A range of commonly used feed ingredients for fish farming was available in the markets of Luxmipur region that include two types of fishmeal, different oilseed cakes, rice bran, rice polish, broken rice (khud), beson, pulse, maize, wheat bran and wheat flour. Cheoa type fishmeal was produced from marine fish called cheoa fish and miscellaneous type fishmeal from fish, small shrimp and crabs. Commonly available oilseed cakes were mustard oil cake, sesame oil cake and coconut oil cake. All the common feed ingredients were found to be available throughout the year with exception of 'cheoa' type fishmeal. The composition of the experimented ingredients indicated the crude protein to be the main component. During the present study the protein percentage of the mustard oil cake was estimated 35.17-37.25%, wheat bran was estimated 14.84-15.40%, wheat flour was 14.15-17.73% and fish meal was estimated 51.32-65.34% (Figure 1). Protein content of fish meal that found in Hazirhat and Alexander had no significant variations but have significant variations that found in Luxmipur city. Fish meal that found in Hazirhat and Alexander contained about 51.32-54.34% protein while fish meal that found in Luxmipur city contain about 65.34% protein. The analyzed crude protein contents of mustard oil cake, wheat bran, wheat flour, fish meal varied between 35.17-37.25%, 14.15-17.73%, 14.84-15.40% and 51.32-65.34% respectively. The mean range of crude lipid was recorded as 10.73 to 15.52% in mustard oil cake, 4.09 to 9.71% in wheat bran, 2.94 to 4.57 % in wheat flour and 3.69 to 12.50% in fish meal respectively. The other feed ingredients viz. mustard oil cake, wheat bran, rice bran and wheat flour had no significant variations in their proximate composition in respect to place. As the feed cost appears to be one of the major constraints against the greater expansion of fish farming it is therefore imperative that the feed should substitute the animal protein with plant protein sources ingredients such as Soybean those are available and rich in protein level to reduce feed cost.

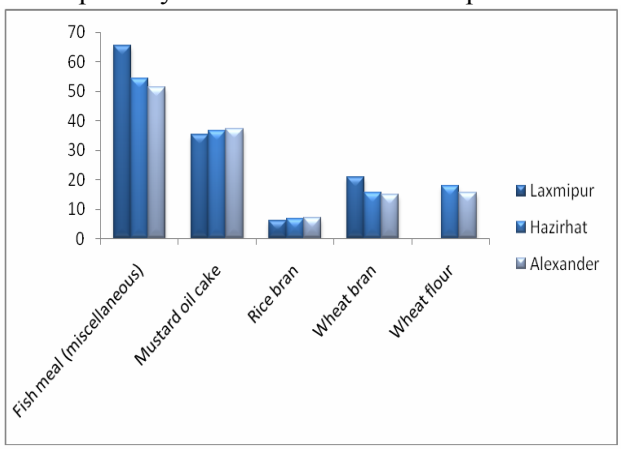

Figure. Comparison of Protein percentage of the ingredients in three regions.

Effects of artificial substrates on nursery production of freshwater prawn *Macrobrachium rosenbergii* in recirculatory system

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Although considerable reports are available on the use of artificial substrates in prawn farming system, reports on improvement in the nursery rearing of freshwater prawn, *M. rosenbergii* PLs, using artificial substrates in recirculation tank (where, better environmental control is possible) is scanty. Moreover, systematic studies for developing suitable substrates to produce more advance juveniles (>0.3g) of *M. rosenbergii* PLs have not been done. Therefore, investigation into potential benefits derived from using artificial substrates for prawn nursery is necessary. Thus, an experiment was conducted in a recirculatory system to evaluate the effects of different artificial substrates on the growth, feed utilization and survival of *M. rosenbergii* PLs.

A study was conducted for two months in a recirculatory system consisting 12 glass aquaria (size 41× 41 × 46 cm) to evaluate the effects of substrates on the growth and survival of *Macribrachium rosenbergii* postlarvae (PL). Treatment T_1 having no substrate was considered as the control. Treatment T_2 contained pieces of hollow PVC pipe, treatment T_3 and T_4 were provided with high density polyethylene (HDPE) and black nylon netting, respectively. Each treatment had three replicates. PL-15 of *M. rosenbergii* (mean initial length 1.20 ± 0.02 cm; mean initial weight 27 ± 0.02 mg) were stocked at the rate of 75 PLs (1.25 PL L^{-1}) in each aquarium. At the beginning PLs were fed three times daily at the rate of 20% of their body weight which was reduced to 10% at the start of 2nd month. The result of the study showed that there was no significant difference (P>0.05) in final weight and specific growth rates (SGR) of PLs in treatments T_3 and T_4 but these values were significantly higher than those in T_2 (PVC pipe) and T_1 (control). Final weights of PLs were 32.70%, 31.54% and 21.05% higher in treatments T_3, T_4 and T_2 respectively than T_1 (without substrate). The survival rate of PLs in all the treatments ranged between 80.33 and 83.00% which was not significantly different (P>0.05). Result of the study indicated that growth of *M. rosenbergii* PLs improved in presence of artificial substrates but the artificial substrates did not improved survival. However, further studies using different substrates should be carried out in nursery ponds to ascertain the usefulness of these substrates for nursing of *M. rosenbergii* PLs.

Table 1. Growth and feed utilization of *M. rosenbergii* PLs under different experimental treatments

Parameters	Treatments			
	T_1	T_2	T_3	T_4
Initial weight (mg)	$27^{a*} \pm 0.02$	$27^{a} \pm 0.02$	$27^{a} \pm 0.02$	$27^{a} \pm 0.02$
Final weight (mg)	$460.67^{c} \pm 9.50$	$557.67^{b} \pm 17.95$	$611.33^{a} \pm 19.14$	$606.00^{a} \pm 11.36$
Weight gain (mg)	$433.67^{c} \pm 9.50$	$530.67^{b} \pm 17.95$	$584.33^{a} \pm 19.14$	$579.00^{a} \pm 11.36$
% weight gain	$1605.67^{c} \pm 35.02$	$1965.00^{b} \pm 66.14$	$2163.67^{a} \pm 71.07$	$2144.33^{a} \pm 41.65$
SGR(%day^{-1})	$4.72^{c} \pm 0.04$	$5.04^{b} \pm 0.05$	$5.19^{a} \pm 0.05$	$5.18^{a} \pm 0.03$
FCR	$1.88^{a} \pm 0.01$	$1.87^{ab} \pm 0.02$	$1.85^{c} \pm 0.01$	$1.86^{bc} \pm 0.02$
PER	$1.83^{a} \pm 0.21$	$1.98^{a} \pm 0.02$	$2.01^{a} \pm 0.02$	$1.98^{a} \pm 0.01$
Survival (%)	$80.33^{a} \pm 3.51$	$80.33^{a} \pm 5.13$	$83.00^{a} \pm 2.65$	$83.00^{a} \pm 2.65$

Determination of a suitable culture media and an optimum duration of media inoculation for commercial production of *Tubificid* worm

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Tubificid worms (Class Oligochaeta, Family Tubificidae) are one of the best quality live foods in intensive aquaculture widely used for feeding certain fish larvae to produce stockable sized seeds in the hatcheries as well as in the rearing of aquarium/ornamental fishes. The study was conducted to culture Tubificid worms under running water with a view to develop a suitable culture media and an optimum duration of media inoculation for commercial production of Tubificid worms.

The worms were cultured under two experiments in cemented culvert system (160×25×10 cm^3) under a tin shed located at the southern side of the Faculty of Fisheries, Bangladesh Agricultural University (BAU), Mymensingh. In both experiments 15 culverts were used for 90 days under a 3×5 factorial design (3 treatments each with 5 replications). In the first experiment, three different media designated as treatment-I, treatment-II and treatment-III were used where media were the only experimental variable. The required amount of ingredients were measured by a laboratory balance on a proportional basis to make up 1000g of media for each culvert and mixed thoroughly with a bamboo stick with sufficient amount of water in three separate fibreglass tanks. The highest yield (503.4±22.9 mg cm^{-2}) was found at 70th day of culture in the culture media containing a mixture of 35% mustard oil cake, 20% wheat bran, 25% cow-dung and 20% fine sand (treatment-III) (Fig. 1). Only 1.99 kg media ingredients valued Tk. 29.8 needed to yield 1 kg worms indicates the suitability of this media for large scale production. In the second experiment, the best media found in the first experiment were used to determine the suitable interval of media application for the commercial production of Tubificid worms. The worms were cultured at three different intervals of media application namely 6, 10 and 15 days designated as treatment-I, treatment-II and treatment-III respectively. Application of media at 10 days interval showed significantly (P<0.01) higher production (488.9±5.6 mg cm^{-2}) (Fig. 2).

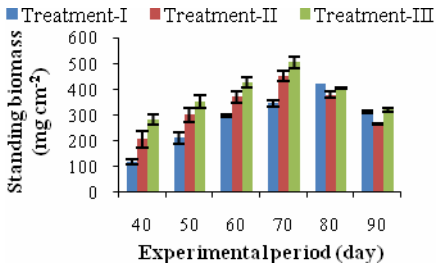

Fig. 1. Standing biomass (mg cm^{-2}) of Tubificid worms in three different treatments during 90 days experimental period (mean±SD). p<0.01

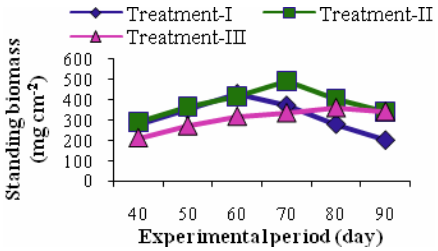

Fig. 2. Standing biomass (mg cm^{-2}) of Tubificid worms at three different intervals (6, 10 and 15 days) of media application (mean±SD). p<0.01

Survivability of exotic ornamental fishes of Bangladesh without food in aquarium

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The research work was conducted for a period of eighteen months (July' 10 to December' 11) to explore the survivability of exotic ornamental fishes of Bangladesh without food in aquarium. The experiment was performed and observation was done in the Department of Fisheries, University of Rajshahi, Bangladesh under laboratory condition. A total of 14 fish species were experimented under 13 genera, 9 fish families and 4 fish orders. The present research was set up under two treatments (T_1: aquarium without aerator facility, and T_2: aquarium with aerator facility) for each experiment. In each experimental treatment, fish was released at the number of three for a same species kept without food condition and here fishes were treated as replication in determining the survivability of fish. Water quality parameters were measured twice in a week. Weight loss of fish body was measured by taking initial and final weight - and especial behaviour of fishes was monitored by careful observation to understand their various behaviour patterns in terms of without food condition in aquarium during experiment. In the study, comparatively higher survivability was found in marble angel (*Pterophyllum scalare*) (T_1, 36.00±1.53 days and T_2, 43.00±2.08 days) under the family cichlidae and order perciformes and lower survivability was recorded for albino suckermouth catfish (*Hypostomus plecostomus*) (T_1, 5.00±0.58 days and T_2, 7.00±1.00 days) under the family loricariidae and order siluriformes. During the study period, water quality parameters *viz.,* water temperature, dissolved oxygen, free CO_2, pH, total alkalinity, ammonia-nitrogen and chlorine level was found to be varied from 25.66±0.17°C to 28.66±0.35°C, 3.80±0.06 mg/l to 4.73±0.07 mg/l, 9.21±0.05 mg/l to 11.75±0.03 mg/l, 7.13±0.05 to 7.47±0.07, 76.66±1.64 mg/l to 108.92±3.20 mg/l, 0.0010±0.0006 mg/l to 0.0133±0.002 mg/l, and 0.0045±0.001 mg/l to 0.012±0.0014 mg/l,respectively among different treatments. Weight loss of fishes was found to be varied from 0.04±0.008g to 1.62±0.09g during the study period. Especial behaviour of fishes was subdivided into four phases namely; primitive phase, acute phase, moribund phase and death phase and all of the experimented fishes were fallen into these types of behaviour with some differential behavioural patterns. The study concluded with the recommendations- cultured native and exotic fishes (especially brood fish and fingerling) which are used to transport at distant places without feeding condition should be introduced in this type of research work; native ornamental fish species should be incorporated into such type of research work to clarify their good husbandry practice in aquarium; and further research work is needed to explore the feasibility of species combination of native ornamental fish species along with exotic ornamental fishes in terms of their survivability and behavioural pattern without feeding condition.

Reap the benefits from fish farming under community based fisheries management programme in Bangladesh

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Community Based Fisheries Management (CBFM) project carried out thorough study at seven CBFM sites where farming was considered as a means of enhancing fish production. The study covered stocking and harvesting performance, fisher's participation in managing fishery resources and biodiversity of indigenous (non-stocked) species. Fish harvest monitoring results showed that production and species diversity increased over the duration of the study, due to community management approach which encouraged participation of the fishers and communities in managing the fishery resources. The study revealed that net increased of annual fish production were found 156 kg/ha, 1229 kg/ha, 575 kg/ha, 205 kg/ha, 252 kg/ha and 1151 kg/ha in Dhum nodi, Ruhia-Baisha, Hamil beel, Tulshidanga, Kafri Khal and Chapandaha in 2005, respectively, compared to the baseline production in 2002. In contrast, production decreased was also observed 240 kg/ha in Sarala beel in 2005, compared to the baseline catch in 2002. The increases in fish production were also reflected in biodiversity measured for non-stocked natural species using the Shannon-Weiner Index (H') and were found 2.43, 3.433, 2.01, 3.102, 2.67 and 2.526 in Dhum nodi, Ruhia-Baisha, Hamil beel, Sarala beel, Kafri Khal and Chapandaha in 2005 respectively. The indices were higher compared to the baseline indices in 2002. However, Biodiversity index for Tulshidanga was found low in 2005.

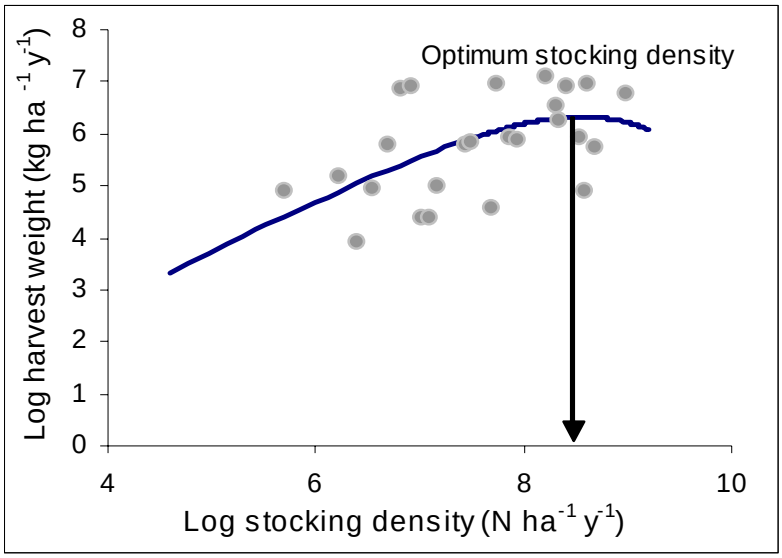

Figure 1: Proposed optimum stocking density per hectare.

The study also revealed that single-stocking of carps with a density of 3,000–4,000 fingerlings/ha/year with a appropriate species composition ratio did not affect yield of indigenous fish in closed waterbodies.

Use of mussel tissue metal concentration as pollution indicator from an urban lake

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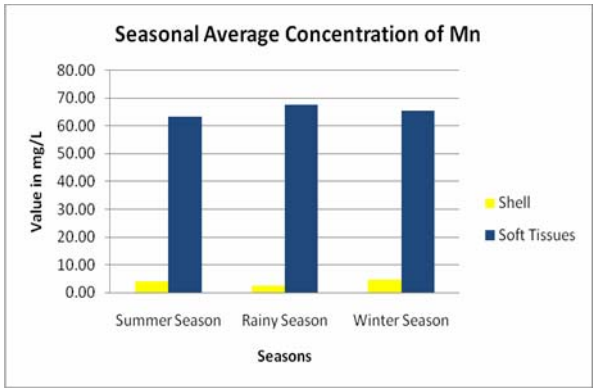
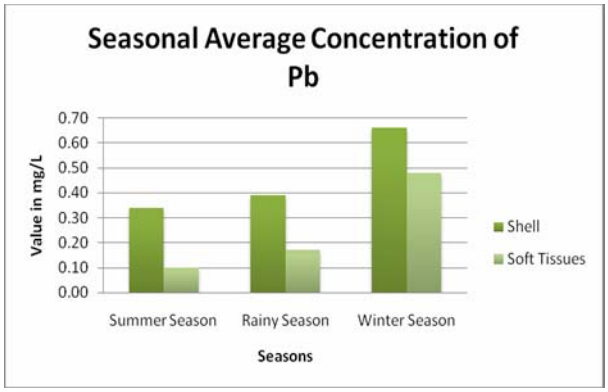
An attempt has been made to assess some selected heavy metals in freshwater mussel (*Lamellidens marginalis*) in Dhanmondi lake in different seasons during 2010- 2011. The results of mussel tissue Mn, Zn, Pb, Ni and Cd revealed variation with season and tissue types. The shell and tissue values of Mn, Zn and Pb concentration varied significantly ($P<0.01$) while no differences found in Ni. Mn was found to be at higher concentration in soft tissues than shell while the average value of Pb was higher in shell than soft tissues. Pb contamination in lake might occur due to the traffic around the lake. Cd was found to be absent from the lake or may be present at below detectable level.





From ecological point of view, the *L. marginalis* is widely distributed in abundance along the Dhanmondi lake. However, from the toxicological point of view, the accumulation of high levels of Mn in the tissue of *L. mrginalis* collected from Dhanmondi road 2A lake area, indicared that the contamination for any filter feeding animal witha risk of bioaccumulation. In addition it was proved that the freshwater mussel species could be used as a potential biomonitor species for heavy metal assessment in lake organisms especially for Mn and Pb.

Proximate composition of earthworm *Perionyx excavatus* cultured using different organic food composites

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The study was conducted to determine the nutritional composition of earthworm (*Perionyx excavatus*) reared in different organic food composites for 120 days. The principal aim of the research was to assess how the proximate composition of earthworm varies in response to different organic food used in the experiment. The food were composed of soil, cow-dung, paddy straw, water hyacinth and kitchen wastes, of which different proportions were used in formulating the four experimental groups namely, T_1 (soil: cow-dung: paddy straw: water hyacinth: kitchen waste = 5:50:5:30:10), T_2(5:40:10:20:25), T_3 (5:30:15:10:40) and control (C, 95% cow-dung and 5% soil). How much of each of these feeds were supplied?

The adults of *P. excavates* were collected from wild and stocked into cemented ring tank of 0.5 m height and 0.28 m diameter at the rate of 5 adult / tank. After 120 days, the earthworms (spawned and reared) were harvested for laboratory analysis. The sample of culture bed was collected before and after earthworm culture for determining total organic carbon (TOC), and total nitrogen (TN) of different treatment composites. The proximate analysis of earthworm was done in the Fish Nutrition Laboratory of Fisheries and Marine Resource Technology Discipline, Khulna University.
The earthworms in T_2 had the highest level of protein (48.36±1.329%), lipid (4.59± 0.194%) and moisture (81.85±0.735%) content. The lowest ash level (12.35± 1.858%) was found in control group followed by T_2 (13.62± 3.042%). The results of the investigation reveal that the earthworm species reared in T_2 is nutritionally superior to other groups. No statistics! How do you conclude a difference withouf statistical analysis. If you calculated nutrients on a dry matter basis and used statistical analyses, your conclusion might be different! Unacceptable without stat!!!

Table 1. % Composition of four different mediums for *Perionyx excavatus*

Materials	C	T_1	T_2	T_3
Soil	5	5	5	5
Cow dung	95	50	40	30
Paddy straw	-	5	10	15
Water hyacinth	-	30	20	10
Kitchen Wastes	-	10	25	40
Total	100	100	100	100

Effect of various loading rates of rice straw on physical, chemical and biological parameters of water

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An experiment was conducted to assess the effect of different loading rates of rice straw on the physical, chemical and biological parameters of fertilized water in 21 cemented tanks for 35 days using seven treatments with three replicates. Treatments were: Control (T1), rice straw mats with loading rate of 625 kg ha^{-1} (T2), 1,250 kg ha^{-1} (T3), 2,500 kg ha^{-1} (T4), 5,000 kg ha^{-1} (T5), 10,000 kg ha^{-1} (T6), 20,000 kg ha^{-1} (T7) on dry weight basis. Result showed that water quality deteriorated with increased loading rates of rice straw. Dissolved oxygen and pH were significantly lower in rice straw treatments than control. Transparency was significantly higher in the treatment T4 and lower in treatment T7. Total alkalinity, total ammonia, nitrite, TKN, total phosphorus, TSS, TVS and chlorophyll-*a* in treatment T7 was significantly higher than other treatments ($p<0.05$). Plankton, periphyton densities and bacterial load did not differ significantly among treatments. Dry matter and ash free dry matter of periphytons were significantly higher in the treatments T2, T3, T4 and T5. Chlorophyll-*a* concentration of periphytons was significantly higher in the treatment T3 than in the treatment T6 and T7. In conclusion, it can be said that the loading rate of 625 kg ha^{-1} appeared to be best among treatments. However, the experiment was carried out in tank without fish, so, effects of decomposition on fish growth and production needs to be assessed in ponds.

Toxicological effects of commonly used organophodphates on histology and acetylcholinesterase (ache) activity of *Labeo rohita* and *Barbonymus gonionotus*

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The use of pesticides has soared over the last decades where the massive introduction of high yielding varieties (HYV) and indiscriminate use of pesticides are gaining attention. The agricultural pesticides specially the organophosphates have been suggested to be acutely neurotoxic for aquatic biota when the land wash roll down to the open water whereas some fishes are considered as suitable species for rice-fish farming are more susceptible to pesticides exposure. In this study, the effects of three currently used organophosphate pesticides, Envoy 50 SC, Samcup 50 EC and Darsban 20 EC on histopathology and acetylcholinesterase (AChE) activity of two fish species, *Labeo rohita* and *Barbonymus gonionotus* were studied. The medium lethal concentration (LC_{50}) value of Envoy, Samcup and Darsban were calculated as 0.116, 0.192 and 0.073 ppm for *L. rohita* where 0.458, 0.765 and 0.269 ppm were recorded for *B. gonionotus.* A major alteration of histology were observed after 7 days exposure of fish at and below the agricultural recommended dose. The histopathological changes were hemorrhage, necrosis, pyknosis, fatty degeneration, lipid droplets, nuclear alteration, gill clubbing, missing of secondary gill lamellae, fungal granuloma, hypertrophy degenerating kidney and glomerular tubule and vacuoles found in gills, hepatocytes, and hematopoietes. The AChE activity, a potential biomarker has been used as an indicator of neurotoxicity. A significant decline of that enzyme (P<0.001) of both two fish brain were observed. Histological alteration and AChE inhibition is a dose dependent manner where Darsban showed more devastating effects followed by samcup and Envoy. This study suggests that the organophosphastes affect vital organs and nervous system of fish that eventually shrink the vulnerable lifeline of fish.

Reproductive physiology of mud eel *Monopterus cuchia* for artificial propagation

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Mud eel, *Monopterus cuchia*, native to Bangladesh, is considered to be a nutritious and tasty fish and is also a valued remedy in oriental medicine. Out of more than 800 fresh and saltwater fish and shrimp species of Bangladesh, only four are exported to foreign consumer market; *M. cuchia* is one of them. *M. cuchia* is also a threatened species of Bangladesh. Because of its indiscriminate harvest from nature, we will not be able to export this in future if artificial propagation and fry production techniques are not developed soon. Therefore, the study of reproductive physiology and GSI of this threatened species from the haor area of Mohongonj, Netrakona will not only prevent this fish from extinction but also will help to introduce aquaculture of this exportable fish species. Histological observation of ovary observed presence of undeveloped oocyte (UO), early perinuclear oocyte (EPNO), late perinuclear oocyte (LPN), yolk granule stage (YG) and mature stage (M) oocytes in ovary. The M oocytes were observed in the ovary sections collected late March to April; increasing in number of M oocytes in April compared to March. It was also observed that oocytes did not develop synchronously. It is evident that the ovary of captive *M. cuciha* gets mature in later March and April. The GSI was calculated for female mud eel during July to September, 2011. Month wise changes in mean GSI of female cuchia are presented in Table 1. Values of GSI decreased from 1.67±0.37 to 0.36±0.18 during July to September. The higher values of GSI was observed during July was 1.67±0.37. This study provides the first detailed information about breeding season of endangered *M. cuchia* that will contribute to develop artificial propagation of this species.

Table 1. Mean (± SD) body weight, ovary weight and GSI (%) in female *M. cuchia*

Month	Mean body wt (g)	Mean ovary wt (g)	GSI (%)
July	157±6.38	2.61± 0.47	1.67±0.37
August	164±46	2±0.15	1.23±0.20
September	293±14	1.07 ±0.94	0.36±0.18

Availability of anti-oxidants in different small indigenous fish species of Bangladesh

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In the present study 16 fish species; 8 Small Indigenous Species (SIS) from marine water and the others 8 from freshwater were assessed for antioxidant activities. The assessment was done by both qualitative and quantitative ways. To measure the antioxidant activity, the qualitative analysis was done by Thin Layer Chromatography (TLC) and the quantitative analysis was done by 1, 1-diphenyl-2-picryl hydrazyl (DPPH) free radical scavenging method respectively. Light yellow spot on TLC plate after spraying DPPH indicated the presence of antioxidant components. For quantitative test, the half maximal inhibitory concentration (IC_{50}) was found at 364 µg/ml, 489 µg/ml, 398 µg/ml, 480 µg/ml, 405 µg/ml, 327 µg/ml for *Mystus gulio*, *Silonia silondia*, *Hemirhamphus gaimardi*, *Megalaspis cordyla*, *Mystus vittatus*, *Heteropneustes fossilis* respectively and whereas the IC_{50} values of standard antioxidant ascorbic acid was 22 µg/ml. Again the IC_{50} value of *Gobioides anguillaris*, *Coilia dussumieri*, *Mugil cephalus, Chela laubuca, Plotosus canius*, *Amblypharyngodon mola*, *Oxygaster phulo, Tetraodon cutcutia, Colisa fasciatus* and *Mugil cephalus* was > 500 µg/ml.

Organic prawn in polyculture: Effects of stocking density of tilapia on environment and production

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An experiment was conducted to evaluate the effects of stocking density of tilapia on water quality, planktonic community and production in organic prawn farming system over a period of 122 days at the Fisheries Field Laboratory, Bangladesh Agricultural University, Mymensingh. There were three treatments T_1, T_2 and T_3 with 10,000, 15,000 and 20,000 tilapia . ha^{-1}, respectively. A fixed density of freshwater prawn and silver carp at 30,000 and 1,250 indiv. ha^{-1}, respectively, was maintained in all treatment ponds. The area of each pond was 130 m^2 with water depth 1.5 m. *Kanchi* (bamboo branch) (mean diameter 2.8 cm) were posted at a density of 15.0 poles m^{-2} vertically into pond bottom as periphyton substrates. Water quality parameters such as water temperature, transparency, total alkalinity, pH, dissolved oxygen were measured weekly, while nitrate-nitrogen, nitrite-nitrogen, ammonia-nitrogen, phosphate-phosphorus, and chlorophyll-*a* were measured monthly. Plankton samples were collected once in a month.

Among the water quality parameters, significant differences ($P<0.05$) were observed in case of transparency and chlorophyll-*a*. The highest PO_4-P and lowest chlorophyll-*a* concentrations in water were observed in treatment T_3 with highest density of stocked tilapia. There were no significant differences ($P>0.05$) for plankton and benthos among three treatments. The mean weight of tilapia at harvest decreased significantly ($p<0.05$) with increasing stocking density, but survival rate did not differ significantly. The net production of organic prawn was higher (668.35 $kg.ha^{-1}$) in T_3 than in T_2 (647.46 kg ha^{-1}) and T_1 (640.00 kg ha^{-1}). Similarly, the net production of tilapia was significantly higher in treatments T_3 (2117.5 kg ha^{-1}) and T_2 (1778.71 kg ha^{-1}) than in treatment T_1 (1422.36 kg ha^{-1}). When combined production of all three species were compared, it was found that treatment T_3 resulted in significantly higher net production (3196.13 kg ha^{-1}) than those of T_1 (2797.19 kg ha^{-1}) and T_2 (2392.47 kg ha^{-1}). The results revealed that an addition of tilapia at a density at 20,000 ha^{-1} increased the production of prawn as well as silver carp, and thus contributed to earn higher net profit (Tk. 1,78,321 ha^{-1}) with a BCR of 0.53. It may be concluded that the polyculture of prawn, tilapia and silver carp at the stocking densities of 30,000, 20,000 and 1250 ha^{-1}, respectively provided the higher net production and economic benefit, and may be recommended for on-farm trials.

Effects of tertiary amyl alcohol and 2-phenoxyethanol on the survival of silver carp fingerlings with compressed oxygen during transportation

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Mortality, however, occurs during transportation of silver carp fingerlings owing to insufficient data available on the use of anesthetics. Current study was thus conducted to determine the best anesthetics and their optimal dosages to improve the transport technique of silver carp fingerlings. Efficacy and the optimal dosages of Tertiary Amyl Alcohol (TAA), 2-Phenoxyethanol (2-PE), Quinaldine (4%) and Benzocaine were evaluated in silver carp fingerlings transportation in the preliminary experiment. Based on the results of preliminary experiments, TAA (at 1.0 mL/L) and 2-PE (at 115 µL/L) were selected for final experiment. A 3^3 factorial design was used at 400 g/L in triplicate. Initial and delayed mortally, water quality, immobilization and recovery period were the indicators to determine the efficacy and optimal dosages of the above four anesthetics. Compressed oxygen was used in all the treatments of the final experiments. No initial and delayed mortality were observed in all three treatments up to three hours. Six hours after simulation 1.02, 0.62 and 0.01% delayed mortality were observed in the control, 2-PE and TAA treatments, respectively (Fig. 1). No significant difference was detected in the temperature and pH in all treatments while significantly higher DO content (above 22 mg/L) was found in TAA treatment than that of control and 2-PE (about 9 mg/L) treatments (Fig. 2).

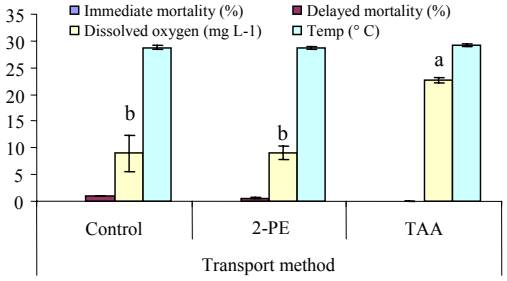

Fig. 1. Immediate and delayed mortality rate (%) observed 24h after treatment in silver carp sampled from the control group and two treatment groups. Bars (mean ± SEM) with different letters denote significant differences (ANOVA, HSD; $p<0.05$).

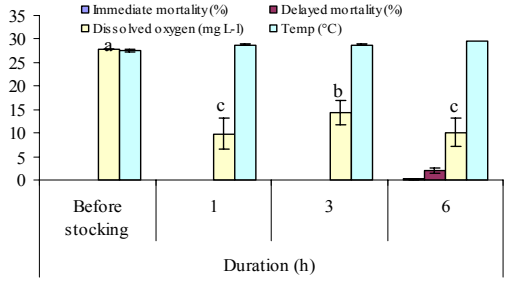

Fig. 2. Immediate and delayed mortality rate (%) observed during 6 h transportation in silver carp. Bars (mean ± SEM) with different letters indicate significant differences (ANOVA, HSD; $p<0.05$).

The findings of this study shows that, TAA at 1 mL/L and 2-PE at 115 µL/L can be used as sedative with compressed oxygen during transport of silver carp fingerlings at 400 g/L for a duration of six hours with a few mortality by reducing transport related stress which will improve the post-transport survival and hence reduce economic loss.

Transportation of mola brood (*Amblypharyngodon mola*) for stocking in the homestead ponds in North-west Bangladesh

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Collection and transportation of live mola (*Amblypharyngodon mola*) from different sources for stocking in ponds and wetlands to get increased fish production is a major problem. The purpose of this study was to develop an effective method to reduce mortality and stress of mola during transportation aiming at successful incorporation of micronutrient dense mola broodfish into carp polyculture in ponds. . The IFAD funded small fish and nutrition project took initiatives to devise effective methods of transportation of micronutrient dense small fish mola in order to stock in ponds of 1500 households in NW Bangladesh. The major sources of collection of mola broodfish were ponds connected with beel (natural depression), seasonal ditches inside dead rivers, rice field connected ponds and grow-out (carp polyculture) ponds. The locations where the project activities carried out were - three Upazilas (Sadar, Chirirbandar and Parbatipur) in Dinajpur District and two Upazilas (Kaunia and Pirgacha) in Rangpur District during November 2010 to May 2011.

The devices used for mola transportation were- aluminum pot (*patil*)_ improvised containers developed using polythene sheet inside pickup van/engine van locally called *votvoti* and plastic barrels. Pickup van, engine van, power tiller/trolly and rickshaw van were used to carry mola broodfish from sources to stocking ponds. The transported mola were grouped under two categories (1) mola with proper conditioning (2) mola with less or no conditioning. Proper conditioning meant separation of mola in separate ponds as single species, regular netting, and use of good feeds as supplementary feeds before harvest. Less or no conditioning meant - no special initiatives were taken to pre-condition the mola before harvest. Careful and sensible handling, adding saline solution, using oxygen releasing agents, agitation of water, hand splashing and using aerator during broodfish transportation showed better result. Saline solution and/or oxygen releasing agent were used during broodfish transportation.

The transportation of 1655.5 kg mola on 131 out of of a total 156 occasions using properly conditioned different resulted very high survival (91%). Proper pre-conditioning and better handling management was found to be the safe way of mola broodfish transportation up to 62 km distance for more than 2 hours. The method developed was found to be very effective for transportation of mola which was very useful for its promotion for culture in ponds and wetlands.

Development of Black Soldier Fly- *Hermetia illucens* larvae (BSFL) production technique for fish feed supplement

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Conventional feedstuffs such as fish meal, rice bran, wheat bran and mustard oil cake are in short supply and aggressively sought for more established livestock and poultry industries in Bangladesh. Due to the shortage and lack of expertise testing lab in the country most of the feed industry marketed adulterated feed for extra profit. They use cheap adulterants to inflate the apparent protein content of the products, so that inexpensive ingredients can pass through for more expensive and concentrated proteins. To overcome the problem black soldier fly, *Hermetia illucens* larvae (BSFL) production technique has developed in the Department of Aquaculture, Bangladesh Agricultural University, Mymensingh. In the system a specialized plastic chamber was build where house hold kitchen wastes was placed and egg laying chamber made of corrugated hard board sheet was hanged in the chamber for laying eggs. The fly was attracted with the rotting small of kitchen wastes and entered into the chamber through the holes and lay eggs. The eggs hatched and light cream colour larvae come out and crawl on to the wastes within 4-5 days in optimum temperature (26-30^0 C) and begin to consume it with amazing speed. It took 21-28 days to come out the adult fly from eggs to larvae, larvae to pupae and pupae to adult in the system. A mosquito net was set to trap the adult and the adult again engaged in laying eggs in the system. The larva is self harvested from the system and very rich in protein, lipid and minerals which can be used in angling, aquarium, hatchery and small scale fish culture. The dried larvae can be replaced with fish meal in fish feed preparation. The easy to use technique can be utilized throughout the country for fish and poultry feed supplement.

Table: Comparison of nutritional composition of live BSF larvae and other worms

Nutrient properties	Cricket worms	Meal worms	Super worm	BSF Larvae
Fat (%)	6	12.7	17.9	9.4
Protein (%)	21.3	20.3	17.4	17.3
Calcium ppm	345	133	124	8155
Phosphorous ppm	4328	3345	2320	5355
Ratio	0.08	0.04	0.05	1.52

Backyard aquaponics for sustainable fish and vegetable production

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Production and supply of fish and vegetable round the year is fluctuating due to natural disasters, high price of feed and fertilizer, adulterated feed and season. Moreover, food needs to be produced with in the short distance of consumers to keep freshness, reduce quality loss and transport cost and to handle the climate change impact. To minimize the above problems and make the country food secure an innovative and new fish and vegetable production technique "backyard aquaponics system" was developed where 36 empty water bottles were fixed in upside down with ropes in a wooden rack. Each bottle was cut both the sides and made a small hole on the mouth cork to allow water to drain out. Inside the cork a piece of sponge was placed to filter the water before fall down from the bottle to the fish tank. One thousand liter plastic water tank was placed beside the rack where tilapia (13 fish/liter) was released. Pea gravel was placed inside the bottle and two vegetable saplings were planted in each upside down bottle. Fish tank water was installed manually in a 30 liter container 7 feet higher in a platform and siphoned to the vegetable containing bottles. Floating peletted feed was administered to the fish 5% of their body weight twice daily. Vegetable and fish growth was monitored closely and fish sample was taken fortnightly. Data analysis clearly showed that growth of fish was satisfactory when temperature was above 22^{0} C, however; growth rate has reduced with the decreasing temperature. Lettuce, pudina and tomato plant growth is quite good in the system. The system can be tested anywhere in the country for food production and food security purposes especially in disaster prone areas.

Raft aquaponics for sustainable fish and vegetable production from high density fish pond

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Fish production through aquaculture has increased in recent past to keep pace with the country's ever increasing population. This has accelerated environmental pollution, land degradation and land converted to fish ponds. To address the problems and keep steady fish and crop production to feed the country's huge population, "aquaponics system" an innovative, environmental friendly fish and vegetable production technique has developed. In the system a bamboo made floating raft with half empty plastic bottle full of coconut fiber and pea gravel have set in high density fish pond. Vegetable like pudina (*Mentha* sp), kochu, pui shak (*Basella alba* L.), kolmi (*Ipomoea aquatica*), begun (*Solanum melongena*) and Dherosh (*Abelmoschus esculentus*) saplings were planted in the bottles to see their performances with the pond water. The half of the bottle keeps under water along with the roots of saplings where denitrifying bacteria convert nitrite and ammonia to plant food as nitrate and remove pond wastes. One tenth of the pond surface was covered with the raft. The growth was monitor weekly and recorded. No chemical was used and IPM technique was applied to eradicate insecticides. Kolmi shak was harvested every month and dherosh only once in three months period. The end of the growth phase the total production was calculated. The growth of pudina, kalmi and kachu was found satisfactory. Each dherosh tree gave 2 fruits except some disease infected trees. Few flowers have seen on begun tree but no fruit was seen as it was infected with disease. Pui shak growth was not satisfactory but at the end it gave fruits. Waste concentration change was not noticed in the pond may be the density of plant was less. The experiment needs to be placed in the commercial ponds which are highly nutrient rich. It also needs to test the various vegetable and herbs in various seasons to see their growth. The technology can be piloted in different agro-ecological zone in the country.

Table: Per hectare vegetable production in three months

Plant name	Percentage plantation	Plant (No)	Production (kg)
Kolmi	20	21,553	1,437
Pudina	20	21,553	718
Dherosh	20	21,553	251
kochu	20	21,553	Yet to harvest
Begun	10	10,777	Nil
Total	100	107,765	2,406

Impact of stocking density on growth of mono-sex (male) giant freshwater prawn (*Macrobrachium rosenbergii*)

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Freshwater prawn (*Macrobrachium rosenbergii*) farming have been playing a pivotal role in the national economy of Bangladesh by earning substantial foreign currency each year. Culture of mono-sex male of freshwater prawn can enhance production by several folds within the same culture duration compared to female and mixed sex culture of the species. Considering this, the present study was aimed at identification of a suitable stocking density of mono-sex male prawn for getting more production and profit. Three different stocking densities were maintained *viz*., 1/m^2, 2/m^2 and 3/m^2 with 3 replications in 9 different ponds. After 3 months culture period, the mean body weights for 3 different treatments reached at 14.14 gm, 16.49 gm and 19.3 gm for 3/m^2, 2/m^2 and 1/m^2 respectively. By the end of the culture experiment, mean survival rates were obtained at 65%, 71% and 78% for 3/m^2, 2/m^2 and 1/m^2 stocking densities respectively. Total production was found to vary among the treatments, providing 3308.76 g for 3/m^2 stocking density, 2796.58 g for 2/m^2 and 1806.48 g for 1/m^2. Differences in growth performance, survivability and total production between different stocking densities found to vary significantly ($p=0.00<0.05$) in all cases. As the total production at 3/m^2 stocking density was found to be significantly higher over the other stocking densities, this treatment could effectively be introduced in the culture of mono-sex giant fresh water prawn for optimum benefit.

Effects of aflatoxin b_1 contaminated feed on Thai koi

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Air breathing climbing perch is a commercially important high value fish in Bangladesh. This hardy fish is very suitable for cultivation in ponds, reservoirs and rice fields. Aflatoxin contamination in aqua feeds is a widespread problem in aquaculture due to use of waste materials. Aflatoxin B_1 (AfB_1) is the most common in food and amongst the most potent genotoxic and carcinogenic aflatoxins.

The effects of five levels of aflatoxin B_1 (0, 25, 50, 100 & 200 ppb) in Thai koi, *Anabas oligolepis* for three (15, 30 and 45 day) culture duration have been investigated in indoor plastic tanks. No mortality was observed in any of the treatments. Significant differences were found in 100 & 200 ppb treatment group in average daily weight gain and specific growth rate compared to those of control, 25 and 50 ppb treatment groups (Fig. 1). Body muscle in 200 ppb treatment group had significantly higher concentration of aflatoxin B_1 (AFB) residues than in the 100 & 50 ppb treatments. Control and 25 ppb did not have any residue. Total protein content and fat content was decreased compared to control, 25 & 50 ppb treatment groups (Fig. 2). However, similar but lower moisture and ash content was detected in control and 25 ppb treatments. Conversely, 50, 100 & 200 ppb concentration groups were significantly different.

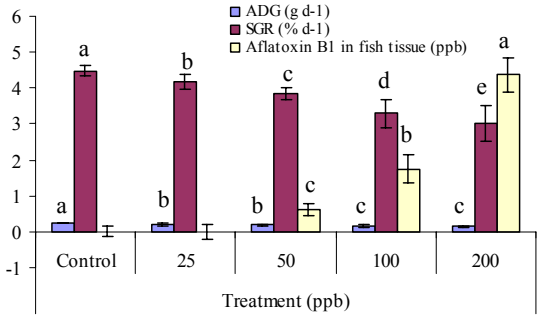

Fig. 1. Effects of aflatoxin B_1 on the average daily weight gain, specific growth rate and residue in fish tissue at different levels of aflatoxin B_1. Bars (mean±SEM) with same color, different letters are significantly different (ANOVA, $p<0.05$)

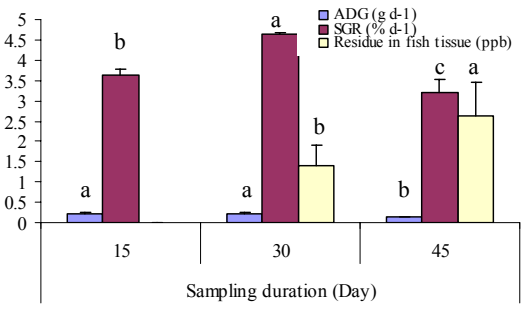

Fig. 2. Overall effects of aflatoxin B_1 on the average daily weight gain, specific growth rate and aflatoxin B_1 residue in fish tissue at different sampling duration (day). Bars (mean±SEM) with same color, different letters are significantly different (ANOVA, $p<0.05$).

Result suggests that the level of contamination by 50, 100 & 200 ppb aflatoxin B_1 in the feed of Thai koi fingerlings may concentrates in the body muscle at a level of above human health hazards. Any feeds with even 50 ppb AFB_1 should not be used as feed for raising food fishes.

Pathogenecity, antibiotic and herbal sensitivity of *Edwardsiella* sp. isolates collected from fish sample

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Studies were conducted to identify suspected *Edwardsiella* sp. isolates collected from diseased carp, tilapia and catfish and to find out their pathogenesity and sensitivity of the isolates to different commercial antibiotic disc and crude herb extracts. From a total of sixty isolates, twelve were identified as *Edwardsiella* sp. through morphological, physiolgical and biochemical tests. Artificial infection test was performed to find out the pathogenicity of the selected isolates to fingerlings of mrigal (*Cirrhinus mrigala*) through intraperitoneal route, where all of isolates caused pathological effect in experimental fish. Among these, three isolates were found highly virulent exhibiting lesions and high mortality (80%). Sensitivity pattern of the isolates were carried out against seven commercial antibiotic discs *viz*., azithromycin, cephradine, chloramphenicol, ciprofloxacin, erythromycin, streptomycin and sulfamethoxazol where, all of the isolates were found resistant to multiple antibiotics. A total of 50 herb samples were screened to evaluate their inhibitory effect on the isolates. Among them, several herb extracts (*viz.*, Garlic - *Allium sativum,* Tamarind - *Tamarindus indica* and Amla - *Emblica officinalis*) were found to possess antimicrobial activity which could be used as alternatives to chemical antibiotics.

Effect of different protein levels on nursery feed for production of quality tilapia *Oreochromis niloticus* fry

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In tilapia hatchery production, artificial feed is very important because the quality of fry depends on the quality of feed. Feeds at fry stage generally required higher level of protein because it is believed that the protein and energy requirements on a unit mass basis are much higher in the early stages of life. The protein content of nursery feed in our tilapia farms have not yet been standardized although some farms use feed having as much as 40% protein. So it is essential to recommend the appropriate protein level of nursery feed for economic production of healthy fry.

A 4-week feeding trail was conducted for two experiments in Agro-3 Fish Hatchery and Culture Farm, Trishal, Mymensingh. Four days old 1,247 fry of initial average length of 0.8 cm and weight of 0.012 g were released at the same stocking density (1,559/m^2) in 12 synthetic hapas. Four different treatments (T_1, T_2, T_3 and T_4) in three replications were used having different (35.95%, 40.43%, 45.61% and 50.85%) protein containing diets for experiment 1. The best growth was obtained at 35.95% protein level which was the lowest in protein content. Therefore, a follow up second experiment with feeds having protein levels both higher and lower than the best performed diet of the first experiment *viz.* 30.12%, 33.42%, 36.19% and 39.01% was conducted. At the end of two experiments the significantly ($p<0.05$) highest mean weight gain (g), percent weight gain (%), specific growth rate (%/day) and the best feed utilization in terms of food conversion ratio and protein efficiency ratio and survival rate (%) of *O. niloticus* fry were found at 35.95% protein containing diet compared to others for experiment 1 and at 36.19% protein containing diet compared to others for experiment 2. So from both experiments, the best result was obtained at approximately 36% protein containing diet. Thus, the feed containing 36% protein could be highly recommended for the production of quality tilapia fry. It may be a good to prepare feed of 36% protein from ingredients other than fish meal through replacement with cheaper protein based ingredients to economize the feed cost

The potential of nutrient-rich small fish species in aquaculture to improve nutrition and health

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Small fish are a common food, and an integral part of the everyday carbohydrate-rich diets of many population groups in poor countries. These populations also suffer from undernutrition, including micronutrient deficiencies – the hidden hunger. Small fish species, as well as the little oil, vegetables and spices with which they are cooked enhance diet diversity. Small fish are a rich source of animal protein, essential fatty acids, vitamins and minerals. Studies in rural Bangladesh and Cambodia showed that small fish make up 50-80% of total fish intake, in the peak fish production season. Although consumed in small quantities, the frequency of small fish intake was high. As many small fish species are eaten whole, with head, viscera and bones, they are particularly rich in bioavailable calcium, and some are also rich in vitamin A, iron and zinc. A traditional daily meal of rice and sour soup, made with the iron-rich fish, trey changwa plieng (*Esomus longimanus*), with the head intact can meet 45% of the daily iron requirement of a Cambodian woman. Small fish are a preferred, well-liked animal source food, supplying multiple, essential nutrients, and with positive perceptions for nutrition, health and well-being. Thus, in areas with fisheries resources and habitual fish intake, there is good scope to include micronutrient-rich small fish in agricultural policy and programmes, thereby increasing intakes which can lead to improved nutrition and health. Many aquaculture studies and field trials have been conducted in Bangladesh with carps and small fish species. Results have shown that without eradication of native fish in pond polyculture, and stocking of the vitamin A-rich small fish, mola (*Amblypharyngodon mola*), the total production of carps did not decrease; however, the nutritional quality of the total fish production improved greatly. In addition, mola breeds in the pond, and partial, frequent harvesting of small quantities is practised, favouring home consumption. A production of only 10 kg/pond/year of mola in the estimated 1.3 million small, seasonal ponds in Bangladesh can meet the annual recommended intake of two million children. Successful aquaculture trials with polyculture of small and large fish species have also been conducted in rice fields and wetlands. Thus, aquaculture has a large, untapped potential to combat the hidden hunger. To make full use of this potential, further data on nutrient bioavailability, intra-household, seasonal consumption, nutrient analyses, cleaning, processing and cooking methods of small fish species are needed. Advocacy, awareness and nutrition education on the role small fish can play in increasing diet diversity and micronutrient intakes must be strengthened. Measures to develop and implement sustainable, low-cost technologies for management, conservation, production, availability and accessibility of small fish must be undertaken. Also, an analysis of the cost-effectiveness of micronutrient-rich small fish species in combating micronutrient deficiencies, using the Disability-Adjusted Life Years (DALYs) framework should be carried out.

Propensity of using fish medicines on the basis of farmers age, educational status and landownership of six Upazilas, Noakhali

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The intensity of aquaculture is increasing day by day in Bangladesh. To meet the increasing demand new technologies are using to enhance production. Recently the use of fish medicines in aquaculture is popularizing among fish farmers in Bangladesh. In present study, the propensity of using fish medicines on the basis of farmer's age, educational status and land ownership was observed. The study was conducted in six upazilas of Noakhali district. Data were collected through semi-structured questionnaire survey of 77 fishermen and discussing with the upazila fisheries officer, retailers of fish medicines and representatives of pharmaceutical companies. The propensity of using Harmful gas controller is higher than any other medicines among the farmers. In six upazilas the tendency of using Harmful gas controller, Oxygen supplier, Natural productivity enhancer, Insecticides, Growth promoter, Vitamins and TSP are 36%, 22%, 21%, 19%, 14%, 16%, and 16% respectively. In considering the age groups; farmers of 26-35 years and 36-45 years apply medicines frequently. Farmers of 16-25 years and 56-65 years show average and less tendencies to adopt and apply medicines respectively. Illiterate and primary level educated farmer show less tendency to use medicines. But the farmer whose education level is above H.S.C shows more tendency to apply medicines. Rich Farmers having above 6 acres of land show more tendencies than poor and moderately rich farmers to apply medicines in their ponds. The study clearly shows that, there is a relationship between farmer's age, educational status and land ownership with the adoption of fish medicines but the use of it, it's appropriate doses, application methods and discriminate uses is not up to the mark in the Noakhali district.

Microbial analyses of formulated feed for *Macrobrachium rosenbergii* prepared by two commercial feed industries

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Microbial status of formulated feeds of two prawn feed manufacturing companies of Bangladesh, viz. Saudi Bangla Fish Feeds Limited, and Niribili Feeds Limited, was investigated. Total bacterial load, coliform, faecal coliform/*E. coli* and pathogenic bacteria (*Salmonella* and *Vibrio sp.*) in five stages of formulated prawn feed were studied. The range of the total bacterial load in the five stages of Saudi Bangla feeds was 2.52×10^4 to 1.44×10^5 $CFUg^{-1}$, coliform was 6 to 23 $MPNg^{-1}$ and faecal coliform / *E. coli* was 3 to 9 $MPNg^{-1}$. In the Niribili Feeds, the range of the total bacterial load was 1.31×10^5 to 2.07×10^5 $CFUg^{-1}$, coliform was 6 to 26 $MPNg^{-1}$ and faecal coliform / *E. coli* was 3 to 9 $MPNg^{-1}$. V*ibrio cholerae* was found only in the '*Golda Nursery-1 Feed*' of Saudi Bangla. Investigations revealed that commercial prawn feeds used in the grow-out farms were not always free from health hazard bacteria.

A study on how people are influenced to start fisheries activities in Pakundia Upazila, Kishoreganj

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The research work was conducted by collection of primary data from individual fish farmers, hatchery owners people take lease of jolmohal , fish feed manufacturers & sellers and the foodfish & fish seed traders by a questionnaire survey. Different types of media (Radio, Television, Newspapers, Extension workers, workers from NGOs & other private organizations normally play role to motivate people to involve in fisheries (aquaculture and open water fisheries management) activities. The involvement of people in fisheries activities is increasing day by day in Bangladesh. However, what sort of meida is effectively them inspired them to be involved in fisheries activities is not clearly known.

In order to get clear understanding about this , 18 villages under 5 Unions of Pakundia Upazila in Kishoreganj were selected. Information from 50 people selected for the purpose were collected using questionnaire. The results showed that of the people studied 92% of them were involved in fish culture, 4% involved in fish seed production, foodfish and fish seed trading. The result showed that of the people 50% of them were inspired by following others who had already been involved in fisheries activities. The influence of the YDP was only 8%. About 40% of the individuals of 15-24 years age group were influenced by their family. Among other age groups, 26% and 43% of the people of 25-34 and 35-44 years age groups respectively were influenced by following others. So, it came out that other an formal media/methods more people were inspired in s fisheries activities for fish culture and jolmohal leasing through influence by others –largely informal way in the area. Of the activities the involved fish culture and taking lease of jalmohal were given more importance as these were found to becomparatively easier them to involve getting benefit. The extension workers can set up various techniques to motivate the people of different ages and educational levels towards different fisheries activities by using the concepts from the research work.

Community led framework for estimation of sustainable exploitation level of fish and reeds in Tanguar *haor*

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The Tanguar Haor is rich in flora and fauna especially with fisheries, avians and reeds. The natural recruitment of natural fish and non fish organisms takes place from outside and also from the area to balance the depleted resources due to harvest, migration, predation and other natural deaths. The resources of the Tanguar Haor has been under wise-use concept of management by IUCN under Ministry of Environment and Forest supported by SDC based on conservation and rational harvest for sustainable environment. Specifically for Fish and Reeds the sustainable exploitation (in the form of maximum sustainable yield-MSY) is being targeted. There has been a need perceived for the community to develop a framework for sustainable harvest of fish and reeds.

In view of this the present investigation was made, the overall objective of this investigation was to develop a Community led framework for estimation of sustainable exploitation level of fish and reeds in Tanguar Haor. The investigation methodology was to review different concepts and MSY determination methodologies/approaches as one part and adoption of a methodology that best suited with the community and in Biological context of Tanguar Haor. The approach has been considered to be a community led approach instead of complex scientific process but with a simplified but acceptable modality. The investigation covers the concept of MSY, sustainable resource management, adoption of MSY in a simple form for the community to handle, development of community led framework, data collection format (including number of questionnaires) and modality of resource enhancement and harvest of fish and reeds with proper attention to social environment and biological environment. More than 15 reeds were identified along with 8 Swamps plant species and 10 aquatic vegetations along with their distribution pattern that support fish, birds and wildlife of Tanguar Haor. Based on most commonly accepted level of MSY which is about 50 percent harvest limit was refined based on shared experiences and comments of the community for the major groups of the resources considering local breeding, nature and extent of natural recruitment (Table 1).

Table 1. Estimated Sustainable Harvest Limit

Sl	Fish Group	Harvest Limit (Percent)
1	Major Carp	35
2	Minor Carp	50
3	Large Catfishes	40
4	Catfishes	50
5	Small Fishes	60
6	Live Fishes	50
7	Small Shrimps	55
8	Snails/Mussels	50

Decentralized aquaculture extension services of the Department of Fisheries through NATP Project: Understanding the impacts on Phulpur Upazila, Mymensingh

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Many projects have been implemented in Bangladesh in promoting aquaculture with the assistance of national and/or international funds. The National Agricultural Technology Project (NATP) is a joint venture project, assisted by the World Bank and the Government of Bangladesh and carried out in 120 Upazilas (sub-districts) of 25 districts in Bangladesh. This research studied the impacts of the NATP in the Phulpur Upazila of Mymensingh District with particular interest being paid to the aquaculture service provider.

The LEAFs (Local Extension Agent for Fish) were characterized by rural people, mostly fish farmers, as being educated individuals, effectively trained by the Department of Fisheries (DoF), Bangladesh and were motivated to advise the farmers on fish production and sale oriented activities on behalf of the DoF extension workers. The LEAFs established an effective communication bridge between the fish farmers of the Union (an administrative unit consisting of two or more villages) and the Senior/Upazila Fisheries Officer (SUFO/UFO) at the Upazila level. All the necessary supporting materials such as a water-testing kit box and various inputs *e.g.* seed, feed, nets or other equipment etc. were made available to the farmers through the close relationships that developed with the LEAFs. For the impacts study, a number of small, medium and large pond operators and the LEAFs interacting with them were surveyed. According to the results, the additional income and benefit were gained by fish farmers due to the instant services provided by the LEAFs. Overall, the NATP extension project made a positive impact on the local people in the areas of income generation and food security.

The research also highlighted the institutional enhancements that was achieved through the activities of the LEAFs and the grassroot level organization i.e. the CIG (common interest group) farmers in Phulpur. The results revealed that the village organization played a significant role in the process of technology transfer from the Upazila Fisheries Office to the village level farmers. The aquaculture planning of the CIG farmers through a demand-driven approach prioritized the stakeholder's participation. The research finally argued that a bottom-up approach of the extension system appeared to be an effective approach as a means of technology transfer.

Cage culture of tilapia *Oreochromis niloticus* in the Old Brahmaputra river and growth performances at different densities

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Cage culture of fish allows intensive production in water bodies without conventional preparation for aquaculture. This is highly important in a country like Bangladesh, which has a huge amount of inland water resources. Considering the importance and prospects of cage culture in Bangladesh, the present investigation was undertaken to study the effect of stocking density on growth performances and production potential of tilapia (*Oreochromis niloticus*) under cage culture and to develop method of tilapia cage culture in inland open water body like Old Brahmaputra River. Three stocking densities (100, 150 and 200 fish/m^3) of 2.78 g mean initial individual body weight fingerlings in three different treatments (T-100, T-150 and T-200) each with three replicates were used. The fishes were supplied with high protein (30%) commercial feed at 10% of body weight (twice daily). During the experimental period, surface water temperature, DO, pH and phosphate ranged between 20 to 30°C, 10 to 13 mg/L, 7 to 8 and 1 to 2 mg/L, respectively. Ammonia and nitrate were below detectable limit. Water quality parameters were found within the suitable limit for fish culture. The mean individual weight gains were 77.72±9.50 g, 90.72±8.41 g and 47.22±3.00 g in treatments T-100, T-150 and T-200, respectively. The average daily gains were 0.58±0.07 g, 0.67±0.06 g and 0.35±0.02 g, respectively. The percent weight gains were 2796±341.73%, 3263±302.56% and 1699±107.91%, respectively. The specific growth rates (SGR) were 1.08±0.04 %/day, 1.13±0.03 %/day and 0.91±0.02 %/day, respectively. The net production rates were 7772±950 g/m^3/135 days, 13608±1261.70 g/m^3/135 days and 9444±600 g/m^3/135 days, respectively. From the study it is found that growth performances and production rate (g/m^3) of tilapia were significantly different at different stocking densities (at 1% level of significance). Stocking density significantly influenced live weight gain, average daily gain, percent (%) weight gain and specific growth rate. From the experiment the best production was found in T-150 (150 fish/m^3). The net production rate in T-150 was 13608±1261.70 g/m^3/135 days. Therefore, tilapia cage culture can produce 368 ton fish/ha/yr.

Table 1. Mean individual weight gain (g) of *O. niloticus* at 15 days interval

Treatments	Sampling date				
	18 Dec. 09	2 Feb. 10	5 Mar. 10	1 Apr. 10	1 May.10
T-100	2.78	10.5	30	51.5	80.5
T-150	2.78	14.25	42	78.5	93.5
T-200	2.78	5.5	16.5	37.5	50

Habitat quality assessment of sewage-fed canal at Dhaka-Narayongonj-Demra area

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The physico-chemical factors canal water in six reference sites of Dhaka-Narayongonj-Demra (DND) Dam areas were studied during 2010-2011 to assess the monthly and seasonal variation in physicochemical conditions. Release of various pollutants, both industrial and household to the canal was visible and played major role in the canal water uses for fish culture and public health concerns. Maximum average transparency of water at different sampling sites was 15″ as observed in February, 2011 and minimum was 09.7″ in May, 2010. Conversely, minimum secchi depth or high turbidity occurred in the summer months was evidently due to heavy precipitation and strong wind action. Maximum average temperature of the canal, 31.5 °C, was observed in May, 2010 and minimum average temperature, 18.3 °C, in December, 2010. Temperature showed diurnal as well as seasonal variations. The average pH values of the six sampling sites water ranged from 6.74 in May to 7.66 in August. Maximum pH value in August may be attributed to overflow of flood water for three months. In the present study pH values found to show variations in different months. The seasonal fluctuations of pH values were conspicuous and showed decreasing tendency from October, 2010 to March, 2011. During March, 2011 and April, 2011 the pH values were more or less neutral. On the other hand, pH values showed an increasing tendency of acidic character of water from May, 2010 to October, 2010 except September. In this month, water level was increased because of run-off from the Buriganga which is common in every year. Concentration of dissolved oxygen (DO) increased gradually from September, 2010 to December, 2010 when it attained its maximum average value 6.83mg/L and then decreased till April, 2011 to minimum average value of 4.57mg/L. The lowest average value of dissolved oxygen, 4.00mg/L, was observed in May, 2010. Maximum average concentration of carbon dioxide (CO_2), 61.3 ppm, was observed in January, 2011 and minimum, 10.4 ppm, was observed in August, 2010. Most of the physicochemical parameters were found to be favorable for fish culture except carbon dioxide. Some area of the dam found to contain much organic matters on the basin. The canal could be used for culturing fishes like Thai pangas (*Pangasius hypophthalmus*) as well as Nile tilapia (*Oreochromis niloticus*).

Feasibility analysis : A case study of carp seed production farm in Bangladesh

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The quality of fish seeds in Bangladesh has declined over the years. The quality reduction is mostly observed in private hatcheries. There are many reasons for the low quality, for instance, inbreeding, inter-specific hybridization, negative selection, improper brood stock management, etc., which lead to poor performance in aquaculture production. Quality artificial seed production is necessary to fulfill the shortage of natural seeds and to satisfy the growing demand for quality fish fingerlings in aquaculture. New investment is needed to escalate the supply of good quality fish seed, which can improve the performance of cultivated species. Before making an investment in carp seed production farm, it is necessary to determine whether the planned investment idea is feasible or not. Given this thought, the present study was undertaken to evaluate the feasibility of operating carp seed production f arm on sustainable basis.

The study report represents analytical tool developed for the purposes of evaluating the feasibility of carp seed production farm in Bangladesh. The analyses were based on the assumptions of secondary data, which were collected from both the printed and the web publications. The financial feasibility of the farm was studied using Profitability Assessment Model, which utilized some indicators of investment returns such as Net present Value (NPV), Internal Rate of Return (IRR), Payback Period, Financial Ratios, Modified Internal Rate of Return (MIRR), etc. The risk of the investment was assessed through Impact Analysis, Sensitivity analysis and Monte Carlo Simulation. Similarly, Technical and Environmental feasibility were studied.

The findings of the analyses indicated that the proposed carp seed production farm was financially, technically and environmentally feasible. Total financing of the project was calculated to be 15 MBDT of which equity is 30%. The results obtained from the study showed a positive NPV, i.e. 26 MBDT of capital and 25 MBDT of equity from a 10-year-operation, which was acceptable. The IRR of capital and the IRR of equity were found to be 37% and 60% respectively, which were also adequate because the Marginal Attractive Rate of Return was determined to be 10%. The payback period of the investment was measured to be only 4 years. As a result, the project was recommended to be financially feasible even if it was operated only for 5 years. Further, the results of Risk Assessment presented that there was 98% probability of getting profit from the investment. However, the project was sensitive to sales price followed by sales quantity. Alike other fish selective breeding programme, the project was also considered to be feasible both technically and environmentally. It was concluded that the planned investment was highly feasible to operate in Bangladesh.

Fishers' access to fisheries resources under different management systems and their livelihood issues

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The present study was undertaken during 2009 as a part of policy support to the National Food Policy Capacity Strengthening Programme (NFPCSP) of the Ministry of Food and Disaster Management supported by FAO/USAID/EC to analyze and understand fishers access mechanisms to fisheries resources, fishers' livelihood including coping strategies during the ban and lean fishing periods and to suggest appropriate access mechanisms, fisheries management systems and coping strategies during ban and lean fishing periods. The study has been undertaken based on secondary and primary data in respect of fisheries management systems, fishers' access mechanisms to fisheries resources, and fishers livelihood. The primary data have been collected from 7 study sites in different ecological and geographical regions of the country with different types of water bodies under different fisheries management systems.

The study shows that 87% of fishers are poor with monthly income less than Tk.5000/-. They depend on loan from money lender/NGO. About 43% fishers do not have fishing equipment. They work as labor fishers or on catch share basis in others boat. Revenue oriented fisheries management and fishers' poverty, have been found to affect the fishers access to the resource, their income and livelihoods. Fishers access right to the fisheries have been found ensured in 3 management systems such as (i) the open access system in the flowing river, (ii) fishing right through license, and (iii) community based fisheries management system. While the revenue oriented leasing system has been found to affect fishers access to fisheries. During lean and ban fishing period the poor fishers suffer most as they do not have alternate option of work and as such most of them take loan from Mohajon/Aratdar, NGOs and relatives. However, some fishers work as day laborer and rickshaw pullers and also take less food. Fishers affected by 2-3 months fishing ban in 330 km stretches of the lower Meghna for protecting *jatka* (Juvenile hilsa) get some compensation from Govt. but is quite insufficient.

Micro-credit programme of Bangladesh Rural Development Board (BRDB): Socio-economic impacts on coastal fishers in Bhola

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In Bangladesh, micro-credit programmes are claimed to have positive socio-economic impacts on poor through different income generating activities (IGAs). However, there is lack of evidence for the impacts of such micro-credit programmes on the fishers in Bangladesh. This study was carried out to assess the socio-economic impacts of micro-credit on the fishers in Bhola, Bangladesh who were provided with micro-credit through the Integrated Poverty Alleviation Programme (IPAP) of Bangladesh Rural Development Board (BRDB). Along with participatory rural appraisal (PRA) tools, data were collected by questionnaire interview from 60 randomly sampled respondents from the study area, of which 30 were fishers, 15 related to fishing (RTF- connected through other value chain activities) and 15 not related to fishing (NRF) who received micro-credit from BRDB, other organizations (GOs, NGOs and *aratdars*/middlemen) or non-receivers of micro-credit. The average education level of BRDB fishers was less than that of other groups receiving credit from BRDB as well as other organizations. Only 64% of BRDB fishers encouraged their children to go to school which was less than the RTF (100%) and NRF (80%) groups. Fishing was the first profession of the fishers group irrespective of micro-credit providing organizations. Agriculture stood out as the second profession of 65% BRDB fishers but there was no remarkable second profession of fishers provided with micro-credit by other organizations and the non micro-credit group. Fishers had no significant decision making roles on their society and their leadership development were not grown up compared to non-fishers of BRDB and other organizations. Women empowerment through self-dependence and participation in decision making on family and social issue were not developed well. Landless households (having only or no land for homestead), either fishers or non-fishers of BRDB, got less but marginal households (having lands 0.2-1 hectare) more access to BRDB's micro-credit.

The average amount of micro-credit received by the fishers of BRDB was lower but they used the received micro-credit more frequently in IGAs, than the fishers of other organizations. BRDB fishers along with their family members reported having three meals a day, accessed more health and family planning services compared to other groups. The rate of use of sanitary latrine was higher for BRDB irrespective of fisher and non-fisher than other organizations. BRDB fishers used 73% of micro-credit in IGAs which was more than fishers, RTF and NRF of other organizations and they used 27% of their micro-credit in non-productive activities which was less than fishers, RTF and NRF of other organizations. However, fishers getting micro-credit from other sources purchased fishing net and repaired fishing boats which increased fishing pressure in the river. Compared to fishers of other organizations, BRDB's micro-credit receivers benefited more through implementing a range of IGAs but they could not strongly develop copping crisis as they were mainly depended on fishing. Moreover, alternative IGAs created additional income which ultimately reduced fishing pressure in the river.

Catch composition and selectivity of fishing gears of the River Halda

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An investigation on the catch composition and species selectivity of different fishing gears of the River Halda was conducted from January 2007 to December 2008. A total of 93 aquatic species (prawn, fish and turtle) were found in 1019 catch samples harvested by 31 kinds of gears. Catch composition by number and weight of each species for each kind of gear were determined. On the basis of species caught, enclosure net (ghera jal), brush shelter (jag), seine net (ber jal), bag nets (behundi jal and ichar jal), cast nets (jhaki jal, shotki jal, jele jhaki jal) and two kinds of push net (tengua jal and small thela jal) were identified as non selective gear. Gill nets (chiring jal, current jal, vashsa phaissha jal, catla jal), scoop net (phaissha jal), drag net (moi jal), one kind of push net (dhoka jal) and all hook and lines and long lines were moderately selective gears. Highest number of species were recorded in the catches of enclosure net (73 species), followed by the catch of seine net (57 species), set-bag net (50 species) and MM (medium mesh) cast net (46 species). Considering the fish size, seine net, lift net, bag net, drag net, SM (small mesh) enclosure net, push net, brush shelter, MM cast net, scoop net, MM gill net and long line were identified as small species gear while LM (large mesh) cast net, LM enclosure net, LM gill net and hook-lines were identified as large species gear. Scoop net, hook-line and long line were identified as strictly selective for single or a few species. LM gill net, LM cast net and hook and line with rod and reel were found to be deleterious for carps while bag net and enclosure net for prawns.

Food and feeding habits of a clupeid fish, *Setipinna phasa* from the River Halda

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Commercially important clupeid, *Setipinna phasa* (Hamilton), is well distributed in the lower Halda River. The fish is also adapted in Kaptai reservoir. But, so far, no program was undertaken for its aquaculture development. Knowledge on food and feeding habit is pre-requisite for aquaculture development of any species. Considering the fact, a one-year study on food and feeding habit of *S. phasa* (Hamilton) from the Halda River was carried out during January 2008 to December 2008.
A total of 193 specimens of *S. phasa* were examined on monthly basis for one year. The fish was found to be stenophagic, cannibal, and selective carnivore mainly feeding on small fish and prawn. The fish also showed cannibalistic habit in certain months. The food items found were small teleost (46%), shrimps (45.7 %), mollusk and insects (0.13%) and parts of fishes and shrimps (8.1%). Small fry of its own comprised 20.18% of the total stomach contents, which confirmed its cannibal nature. *C. soborna* a clupeid was found to be another most prominent food item in the stomach contents throughout the year. Index of Abundance showed that fish and shrimps were the most fovoured food items with almost equal choice. The relationship between total fish length (TL) and total gut length (TGL) was found to be: $TGL = 0.13251\ TL^{1.331}$ or $\text{Log } TGL = -0.878+1.331 \log TL$ ($r = 0.956$, $t = 11.825$, n (groups) = 15, $P < 0.01$). Gut length was less than half the of the total fish length (1:0.38), which confirmed the carnivorous nature of feeding habit of the fish.

Operation of fishing gears and crafts in the River Halda

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Types and methods of operation of fishing gears and crafts of€ the River Halda were investigated for a period of four years from September 2004 to December 2008. A total of 37 different types of gears (35 fishing gears including hand picking, two types of fry collecting nets) and two types of crafts of different sizes were identified. Out of 37 types of gears 16 were identified as destructive. Seven new types of gears were recorded during the present study. Particulars regarding the mode of operation, length, width, mesh size, users' type, number of gear used by fisher or by fishing unit, gear material, species selectivity, size selectivity, number of people in fishing unit, duration of fishing, fishing season and crafts materials were studied. Highest mean fishing time was estimated to be 13.27±05.07 hours for set-bag net and the lowest to be 01:00 hours for scoop net. Most destructive gears identified were fine mesh multifilament knotless nylon screen (mosquito net) for harvesting juvenile, sub-adult and broods and large mesh multifilament net for brood harvest.

Spawn fishery of major carps (*Catla catla, Labeo rohita, Cirrhinus mrigala* and *Labeo calbasu*) of the River Halda

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A study was conducted for five years from 2007 to 2011 on the spawn fishery of major carps (*Catla catla, Labeo rohita, Cirrhinus mrigala* and *Labeo calbasu*) of the River Halda. Major carps generally spawn during April to June in the oxbow band areas of lower Halda River extended about 20 km area from Madunaghat bridge to Sattarghat bridge. The amount of fry produced (from collected eggs) were found to be increased in 2007 (371 kg) and again decreased in 2010 (121 kg) and a little bit increased in 2011 (234.5 kg). Inefficient traditional mud pit incubation method (hatching methods) is now gradually being replaced by cement cistern hatching technique by government and private hatcheries. Anthropogenic and natural causes were found to be responsible for declining egg and fry production. Fry production decreased tremendously from 2470 kg in 1945 to 121 kg in 2010 with lowest (20 kg) in 2004. Price of fry varied from five thousand taka per kilogram to 60 thousand taka since 1979. Causes for declining trend were identified. Suggestions were provided to restore and revive the spawning ground and spawn fishery of the River Halda.

Socio-economic status of indigenous fishers in Bandhuk-Vanga, Rangamati, Bangladesh

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The present study was conducted to assess the socio-economic conditions of the indigenous fishermen in Banduk-vanga Union under the district of Rangamati, Bangladesh. Data were collected from randomly selected 50 fishers by personal interviewing with a well structured questionnaire, Focus Group Discussion (FGD) and Crosscheck Interviews (CI) with key informants during March to August, 2011. Majority of fishers (96%) were men and 4% them were women. All of them were Buddhist, in 92% were married. Joint families were 58% and 42% were nuclear families. Most of them had education up to primary level and only 2% of them have higher level of educationThe number of school going children were 1.56/ household, the proportion of dropout of school for boys 58% and girls 42% . Katcha houses (88%) were dominant, while the semi-pacca houses (12%) were few and about 60% did not used electricity, 68% of them used sanitary latrine with ring and slaves and 28% used katcha toilet. It was found that 70% of them took allopathic treatment for their health and 20% took homeopathic treatment. There were 86% fishers were permanent and 14% were temporary fishers. Ber jal, Khepla jal, Fash jal, Chandi bair, Polo, Aro, Jhupi etc were used as fishing gears. In the study area 50% fishermen had below 50 decimal lands and 46% fishermen had no lands and 4% fishermen had above 50 decimal lands. Their monthly average income was recorded BDT 3500.00 to 4000.00. In this study, it was found that 10% of the fishermen borrowed money from the NGOs, 20% from relatives, 50% moneylenders, 4% banks and 16% from neighbours. It was apparent from the present study that majority (76%) of people took meal three times per day and 18% took two meals per day and 6% took four times meal per day. About 70% of the fishermen used tube-well water for drinking, 16% of the fishermen used well or indira water for drinking, 12% of the fishermen used ring- well water for drinking and 2% found Kaptai Lake or others sources. The main problems were identified as extortion by local extortionist; other problems were inadequate credit, lack of appropriate gears and increase rate of theft and robbing. They need more institutional, organizational and technical and credit support for their better socio-economic and sustainable livelihood.

Present status of biodiversity in Ghuradia *beel* in Northern Bangladesh and prospect for using as fish nursery

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A total of eighty-nine aquatic wild fauna (78 species of wild fishes, four species of prawn, one species of crabs, two species of snails and four species of turtles) belonging to 53 genera and 23 families was found in the Ghuradia *beel*. The annual total catch Ghuradia *beel* was around 87.48±4.93; 72.63±4.09, 60.84±3.50 and 86.14±7.46 mt in the year 2006, 2007, 2008 and 2009, respectively consisting of 10 groups. Ten types of fishing gears and crafts were found to be used by the fishers' in the surveyed *beel*. Increasing use of current jal (gill net), Kapuri jal (sein net) and FAD (Fish aggregating device) were identified as detrimental gear killing almost all type of species. Over a period of three years, total production of fish and allied species in Ghuradia *beel* was found to decrease from 87.48 to 60.84 mt indicating 30.33% declination. Due to increasing fishing pressure, deterioration of ecosystem health and biological diversity, 05 aquatic fauna were extinct, 18 species were in high risk, 33 species were endangered, 22 species were more or less at risk of extinction, 06 species were in lower risk and 04 species were not threatened from biodiversity view point. In 2009, strict enforcement of fish Act-1950 in Nagdura *beel* resulted in reducing the use of current jal, Kapuri jal and FAD. Initiation of new technology for production of carp fingerlings in the *beel* through community based co-management approach and enforcement of Fish Regulation Act-1950, helped to augment productivity of the *beel* from 60.84 to 86.14 mt, exhibiting 41.57% biomass enhancement. Two species of fish was found to have reappeared in the beel and surroundings floodplain. The number of six code of IUCN was followed to categorize the status of the *beel*, and Shannon index was followed to compare the trend among different years.

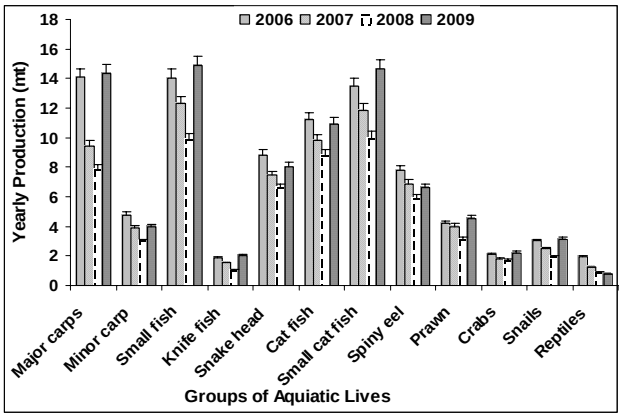

Fig. 1: The production of different groups of aquatic wild lives in the Ghuradia *beel* decreased between 2006 and 2008 and increased in 2009.

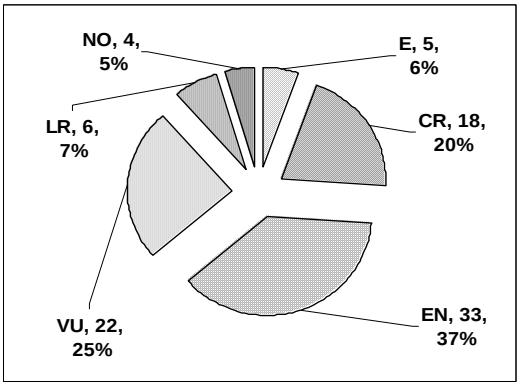

Fig. 2. Status and position of different species of aquatic lives in the Ghuradia *beel* during 2006-09.

Women participation in fish marketing at Sitakunda coast, Bangladesh

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Women in Bangladesh, as ignored but significant group, are playing important role in fishery resource marketing. Present study was conducted at Sitakunda Upazilla (sub district), a coastal area of Bangladesh under Chittagong district and aimed to identify the women activities of coastal fishing community, their role in fish marketing and to assess their livelihood status. Data were collected by using PRA (Participatory Rural Apprisal) techniques and analyzed using Microsoft Excell softwere. Findings shows that all women who are participating in fisheries resource marketing are also involved with coocking, cleaning of house, water carrying, caring of children, community event, personal trust, and gossiping and resting with some other activities. Women are playing role in fish marketing (Figure 1) by sellling fish and crab in door to door (50%), sell fish in local market (10%), Sell dry fish (25%) with a small number of selling salting fish in door to door (15%) by collecting from husband and children, fishermen and middle men. Most of the women involved with livestock rearing (70.83%) along with net making (29.17%) and mendoring (20.83%), handicraft making (8.33%), tailoring (3.33%) and laboring (16.67%) as alternative income generating activities.

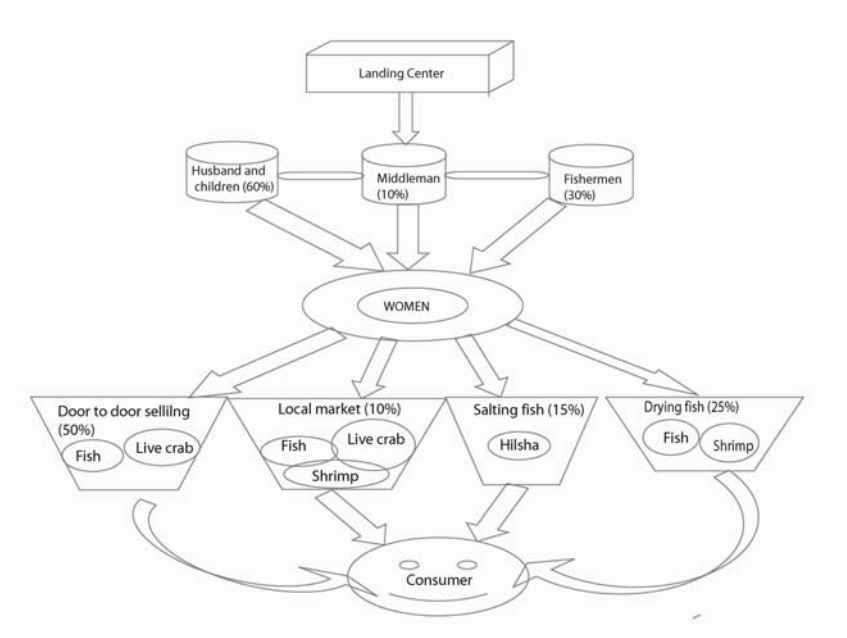

Fig. 1. Fish marketing process at Sitakunda coast by women

Aquaculture development under the Regional Fisheries & Livestock Development Component (RFLDC), Noakhali

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DANIDA has been engaged in aquaculture development in Bangladesh for almost 30 years, beginning in 1984 with support to what was then the Fisheries Research Institute in Mymensingh and continuing with successive aquaculture development projects, MAEP (1989-2003), PBAEP (1997-2006) and GNAEP (1998-2006). This lengthy experience has provided a good deal of learning over time, notably involving a shift away from the notion of standard technical models which can be applied for the development of small-scale aquaculture to a realization of the need for adaptations to the environmental and socio-economic conditions of particular geographic areas and groups of farm households. This was sharply highlighted in the expansion of support from MAEP to PBAEP and especially GNAEP after 2002, when a range of livelihood interventions were introduced focusing upon resource-poor households. The latest manifestation of this trend in development thinking has been in the Regional Fisheries and Livestock Development Component, in which the extension mode has been the adoption of the Farmer Field School (FFS) approach. This is a highly participatory form of group learning in which farmers are encouraged to analyze their resource base, jointly assess appropriate technical options and test out these options through so-called 'study plots/ponds' before moving to adoption of those alternatives which best suit their own situation. A continuing focus of such developments seems to be addition of giant freshwater prawn to add value to the system, as well as the stocking of sex-reverse tilapia in short-cycle ponds. However, the focus of the FFS is the whole farm and the use of pond water depends upon the emphasis of the household in aquaculture, animal husbandry and homestead gardening.

In this approach, it has frequently been realized that the most important part of the resource base for aquaculture is not managed by the individual farm household, but by the community. Noakhali has two such resource systems: the waterlogged paddy lands (*dogis*) of the north-central part of the region and community ponds in new villages in the char lands in the south. Both these systems require particular management practices, not so much in technical terms, but also in terms of organization within the community. This is particularly the case with the waterlogged paddy land, since management involves both land owners who cultivate rice in the *boro* season and landless households who once harvested wild fish and aquatic plants from the waterlogged lands. If these two groups can be brought together in a common purpose, the waterlogged paddy lands can be turned into a highly productive resource, which may be a model for other parts of the country in the context of waterlogging associated with climate change.

Impacts of banning period on the socio-economic condition of hilsa fishermen of Monpura island, Bangladesh

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The study was conducted by survey method to assess the impacts of banning period on the socio-economic conditions of hilsa fishers of Monpura Island in Bhola district, Bangladesh, during February to July, 2010. The results on socioeconomic condition of the fishers in the study areas revealed that major of them are poor, 36% of them were 31 to 40 years age group.. 74% used *katcha* sanitary latrine, 90% had no own tube well and 64% lived in tin-shed houses. . Of them 40% had own boats and nets and 40% of them had no own land, 42 % were illiterate and during the banning season, no farmer discontinued their children's education but sometimes they were unable to maintain educational expenses. In banning season fishermen's average monthly income decreased to BDT 2,000 from BDT 3,975. This time fishers' tendency of going to village doctor and *kabiraj* increases from 38% to 50% and 12% to 32%, respectively. Besides they suffered from food shortage and reduced meal frequency with less expense foods. Due to embargo on fishing, they hardly find any income generating occupation, 32% fishermen involved in labour activities and 12% more fishermen as compared with non-banning period took loan from local Mohajon at very high interest rate. Most of them (62%) had to sell their own boat and net for paying loan and gradually become poor to poorer. Although 58% fishermen got subsidy from Government during banning period but it is not sufficient to maintain their livelihood. The study suggests, in accordance with the country's hilsa conservation policy, Government and other organizations should come up hurry to diminish the unbearable miseries of fishermen through application of support measures.

Fish aggregation pattern in brush parks (*katha*) of Roktodoha *beel*

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The *Katha* fishery is basically a fish attracting device popularly known as 'brush-park'. An investigation was conducted on brush- parks of Roktadaha beel, Bogra from May'07 to February'08. Fish aggregation pattern *viz*., trophic-level groups, tropho-spatial assemblage and habitat preference was analyzed. During study period a total of 22 katha were observed. In the investigation 42 species of fish and prawn were recorded. Contribution of resident fish and prawn species was 63.70% with *Chanda nama* as dominant species; and migratory 35.35% with dominant species *Pseudotropius atherinoides*. The rest was (0.95%) alien species with dominant species *Barbonemus gonionotus*. In percent composition by weight resident species were also dominant (52.43% with *Chanda nama* as dominant species) following migratory (26.0% with *Wallago attu* as dominant species) and a remarkable (21.56% with the dominant species *Barbonemus gonionotus*) contribution of alien species.

In general categorization by number, cat fish (45.87%) was the most dominant group followed by perches (28.69%), prawns (10.58%), minnows (8.18%), eels (2.89%), others (2.11%), carps (1.03%) and murrells (0.65%). By weight, cat fish (35.75%) was again the most dominant group followed by carps (30.25%), eels (10.01%), perches (9.99%), minnows (5.13%), prawns (3.85%), others (2.52%) and murrells (2.49%). Among cat fish, *Pesudotropius atherinoides* was the most dominant species both in number and weight (85.16% and 70.27%). In case of all species, it was the most dominant in number (39.19%) and second dominant position in weight (9.67%) after *Wallago attu* (14.67%). Considering trophic level and composition in number, abundance of surface feeder was the most dominant group (77.13%) followed by bottom feeder (21.63%) and column feeder (1.24%). While in weight composition, bottom feeders (49.32%) were the most dominant group followed by surface feeders (45.47%) and column feeders (5.21%).

According to food habit and numerical composition, planktivore (48.69%) was found to be the most dominant group with dominant species *Pseudotropius atherinoides* (80.22%) following insectivore (28.40%) with dominant species *Chanda nama*, omnivore (10.74%) with dominant species *Macrobrachium sp.*, predator (8.13%) with dominant species *Mystus tengra*, detrivore (3.17%) with dominant species *Macrognathus pancalus*, benthivore (0.56%) with dominant species *Macrognathus armatus* and herbivore (0.32%) with dominant species *Barbonemus gonionotus*. On the other hand considering weight planktivore (34.65%) was the most dominant group with dominant species *Pseudotropius atherinoides* (70.27%) following predator (26.10%) with dominant species *Wallago attu* 56.2%, detrivore (10.11%) with dominant species *Macrognathus pancalus*, omnivore (9.59%) with dominant species *Pangasius hypophthalmus*, benthivore (7.09%) with dominant species *Macrognathus armatus*, herbivore (3.82%) with dominant species *Ctenopharyngodon idellus*.

Fish marketing and socio-economic condition of aratder in Baneshwar, Puthia and Shingra fish market

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An investigation was carried out during the period from December 2007 to November 2008 to find out the marketing system and socio-economic status of aratders at Baneshwar, Puthia (Rajshahi) and Shingra fish landing centre in Natore district of Bangladesh. Four types of fishes were observed where maximum fishes (70%) were come from the local area and rest (30%) was come from other region of Bangladesh. Four types of marketing channel were identified and the commission agents usually earn about 3-4% of sale price from the farmers. The highest landing was 388144 kg/yr of Silver carp in Shingra, whereas the lowest was 702 kg/yr of Kakila in Baneshwar. The highest price was 190.17±27.33 Tk/kg for Magur in Baneshwar, whereas the lowest was 20.38±4.58 Tk/kg for Chanda in Baneshwar). The average marketing cost varied from 91 to 128 Tk/day whereas the marketing margin varied from 17.75 to 28.25. The educational status of the majority of aratders (53.76% in Puthia to 74.99% in Baneshwar) ranged from class I to class X. Major secondary occupation of the aratders was fish farming (50% in Puthia, 75% in Baneshwar). Most of the (75% in Baneshwar, Shingra and 83% in Puthia) aratders were found to earn Tk. 100-150/day. Infrastructure facilities including packaging, sanitation, water supply, drainage, cleaning and washing, and maintenance, of the studied markets were not satisfactory. Moreover, the socio-economic status of aratders also were not satisfactory.

Morphometric and meristic variations among populations of *Cirrhinus reba* from three rivers of north-west Bangladesh

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Landmark-based morphometrics were carried out to evaluate the population status of the minor carp, *Cirrhinus reba* collected from three different rivers. Morphometric, truss measurements and meristic characters from eighty nine specimens were analyzed. Prior to the comparison, size effects from the dataset were eliminated since samples drawn from the populations with different ages. None of the meristic counts significantly differ among the stocks (Kruskal-Wallis test, $P > 0.05$). Univariate statistics (ANOVA) showed that pre-orbital (PROL) length among morphometric measurements, 4 to 7 of the truss measurements significantly differed to varying degrees ($P < 0.05$) among samples. Plotting discriminant function (DF), first and second DF showed a clear difference among the stocks for both morphometric and landmark measurements. For morphometric and landmark measurements, the first DF accounted for 54.3% and second DF for 45.7% of group variability, together explaining 100% of total group variability. Pooled within-group correlations between discriminant variables and DFs revealed that one of the seven morphometric measurements (PROL) dominantly contributed to the first DF and the remaining six to the second DF. In truss network, 8 of the 22 measurements dominantly contributed to the first DF, and the remaining 14 to the second DF. A dendrogram based on morphometric and truss measurements placed the Punarvaba and the Dhepa river populations in one cluster and the Atrai in another cluster. The distances were nearer between the Punarvaba and the Dhepa population whereas, the Atrai river population was distinctive from those of two river populations.

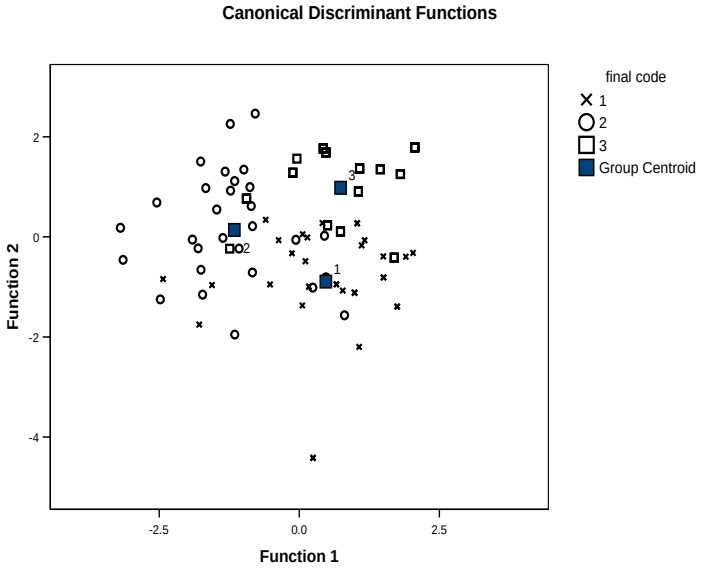

Fig. 1. Sample centroids of discriminant function scores based on morphometric and truss measurements of 1. the Atrai, 2. the Punarbhava, and 3. the Dhepa river populations.

Assessing the impacts of large fish hatchery on employment generation in Mymensingh

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Aquaculture sector plays an important role in Bangladesh in terms of protein rich food supply, foreign currency earning and socio-economic development through employment generation. However, creation of employments in aquaculture value chain is often overlooked in academic literature. This study concerned with the impacts of large hatchery on employment generation and livelihoods improvement of the employees working in fish hatchery. In order to get in-depth understanding, the study was concentrated to hatchery namely Reliance Aqua Farm, which is located on Dhaka-Mymensingh highway at Bailor in Trishal Upazilla under Mymensingh district. The total area of the hatchery was about 8 hectare where mainly mono-sex tilapia (*Oreochromis niloticus*) seed along with Magur *(Clarias batrachus)*, Sing *(Heteropneustis fossilis)* and Thai Koi (*Anabas testudineus*) are produced. In this study, total 25 employees were randomly sampled from the hatchery. Data were collected using participatory rural appraisal tools such as key informant interviews, focus group discussion, and semi-structured questionnaire interviews.

From the study, a total of 75 employees were found working in the hatchery, and out of them 92% were from nearby Upazilas of Mymensingh. The different hatchery operating activities developed 12 different types of employment niches. The majority of the workers had no hatchery operating experiences before appointed in the hatchery, and they were working with very low-paid jobs. The employees were found to get their salary scales equivalent to the categories of national pay-scale. The education attainment of hatchery workers were above primary (48%) followed by primary (28%), SSC (12%), graduate (4%) and illiterate (8%). The majority of them experienced improving their socio-economic conditions with different livelihood assets. About 84% of the workers bought a mobile phone; 40% improved their housing condition; 36% became able to send their children in school; 40% experienced social respect from their neighbours; 40% ensured three times meals a day in their households, and 48% bought livestock for rearing. They experienced friendly environment for working, and operating the hatchery they achieved transferable experiences. This study reveals that a hatchery can support a large number of employees in local areas. This indicates the entrepreneurial development of fish hatchery which could be considered by government and non-government organizations to improve the hatchery workers' knowledge and skills by giving scientific training to produce quality fish seed for sustainable aquaculture.

Impact of fish sanctuaries on rural poor community people in the Ghagot river, Rangpur

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The study was carried out to evaluate the impact of established fish sanctuaries on household fish catch kg day^{-1}, household fish consumption kg day^{-1} and fish species availability in three fish sanctuaries established three year ago, compared with no sanctuary zone in Ghagot river of Rangpur District and to study the income and other livelihood changes of the respondents in 2008, 2009 and 2010. The information was collected through questionnaire interview from the individual household and sampling. Focus group discussions (FGD) were also conducted with the sampled households. The occupation of the respondents were fishing (59%), labour (31%), farming (3%) and small business (7%). Major portions of the respondents were illiterate (64%) and rest 36% completed only primary level education. Average family size of the respondents from Fotepur- Durgapur (FD), Mithapukur Muchir-Dho (MM), Mithapukur Konapara (MK) and control site were 4.97, 4.07, 4.53 and 4.6, respectively. Average age of the respondents from Fotepur- Durgapur (FD), Mithapukur Muchir-Dho (MM), Mithapukur Konapara (MK) and control site were 43.27, 37.23, 36.60 and 37.47, respectively. Around 25-30 indigenous fish species were found in selected fish sanctuaries and 8 fish species were not found in the study site which was available 10-15 years ago.

Individual household fish catch was 0.24±0.02 kg day^{-1} in 2008 which increased to 1.05±0.08 in 2010 of Fotepur-Durgapur (FD) sanctuary site. Similarly fish catch increased from 0.51±0.16 kg day^{-1} to 1.14±0.07 kg day^{-1} in Mithapukur Muchir-Dho (MM) and 0.54±0.16 kg day^{-1} to 0.90±0.16 kg day^{-1} in Mithapukur Konapara (MK) site. There was no significant changes in fish catches in control site. Fish consumption increased from 0.03±0.02 kg day^{-1} to 0.11±0.05 kg day^{-1} in 2010 of Fotepur-Durgapur sanctuary site. Similarly fish consumption increased 0.21±0.07 kg day^{-1} to 0.43±0.06 kg day^{-1} in MM sanctuary site and 0.10±0.03 kg day^{-1} to 0.23±0.07 kg day^{-1} in MK sanctuary site and there was no change in control site. Individual annual household income was increased - 92% in FD study site, 87% in MM study site and 71% in MK study site within the period from 2008 to 2010. The established fish sanctuaries had positive and significant impact on individual household fish catch kg day^{-1}, household fish consumption kg day^{-1}, fish species availability and annual income of the rural poor community people in the study site

Diversity of air-breathing fishes in northwest Bangladesh

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This study was conducted for 18 months, from May 2008 to November 2009 in four districts *viz.* Panchaghar, Rajshahi, Natore and Jessore of northwest Bangladesh to explore the availability of air-breathing fish species and types of different air-breathing organs. A total of 21 air-breathing fish species were collected and identified belonging to eight fish orders, Anguilformes (5%), Synbranchiformes (5%), Channiformes (19%), Cypriniformes (9%), Siluriformes (19%), Clupeiformes (10%), Perciformes (19%) and Matacembaliformes (14%). The collected fishes of order Siluriformes was identified under the following families, Claridae (1 genus and 2 species), Heteropneustidae (1 genus and 1 species) and Bagridae (1 genera and 1 species). Four Channiform species were recorded under the family Channidae (1 genus and 4 species). Four Perciform species were found under family Anabantidae. Family Anabantidae comprises 2 genera. Two species were found under one family (Cobitidae) of order Cypriniformes. Two species were recorded under order Clupeiformes from the following family- Notopturidae. Mastacembeliformes includes the family Mastacembelidae (2 genera and 3 species). Only one fish species were found in order Anguiliformes and Synbranchiformes each. Nine fish species (43%) were in the red list of fishes of Bangladesh declared by the IUCN; 4.76% were critically endangered, 23.81% were vulnerable and 14.29% were endangered. This data indicates the alarming condition of the air-breathing fish species in Bangladesh. Eight different types of air-breathing organs were observed; these were swim bladder (13%), wet skin surface (26%), alimentary canal or intestine (9%), aborescent organ (9%), saccular organ (4%), air sac (4%), labyrinthiform organ (17%) and brancahial chamber (17%). These organs help air-breathing fishes to survive in low dissolved oxygen environmental condition.

Food and feeding habits of *Puntius sarana* (Hamilton, 1822) in the River Padma, Rajshahi

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The present study on food and feeding habits of *Puntius sarana* in the River Padma was conducted from November, 2010 to April, 2011 in Rajshahi, Bangladesh. Intended of this study was assessed the feeding intensity, the pattern of feeding, and the relationship between total length and alimentary canal length of *Puntius sarana*. The qualitative and quantitative analyses of stomach and gut contents of each fish were done by percentage of occurrence method. Fullness of stomach was measured by fullness index method and establishment of the relationship between total length and the alimentary canal length was considered. A survey method was used to collect data from fishermen harvest, total of 130 specimens were taken for this study. The results showed that *Puntius sarana* was mainly omnivorous. The average percentage occurrence of different items was phytoplankton 82.15, zooplankton 10.16, fishes 6.86, debris and mud10.20 and insects 3.17. From the present investigation the feeding intensity was highest average percentage of fullness 94% of the stomach was recorded in February, 2011 where the lowest percentage was 40% found in month of November, 2010. The highest average percentage of emptiness was recorded 60% in November, 2010 and lowest percentage was 10% in the month of February, 2011. Dominant feed items in gut content of *Puntius sarana* were phytoplankton including group of Chlorophyceae, Bacillariophyceae, Cyanophyceae, Euglenophyceae and zooplankton including group of Rotifera, Crustacea; Fishes, Debris and mud, Insects. Total length was positive significant (0.996**, $p<0.01$) with alimentary canal length. Proper management techniques should be taken in future to conserve and increase the population of *Puntius sarana* in the River Padma..

Effects of river pollution on plankton community, histology and acetylcholinesterase activity of fish

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Due to rapid and unplanned urbanization and industrialization, the major three rivers Buriganga, Turag and Shitalakkhya surrounding the Dhaka are now expressing the complicated problem of pollution that eventually affects the aquatic biota including fish. Thereby, plankton community, histopathology and Acetylcholinesterase (AChE) activity were studied from these steadily polluted rivers. Intolerable dissolved oxygen, 1.5, 0.7 and 1.9 ppm in Buriganga, Turag and Shitalakkhya respectively were recorded at the advent of dry season when the water level reduces abruptly but the pollutant concentration remains identical. A total of 33, 26, 35 plankton genera were recorded from Buriganga, Turag and Shitalakkhya respectively at wet season whereas at dry season, lower count were recorded as 21, 19 and 26 from those rivers respectively. *Heteropneustes fossilis* was challenged for 7 days to the water of Buriganga, Turag and Shitalakkhya for histological analysis that revealed severe structural alterations in skin muscle, gills, liver, kidney and gonads. The major pathologies were partial and total epidermal loss, muscle separation, hemorrhage, necrosis, pyknosis, gill clubbing, fungal granuloma, missing of secondary gill lamellae, hypertrophy, fatty degeneration, degenerating kidney and glomelural tubule, scattered spermatozoa, prominent testis interstitial space and vacuoles found in skin muscle, gills, gonads, hepatocytes, and hematopoietes. The AChE activity was used as a neurotoxic biomarker. After 20 days of exposure, brain samples were collected and the activity were recorded as 104.00±5.00, 102.00±5.00 and 130.67±3.51nmol/min/mg protein from Buriganga, Turag and Shitalakkhya respectively. Significant inhibition ($P< 0.001$) of this enzyme reveals the potency of this biomarker against pollution. These results suggest that discharge of industrial pollutants into three major rivers ultimately interrupt with the biological availability of plankton as well as fish altering their normal histology and inhibiting the key enzyme in nervous system.

Biochemical characteristics and accumulation of heavy metals in fishes, water and sediments of the river Buriganga and Shitalakhya

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Heavy metals *viz*., Pb, Cd, Cu, Cr, Zn and Ni present in water, soil and available fish species from the two rivers - Buriganga and Shitalakhya were examined**.** The higher amount of heavy metals was found in soils *viz.* Pb varied between 29.04 and 64.78 mg/kg, Cd between 0.31 and 5.01 mg/kg, Cu between 40.13 and 111.10 mg/kg, Zn between 75.19 and 333.76 mg/kg, Cr between 51.51 and 118.14 mg/kg and Ni between 35.81 and 44.41 mg/kg over the whole year. A remarkable amount of Pb, Zn, Cr was recorded in the whole fish species collected from both rivers. In Buriganga, Pb varied between 4.32 and 31.51 mg/kg and in Shitalakhya 11.44 and 17.03 mg/kg. Zn values ranged 3.95 to 51.50 mg/kg in Buriganga and 6.29 to 62.02 mg/kg in Shitalakhya. The similar trend of Cr was recorded at Buriganga and Shitalakhya and the Zn range was 7.83 - 21.72 mg/kg. Cu and Ni were found under acceptable level. This finding indicated a major threat to human health in regard to consumption of fishes of those rivers.

Dissolved oxygen (DO) content of the river Buriganga and Shitalakhya was found only 1.1 and 4.6 mg/l, respectively during winter. NH_3, BOD, COD and conductivity were recorded and found very high both in winter and summer. The low survival rate of fishes in the two rivers may directly be related to the lower level of oxygen content. In addition, the study made observation that the water of the two rivers was uninhabitable for aquatic organisms during winter and summer. While during monsoon period water of these rivers were found less polluted and which may allow aquatic organisms to live it in that period.

Climate change impacts on fisheries & aquaculture in Bangladesh

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The extensive coastal floodplains of Bangladesh in the lower Ganges-Brahmaputra delta are important for natural fisheries, shrimp farming, agriculture, and other natural resources including the Sundarbans mangrove forests. Recently two cyclones (Aila and Sidr) hit the South-West (SW) region of the country. While many activities have been taking place for rehabilitation and developing adaptation measures in the South-West coastal regions, the nature of impacts on the fisheries and aquaculture as well as on the livelihoods of the people living in the areas are not well documented. Considering the above in view, a DFID funded INSPIRE Climate Change project has started its activities in the cyclone affected greater Khulna and Barguna areas in the SW region over a year. The main objectives of the study were to evaluate the impacts of cyclones (Sidr and Aila) on the inland and coastal fisheries, coastal aquaculture, and the livelihood of the fishing communities for people who were involved in shrimp farming, crab fattening, fish drying and other fisheries related activities. A preliminary facts finding research team carried out a survey for one year from January to December 2010 in the SW region. The selected study areas were Shyamnagor, Piakgacha and Koyra Upazilas. For the study 35 households (20 shrimp farming, 10 crab fattener and and involved in 5 fish drying) were selected randomly. Three wetlands from each Upazila were selected for studying the livelihood status of the inland fishing communities in the pre-and post cyclone times. A detailed survey with pre-tested questionnaire and three Focus Group Discussion (FGD) one in each Upazila has been planned. So far 25% of the households have been covered and other parts of the study are underway.

Most of the people of this region are farmers and fishermen but due to Aila and Sidr, some changes have occurred in their livelihood pattern. About 75% of the shrimp farms and 100% of the crab farms of the Munshiganj Union of Shyamnagor, Satkhira were destroyed in both cyclones. About 40% of the shrimp farms in Paikgacha and 80% in the Koira Upazila were washed away by both Sidr and Aila in two occasions (Fig 1).

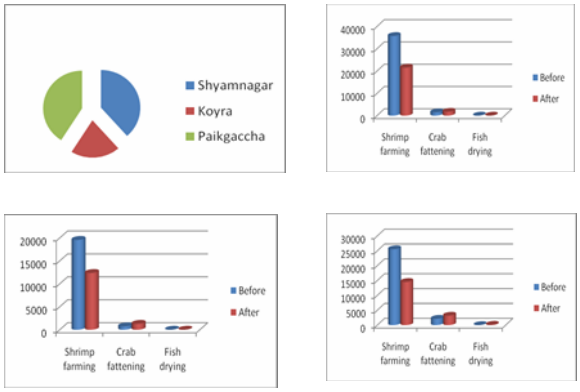

Fig (1, 2, 3 & 4: clock-wise): Shrimp farm destroyed due to cyclone in the selected region; Comparative study in Paikgaccha; in Koyra; & in Shyamnagr. From our preliminary study in first year, it observed that the cyclone has brought a massive change in shrimp farming, crab fattening and fish drying. The data showed that, shrimp farming area has drastically decreased after cyclone in all the study areas. On the other, crab farming has dramatically increased after Aila and Sidr. But in case of fish drying, there is no remarkable change. Some fishers however have given their concentration towards fish drying only in Shyamnagar areas (Fig 2, 3, and 4).

An ecological study on the *beel* joshi of Rajshahi

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The present study has been made on the assessment of ecological aspects of *beel* Joshi covering an area of 630.0 ha in the Rajshahi district, northern part of Bangladesh. Surface run-off and increase in flow of rain water from the upper stretch during monsoon cause inundation and resumption of connection between *beel* and parent rivers. The range of dissolve oxygen (DO) content was 5.26 - 6.08 mg/L and that of pH was 7.5 - 8.2. Lower values of total hardness and total alkalinity indicated poor nutrients status in the *beel* water. Free CO_2 was relatively high in this *beel*. Phytoplankton diversity in the *beel* represented by four groups viz. Myxophyceae, Chlorophyceae, Bacellariophyceae, and Euglenophyceae in order of abundance. A total of 75 fish species belonging to 45 genera and 21 families, and one species of prawn were identified. A total of 14 types fishing method were found in operation during the study. Seine nets (moshari berjal. shono berjal) and gill net (current jal) were identified as detrimental gear killing juveniles of different species during post spawning period. Kua fishing was also found harmful due to its dewatering nature. A total of 12 species of aquatic weeds were identified from the *beel*. The eggs of *Macrobrachium lameri* were also detected during the study period.

Improvement of food security in Bangladesh through farmer-to-farmer program of Winrock International

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Poverty, unemployment and growing food security problem strikes hardest in rural areas worldwide, particularly in the developing countries like Bangladesh. As part of the solution, Winrock International has been implementing Farmer-to-Farmer (FtF) for Food Security Project in Bangladesh with main focus in southern region, along with other highly food insecure countries, under the larger John Ogonowski and Doug Bereuter Farmer-to-Farmer Program of United States Agency for International Development (USAID) for the period from September 29, 2010 to September 28, 2014. FtF goal is to generate rapid, sustained, and broad-based economic growth in the agricultural sector, particularly in aquaculture, livestock, and high-potential crops such as potato, maize and other horticultural crops. The project provides technical assistance to local farms, enterprises, cooperatives, associations, development projects, Government and Non-Government extension and agribusiness support organizations with the objectives of increasing agricultural sector productivity and profitability, strengthening agricultural sector institutions, and improving US and core country public outreach through innovative use of media and information and communication technologies. Technical assistance is provided by highly qualified volunteer experts from US agribusinesses, universities, and research and extension centers for technical as well as organizational capacity enhancement through both hands-on and class room based training supported by many useful materials and new information.

During the period from October 2010 to December 2011 Winrock fielded total 28 US experts out of which 11 were aquaculture experts, who assisted 35 host organizations (received volunteer assistance) directly or through six partner organizations including USAID supported Poverty Reduction by Increasing the Competitiveness of Enterprises (PRICE) Project. With FtF expert assistance 46 Government and NGO extension agents and 8,780 farmers learned how to reduce risks and increase profitability in pond aquaculture through the use of a Secchi disk and other improved techniques. Out of those trained farmers, 2,965 supported by World Vision Bangladesh are expecting 30-40% increased fish production in this harvesting season, and 2,115 farmers under the USDA supported Rural Enterprise for Alleviating Poverty (REAP) project increased production by 1,628 kg/ha. Two fish processing plants were able to develop seven fish and prawn based value-added products, maintaining hygiene and sanitation standards and documentation as a result of FtF support in understanding the value-added product development processes. Nine tilapia and four carp hatcheries received improved seed production and brood rearing techniques. In one hatchery, seed production nearly doubled. Fry quality and fish health also improved, benefitting 1,530 farmers and dealers, who rely on the fry for their own livelihood and nutrition. Besides, three fish farmers' associations received training on improved aquaculture practices. 57 technical staff from 33 feed mills received training on feed quality improvement for better aquaculture practices throughout Bangladesh and improved their knowledge on methods for the preparation of quality fish feed.

Poverty and food insecurity in Bangladesh: Evidence from *haor* areas

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Haors are located mainly in greater Sylhet and greater Mymensingh regions in Bangladesh. A large amount of fertile and arable land (783,939 hectares) lies in the haor areas of six north-eastern districts of Bangladesh. This land is generally used for mono-crop cultivation, mainly *boro* rice in the winter. During the wet season, it goes underwater and is transformed into floodplains for freshwater fishing. The high seasonality of the haor-based economy forces local people to remain out of work for a considerable period of time and as a result they suffer from food insecurity. This study attempted to investigate the facts and factors of food insecurity for the people dwelling in haor areas, some seriously disadvantaged pockets of Bangladesh, with a view to aware the policy-makers to take viable steps and workable strategies in time for addressing the food insecurity problem in consonance with the objectives of National Food Policy (NFP). To assess the status of food security, a household-level interview was carried out covering the characteristics of the household population. The study covered the six haor prone districts of Bangladesh: Sunamganj, Sylhet, Moulvibazar, Habiganj, Kishoreganj and Netrokona. A total of 30 clusters were covered applying the cluster-sampling design in the survey. The clusters were selected using systematic probability proportionate to size (PPS) sampling procedure. The household poverty condition was measured by using both Cost of Basic Needs (CBN) and Direct Calorie Intake (DCI) methods. The depth and severity of household poverty were measured by Foster-Greer-Thorbecke (FGT) method. The differentials of food security were studied employing cross-tabulation analysis. The predictors of food insecurity had been determined by using both binary and ordinal multiple logistic regression models. The result revealed that about 29.6% households lie below the lower poverty line and about 43% below the upper poverty line. About 45% of the respondents were anxious about food deficit in their households. Among them, three-fifths faced the problems for sometimes and about 29% faced the same problem for most of the times of year. A wide variation in the extent of food security was observed according to the occupation status of the household head. Basically, the food insecurity problem of the *haor* people arises because of the reduction of -cereal crop production, restrricted access to food due to economic constrains, and limitation of productive resources.

Biodiversity of threatened fish species from Dingapota *haor* in the North-east Bangladesh

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The study was conducted for a period of six months from December 2010 to May 2011to provide an overview on the threatened fish biodiversity and to identify the opportunities for improvement of the existing threatened fish species and focusing on fish biodiversity conservation in the Dingapota *haor* situated at the North-East part of Bangladesh (Mohongonj Upazilla under Netrokona District). A total of 33 threatened fish species were found in Dingapota *haor* during the study period including 13 vulnerable, 15 endangered and 5 critically endangered species out of 54 threatened fishes in fresh and brackishwaters of Bangladesh. Among the 13 vulnerable fishes (out of 14 reported by IUCN Bangladesh) from the Dingapota *haor* there were 8 species found available, 5 species found rarely available and 1 species not available in our study. Among the 15 endangered fishes (out of 28 reported by IUCN Bangladesh) from the Dingapota *haor* there were 8 species found available, 7 species rarely available and 13 species not available in our study. Among the 5 critically endangered fishes (out of 12 reported by IUCN Bangladesh) from the Dingapota *haor* there were 1 species found available, 4 species rarely available and 7 species not available in our study. A total of 9 exotic fish species were found in the Dingapota *haor* during the study period. The fishing gears used by the fishermen in Dingapota *haor* includes 10 types of nets, 8 types of traps, 6 types of hooks and lines and 4 types of wounding gears. The major fishing crafts and gears used for fishing in the Dingapota *haor* were found to be mainly wooden boat and seine net (locally called 'ber jal'). The fishermen around the Dingapota *haor* area reported that the fishery biodiversity of this *haor* is decreasing day by day due to environmental degradation and manmade causes. Appropriate management and conservation strategies are needed for preserving the fisheries biodiversity of Dingapota *haor*.

Diversity, distribution and abundance of freshwater barb species in some selected water bodies

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The freshwater fish species of Genus – *Puntius* under Family Cyprinidae, order Cypriniformes are known as barbs. Many of the freshwater barbs of Bangladesh once abundantly available in nature are now disappearing from all kinds of water bodies. In the past, these fishes – the main protein source for millions of rural Bangladeshi people were considered though as weed fishes. The small barbs have long been considered as weed fish and till now fish farmers remove them from culture system using different piscicides during the pond preparation. In spite of tremendous significance of barbs not many studies have been done in Bangladesh on their distribution, biology and the abundance. The present study was carried out to assemble adequate information on the diversity, distribution and natural abundance of barbs of the country through collection and identification by studying morphometric and meristic characteristics. The study provided information of present biodiversity status of available barbs of the country along with the recommendation guidelines for their conservation. The study covered the key waterbodies – rivers, floodplains, *haors* and *beels* along with fish markets and landing centers of the greater Sylhet-Mymensingh basin. Ten barb species under the family Cyprinidae were recorded. Among the observed species two were threatened, one critically endangered, one vulnerable and six not threatened according to IUCN Red List. The single critically endangered species observed was *Puntius sarana.* Variations were found in the availability, distribution and abundance of the species among the areas. Species diversity of barbs was found to be higher in rivers and floodplains compared to other water bodies. *Puntius sophore* and *P. chola* were the most common among all. *P. sarana* and *P. terio* were the rarest and also available in very small numbers.

Table 1: Diversity, distribution and abundance of barbs collected throughout the entire period

Sl. No.	Scientific names	Local names	Types of water bodies					
			River	Flood-plains	Beels & haors	Ponds	Abundance	IUCN status
1	*Puntius sophore*	Jat punti	√	√	√	√	Very common	NO
2	*Puntius ticto*	Tit punti	√	√	√	√	Rare	VU
3	*Puntius conchonius*	Kanchan punti	√	√	√	√	Common	NO
4	*Puntius chola*	Chala punti	√	√	√	√	Very common	NO
5	*Puntius phutunio*	Phutani punti	√	-	√	√	Common	NO
6	*Puntius guganio*	Mola punti	-	-	√	√	Rare	NO
7	*Puntius terio*	Teri punti	√	-	√	-	Very rare	NO
8	*Puntius sarana*	Sar punti	√	-	√	√	Very rare	CR
9	*Puntius gelius*	Jeli punti	√	√	√	-	Common	DD
10	*Oreichthys cosuatis*	Kosuati	√	√	-	-	Wide	LC

Comparative production analysis of three community based fish culture management system in the rain fed waterlogged paddy lands, Chatkhil, Noakhali

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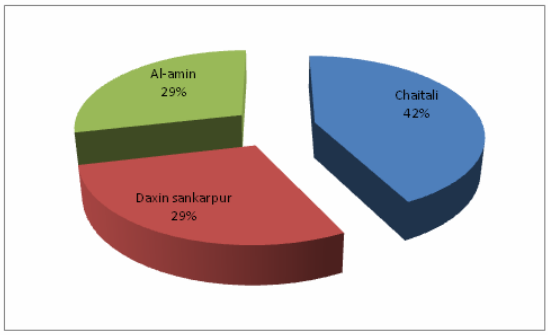
Present investigation was carried out to compare the production of three different rainfed waterlogged culture system according to the management strategies. During the rainy season in extensive river floodplains and deltaic lowlands, floods render the land unavailable for crop production for several months each year. These waters are considerably underutilized in terms of managed aquatic productivity. This raises the opportunity to enclose parts of these floodwater areas to produce a crop of specifically stocked aquatic organisms aside from the naturally occurring 'wild' species that are traditionally fished and are not affected by the culture activity, resulting in more high-quality, nutrient-dense food production and enhanced farm income for all stakeholders, notably the poor. In greater Noakhali district the donor supported RFLDC took the initiative with considerable attention for production of freshwater prawn *Macrobrachium rosenbergii*. in The results of the study showed that fish production in 2010 was 1257 kg/ha, 850 kg/ha and 845 kg/ha at Chaitali, Daxin Sankarpur and Al-amin dogi respectively (Figure). The cost of stocking fingerlings were as 48%, 41% and 38% respectively in Chaitali, Daxin Sankarpur and Al-amin dogi. is The production of freshwater prawn was 39%, 31% and 30% respectively in Chaitali, Daxin Sankarpur and Al-amin dogi respectively The amout of Small Indigenous Species (SIS) was 52%, 31% and 17% respectively in Chaitali, Daxin Sankarpur and Al-amin dogi. In the present study, gross profits were 569500, 281700 and 194000 Tk. that represented 54%, 27% and 19% respectively in Chaitali, Daxin sankarpur and Al-amin dogi. The total production of fish and gross profit increased in Chaitali dogi from the Daxin Sankarpur and Al-amin dogi because they had good management system and among the total participants, they had 2-4 fish specialist and finally RFLDC supported technically all the time. As a result average fish consumption rate has already increased 2-3 kg/head before 2010 in all the dogi. In the longer term, the approach aims to provide rural populations in the floodplain areas and irrigated systems of the targeted basins with an equitable source of additional income and supply of fish, both from natural fish production as well as from stocked culture species. This will directly benefit the members of the communities involved as well as fish consumers outside the culture areas due to the increased supply on the markets, thereby countering the negative trend in production from inland fisheries.

Figure. Percentage of average fish production in Chaitali ,Daxinsankarpur and Al-amin dogi.



Socio-economic impact and sustainability of Thai pangas *Pangasianodon hypophthyalmus* farming in Trishal upazila, Mymensingh

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Thai Pangas, *Pangasianodon hypophthyalmus* farming has been developed in Mymensingh region over the years in which Trishal upazila is dominating. Pangas production having an entrepreneurial growth of aquaculture. A large number of people engaged them in pangas farming and associated activities for their livelihoods. However, in the recent years, pangas farming has been threatened with complex constraining factors. In this changing conduction of pangas farming, farm owners are being segregated - into three categories (marginal, medium and entrepreneur). The present study was carried out to explore the socio-economic condition and sustainability issues of pangas farming in Trishal upazila.

Majority of the farms were concentrated in the union of Dhanikhola in Trishal due to better road communication, infrastructural and other facilities. There were significant differences between owner groups regarding education, farm size, and total land ownerships. Per unit production cost was found lower in case of entrepreneurs than that of the marginal and medium. Income of entrepreneur group was significantly higher than marginal and medium groups. Around 20% of the people were engaged in Pangasius farming and related activities in this area for their livelihood. A huge economic activity has been associated with pangas farming and the socioeconomic status in this area has been considerably uplifted. Along with farm owners, other associated stakeholders including farm labors, day labors, aratders (wholesaler), fry suppliers, snail shell collectors, feed makers, van pullers, duck weed suppliers, feed input sellers and harvesting groups improved their livelihoods condition through working directly and indirectly in the pangas farms. However, there were a number of constraining factors reported by the farmers that impeding their farming. These are quality feed and seed, financial inconsistency and market price. In this situation, some measures such as provision of soft loan, supervision, monitoring and technical support from the government, supply and ensure quality feed ingredients, seed and fish with reasonable market price, expansion of market at both domestic and overseas front and quality control laboratory are required. At the farmer level, reduced tax on electricity and land and training with technical knowledge on aquaculture should be taken into the consideration towards sustainable Pangas farming in this area.

Co-management approaches adopted in the river systems in Bangladesh

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During 1997-2002, a Community Based Fisheries Management (CBFM) project was implemented to monitor fish catches in five rivers located in central Bangladesh (*Kali nodi, Arialkha, Dhaleswari, Ubdakhali* and *Moisherkandi-Boronpur*). These are important tributaries of the Meghna and Brahmaputra basin and major sources of open water fisheries. The study covered fishing activities, fishers' participation in managing fisheries resources, gear-diversification, changes in fishing patterns, and overall catch and effort. The study aimed to understand the importance of fisheries resources in river systems and to explain how the future sustainability of these resources is ensured through community based fisheries management. An analysis of the results shows that production and species diversity increased over the years due to the community management approach, which encourages participation of fishers, beneficiaries and the community in managing their resources.

The species diversity during this time period reached its peak in *Ubdakhali* (86 species), followed by *Kali nodi* (84 species), *Arialkha* (78 species), *Moisherkandi-Boronpur* (65 species) and *Dhaleswari* (62 species). The estimated MSYs from this study were 163, 16, 46, 35 and 33 m.t year^{-1} for *Kali nodi, Arialkha, Dhaleswari, Ubdakhali* and *Moisherkandi-Boronpur*, respectively, and the corresponding effort (f_{msy}) required to achieve the estimated MSY values were 15571, 12419, 30691, 8727 and 8976 gear day's year^{-1}, respectively. The study also traced multiple positive impacts contributing directly towards poverty eradication, food and nutritional security, and sound management of inland fisheries resources.

Community based fish sanctuaries: improving fish biodiversity and protects inland fisheries of Bangladesh

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In Bangladesh fish sanctuaries have been established through various community based action projects which aimed to restore fish habitat for biodiversity conservation, protect their environment and sustainability of inland water fishery resources. This knowledge has been applied to conserve fish production and reduce the climate change threats to fisheries biodiversity, and has been successfully adopted over 500 water bodies under co-management in Bangladesh. The majority of surveyed sites with established sanctuaries indicated that the fishing effort of fishers and other destructive activities has decreased while there is a reasonable increase in their total fish catch. Generally, this has led to a higher biodiversity and to an increasing trend on critically endangered, endangered and vulnerable fish species in the sanctuary sites. The co-management initiatives have achieved a positive acceptance of fish sanctuaries establishment and management at community level. Fisher's communities accepted the concepts of fish sanctuary and participatory management through involving local beneficiaries for resource management. Based on consensus, concerned communities formed Community Based Organizations (CBOs) to implement wetland resource management and conservation activities. Local government and administration also responded positively towards wetland resources in order to sustain biodiversity and support livelihoods. However, there is lack of national legislation specifically related to fish sanctuaries. The key challenge during the initial stages of the co-management initiative was to convince the community to participate and invest their time and effort in setting up and managing fish sanctuaries. This was done through massive awareness raising campaign by MACH, CBFM, CBFM-SSEA, FFP, SCBRMP, SEMP and DWMP projects.

Table-1. GLM test for 8 sites during pre-sanctuary and post-sanctuary periods
Dependent variable: **CPUE per day**

Name of Water body	Habitat type	CPUE (Pre-sanctuary)	CPUE (Post-sanctuary)	Significant	Power (%)
Titas River G-G part	River	3.64	5.13	0.043	0.173
Titas River Ka part	River	2.03	2.006	0.933	0.0001
Pagla nodi (River)	River	3.95	4.48	0.503	0.021
Arial kha river	River	0.75	0.92	0.192	0.08
Kali nodi (River)	River	3.61	3.74	0.834	0.002
Moisharkandi River	River	2.64	2.99	0.349	0.098
Kutir beel	Open beel	1.11	2.37	0.009	0.273
Goakhola-Hatiara	Floodplain	3.85	1.63	0.297	0.077

Present study reveals that sanctuaries provide protection and play a significant role in reducing effect of climate change. Scale up of sanctuary program will reduce climate change threats for thousands of waterbodies in Bangladesh and ensure nutritional security of the poor people. Simultaneously, biodiversity of fish species will also increase and that will ensure resource sustainability at waterbody level. There is also a need to work at the international level to implement biodiversity management policies to protect aquatic resources and mitigate climate change threats.

Pattern of hilsa, *Tenualosa ilisha* migration from the Bay of Bengal

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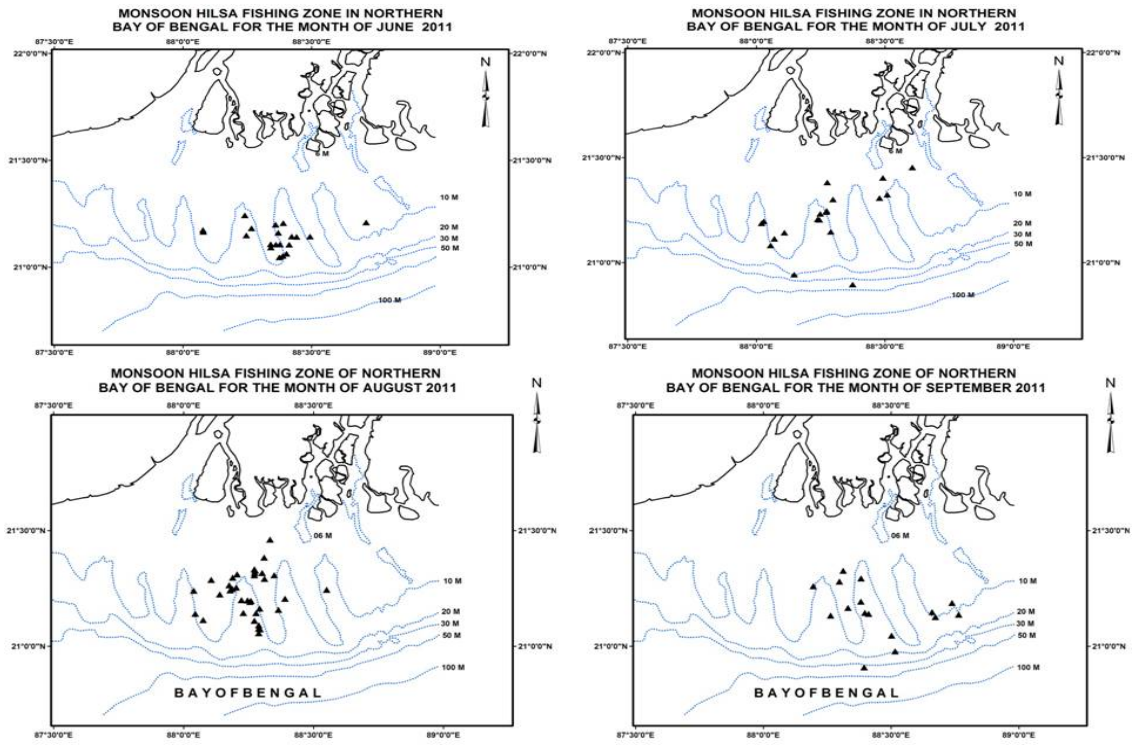
Adult and juvenile hilsa, *Tenualosa ilisha* migrate during different life stages from the Bay of Bengal to the upstream in Meghna-Padma river system in Bangladesh and Hoogly- Bhagirathi river system in India. A joint research shows that the sea stock start migration during the onset of monsoon from the sea towards the freshwater river system. After July rainfall the stock moves towards the Meghna and Hoogly estuary and then after August they move towards the inner side from the estuary. Movement pattern of hilsa stock in Northern Bay of Bengal during June to September of 2011 is shown in the figure.



The average size of fish varied from 250 to 300 g in Bhagirathi River system in India while it varied from 700 to 1500 g in Meghna River system in Bangladesh. The both population were found to be fecund though the difference in size. Detail analyses of habitat quality of hilsa in Bangladesh during the spawning season were evaluated in this study.. Further investigation, however, is needed due to the size-class differences in migration of the same species in the transboundary rivers.

Distribution of the riverine fish in Dinajpur of Bangladesh

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Dinajpur district of northwestern Bangladesh is traversed by several rivers which provide suitable habitat for a large number of freshwater fish and support the livelihoods of many fishermen in this area. The fish present in 3 main rivers, the Dhepa, the Punarbahaba and the Atrai, were investigated over the period from July 2009 to June 2011 using monthly sampling at 9 sites. A total of 3720 fish samples from all the sites were collected and identified in 74 species under 20 families. Of these, 63 species were indeginous and 11 were exotic to Bangladesh. Twenty seven indiginous sepecies are in IUCN red list. One hundred eighty fishermen were interviewed concerning their views about the threats to these riverine fish. Fishermen observed problems of massive siltation of river beds leading to thin flows of water in the dry season and floods in the rainy seasons. During the dry season it was evident that water volume of these rivers became very limited which facilitated indiscriminate fishing by the fishermen. The entrance of exotic fishes to the rivers due to overflow of perrenial ponds was thought to destroy the riverine ecosystem for native speices. The sudden siltation might be due to the impacts of climate change and the upstream river basin development beyond the border of the country.

Table 1. The collected threatened fishes (According to IUCN-Bangladesh 2000)

SL. NO	Scientific name and local name in parenthesis	IUCN Status	SL NO	Scientific name and local name in parenthesis	IUCN Status
1.	*Notopterus chitala* (Chital)	EN	15.	*Ompok pabda*, (Pabda)	EN
2.	*Barilius bendelisis* (Joia)	EN	16.	*Ompok pabo* (Modhu pabda)	EN
3.	*Chela labuca* (Khaira)	EN	17.	*Clupisoma garua* (Ghaura)	CR
4.	*Cirrihinus reba* (Baghna)	VU	18.	*Eutropiichtys vacha* (Bacha)	CR
5.	*Labeo bata* (Bata)	EN	19.	*Silonia silondia* (Shillong)	EN
6.	*Labeo calbasu* (Kalibaus)	EN	20.	*Bagarius bagarius* (Baghair)	CR
7.	*Labeo gonius* (Ghonia)	EN	21.	*Sisor rhabdophorus* (Chenua)	CR
8.	*Puntius sarana* (Sarpunti)	CR	22.	*Chaca chaca* (Cheka)	EN
9.	*Raiamas bola* (Bhol)	EN	23.	*Monopterous cuchia* (Kuchia)	VU
10.	*Botia lohachata* (Rani)	EN	24.	*Chanda nama* (Chanda)	VU
11.	*Aorichthys aor* (Ayre)	VU	25.	*Nandus nandus* (Bheda)	VU
12.	*Mystus cavasius* (Golsha)	VU	26.	*Macrognathus aral* (Tara baim)	VU
13.	*Rita rita* (Rita)	CR	27.	*Mastacembalus armatus* (Sal Baim)	EN
14.	*Ompok bimaculatus (*Boali pabda)	EN			

* CR-Critically Endanger, EN-Endangered and VU-Vulnerable

Multi-criteria analysis for resilience assessment of Nijhum dwip fishing community, Bangladesh

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Resilience of coastal communities is inherently complex. In Bangladesh, coastal community completely depends truly on existing natural resources. Moreover, coastal people have been living in an extremely dynamic environment, facing natural threats that affect almost every aspect of their life and shrink livelihood choices of the people. About thirty thousand people in Nijhum Dwip (an accreted offshore island in the central coastal zone of Bangladesh) having proximity to the Bay of Bengal are facing multiple vulnerabilities every day. The fishing communities' resilience was deliberately sought with extensive field visit and interacting 120 household heads from different occupational groups from Namarbazar, Bandartila and Chuakhali areas. Through the participatory process, resilience assessment focused twenty five basic criteria and the weights were determined by pair-wise comparison matrix of Analytical Hierarchy Process (AHP) according to the effectiveness of the criteria. The study focused on 25 basic criteria i.e. sub-attributes for resilience assessment, namely human assets (fishermen, day labor, farmer, livestock raiser, crab collector), physical assets (house, cyclone shelter, craft & gear, bazar, road network), financial assets (fishery yield, crop, livestock, credit, wage), natural assets (fisheries, mangrove, deer, cropland, grassland), and social assets (social harmony, fishermen association, union parishad, religious bond, trading system). The weights of 25 sub-attributes have developed the Fishing Community Resilience (FCR) assessment scale and also indicated their effectiveness to measure the resilience. The sub-attributes of fishery yield, fisheries, house, and fishermen with 49, 48, 40, and 38% weight respectively indicated the highest role in FCR assessment in Namar Bazar area. The same sub-attributes showed 40, 40, 41, 40% and 45, 47, 40, 41% weight in Bandartila and Chuakhali areas respectively. On the other hand, crab collector, cyclone shelter, credit, deer, and trading system with less than 10% weight indicated the least significance in FCR assessment. The remaining sub-attributes ranged between 10 and 35% weights showed moderately significant in FCR assessment. Considering the overall weights of all attributes, it was quite apparent from the results that the natural assets were the more significant (48% weight), where the vector of weights indicated that physical assets were the least significant (5%) to FCR assessment. The 18, 15, and 13% weights were associated with human, financial and social assets respectively of this model would suggest similar significance to the FCR assessment. The human assets in the Nijhum Dwip with sufficient indigenous knowledge showed professional performance in using other assets to maintain income and food security.

Indigenous resource management in innovative way for food production in rural Bangladesh

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Bangladesh is inherently exposed with climate change impacts and facing food crisis with growing over population. This study was carried out at Hatiya Upazilla under Noakhali district known as heaven of Cheowa (goby) fishery. Present study aimed to identify the role of Cheowa fishery for prawn feed production. Participatory rural appraisal with intensive field visits were conducted among different stakeholders groups to collect data. Findings reveal that 8,757 fishermen have been engaged in Cheowa fishing around Hatiya Island with an annual catch of 19,572 MT. About 82% of the total catches have been dried by the islanders and 18% used for human consumption. Total annual dried Cheowa was estimated 3,699 MT and contain 48.52% protein on an average. About 11,144 MT of prawn feed can be produced annually by adding 30% of dried Cheowa with locally available other ingredients, which can promote prawn farming in 6,737 ha area. Estimating an average production 1,000 kg prawn/ha, a total of 6,737 MT prawn can be harvested annually from the seasonal waterlogged area of Noakhali district. The annual turnover can reach up to Tk 3,200 million (1USD=74 TK) with average price Tk 450-500 per kg prawn. Promotion of forward and backwardly linked sectors, the integration of Cheowa fishery and prawn culture can sustain rural livelihoods (Figure 1) with self employment, food production, household nutrition and cash income.

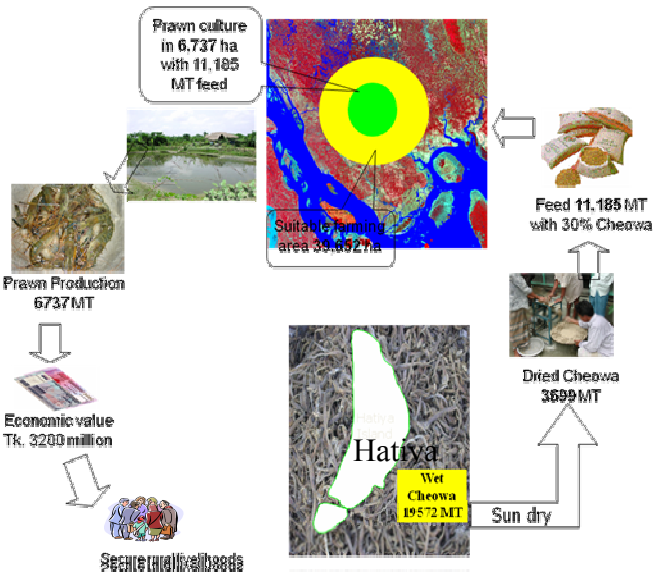

Fig. 1. Role of Cheowa fishery on prawn aquaculture development in Noakhali

Winrock's efforts to promote aqua-agricultural enterprises in selected areas of rural Bangladesh for alleviating poverty

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Winrock International has been working for more than 30 years in development of agribusiness, environment and good governance in Bangladesh through different projects. USDA supported Rural Enterprise for Alleviating Poverty (REAP) may be considered as one of the successful projects of Winrock, which was implemented in 11 Upazilas of Mymensingh, Gazipur, and Tangail during February 2009 to September 2011 in partnership with two NGOs - Society for Social Service (SSS) and Bangladesh Association for Social Advancement (BASA), and in collaboration with the Department of Fisheries (DoF). The objectives of the project were to reduce poverty and ensure steady supply of nutritious and safe food for the rural households through their active participation in integrated aqua-agricultural farming and enterprise.

Mixed culture of freshwater prawn *Macrobrachium rosenbergii* (golda) and major carp integrated with dike cropping was tried to make popular in the project area for increasing farmers' income from ponds, and consequently country's export earnings. The pond water and soil in the project area were found suitable for golda rearing. However, the culture of golda did not expand mainly due to non-availability of its juveniles. To overcome this bottleneck, REAP project selected early adopting farmers from different Upazilas and trained them to establish golda nurseries. Besides, the project executed demonstrations of golda-carp mixed culture through selected farmers to disseminate the technology. Demo farmers and fellow farmers were trained on golda-carp mixed culture and pond dike and homestead horticulture production during the project period. They were provided with golda juveniles, fish fingerlings, vegetable seeds, saplings, and other inputs on a cost sharing basis. Considering the issue of sustainability, the project also facilitated farmers to form associations, and establish linkage with other actors of value chain. A total of 84 associations comprising 2,175 members including 150 women were formed. The major achievements of the project in aqua-agricultural production are shown in the Table 1. Average annual income from aqua-agricultural activities was increased by 89% per family which might lead them to the direction of poverty reduction.

Table 1. Aqua-agricultural production in REAP area during project tenure

Components		No. of Farmers	Area (acres)	Total production	Additional production	Additional income (BDT)
Golda nursery demo		60	10.52	521,889 juvenile 9,994 kg fish	501,889 juvenile 1,578 kg fish	3,671,000
Golda-carp mixed culture	Demo	105	26.30	4,989 kg golda 47,300 kg fish	4,789 kg golda 22,315 kg fish	4,626,000
	Fellow	2035	440.00	17,215 kg golda 686,288 kg fish	17,215 kg golda 268,288 kg fish	35,436,300
Horticulture	Demo	129	9.49	183,095 kg	140,245 kg	1,796,100
	Fellow	2200	155.00	2,730,000 kg	1,955,000 kg	24,320,200

Occurrences of south Asian river dolphin (*Platanista gangetica*) in the Padma and Jamuna rivers, Pabna

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South Asian River Dolphin (*Platanista gangetica*) was surveyed in the Padma, Jamuna and Hurashagar-Baral rivers of Pabna district, Bangladesh during the period of January-September 2011. Seventy-four transects (including upstream and downstream) were made in 79 km distance of the rivers by mechanized boats to estimate abundance and habitat use of dolphins in the rivers.

Over all the size of the dolphin population found to vary from 58 during early monsoon and to 103 during late monsoon in minimum upstream counts. The mean size of dolphin population in the Padma was 19.67 that is one dolphin in 1.72 km; the figure for Jamuna was one in 0.69 km. Of the dolphins 65% were adults and 35% were juveniles. In 22 places of the rivers the occurrence of dolphins were concentrated that is found in every count in three scours locally called '*kum'* e.g., Mohanganj kum of Jamuna-Hurasagor river, Nazirganj ferry ghat kum of the Padma river and in the Nagarbari kum of Jamuna river. More abundance of dolphins found during winter-summer (Jan – Apr) that is 1 dolphin per km that in monsoon (June-July) that is one dolphin in 1.06 km. Water depth was the main factor for survival of the species and net fishing was the main threat for dolphins in the rivers. Local community particularly the fishers were involved for dolphin conservation in the rivers.

Biodiversity, seasonal abundance and marketing chain of small indigenous species (SIS) in the Balikhola fish landing centre, Kishoreganj

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Kishoreganj District in Bangladesh is very rich in inland open water capture fisheries production especially small indigenous species (SIS).However, over the years the production and number of SIS is gradually declining. A 12-month study was conducted to assess the biodiversity status, seasonal abundance and marketing chain of SIS in the Balikhola Fish Landing Center, Kishoreganj. The study was based on frequent monthly visits and collection of information. During the study period, 30 species from 7 Orders and 15 families were found. The highest number of species (9) found were Cyprinidae in which species *Puntius sophore* was the most dominant. Highest number of species (25) were found in October and lowest (3) in February (Fig. 1). Among the species found from river shades, 39% were catfishes, 22% minnows, 17% barbs, 10% perch, 5% snakeheads, 2% gourami. The presence of , loaches, gar, glass fish, goby each 1% (Table 1).

The maximum supply of SIS was was during Sep-Dec and minimum duringJan-Apr. No *Nundas nundas, Chaca chaca, Eutropiicthys vacha* were found which were available in the past.. Habitat destruction by dredging, current jal fishing and pollution are were identified as main causes for SIS biodiversity degradation in openwaters in the area. Non-availability and less availability of some of the species indicated the alarming decline of the biodiversity of SIS in the study area and reflected about the critical situation for the country. Four levels of market or marketing systems were observed in the distribution channel of SIS trade. With The study thus showed the importance SIS biodiversity and suggested for policy implications in this regard.

Table 1. Percentage of species composition of SIS at the landing centre

Species groups	Total yield (kg)	(%) composition
Minnows	61300	22%
Barbs	46000	17%
Gobies	2500	1%
Gars	2500	1%
Snakeheads	13650	5%
Catfishes	108000	39%
Loaches	1700	1%
Perches	26500	10%
Gouramies	4900	2%
Glassfishes	3700	1%
River shads	2200	1%

Nutrient dynamics in Kholpetua-Arpangasia river system of the Sundarbans

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The Kholpetua-Arpangasia River system is an important river system in the Sundarbans, flowing through the western part of Bangladesh and serves as the lifeline for millions of people inhabiting the mangrove dominated Sundarbans. The coastal mangrove forest habitats are considered to be the most productive of all natural habitats of the world, especially for fisheries resources. The plant and vegetation of SRF provide food and shelter for aquatic organisms, used as breeding, nursery and feeding ground by varieties of fishes, mollusks and crustaceans. It contributes 2%-5% of the total capture fisheries in Bangladesh. But the present trend of industrialization, urbanization, expansion of agricultural land in the upstream zone and frequent natural disasters have changed the characteristics of the aquatic sub-system causing extinction of some species and posing a great threat to the remaining. Here starts the real abstract!! This research aimed to know the present status of nutrient concentrations in discrete layers of the water body which act as a limiting factor for the survival of thousands of aquatic organisms. Present study covers both seasonal and tidal variations of nutrients concentrations. Water samples were collected from 2010 to 2011 in different tidal conditions and in three seasons: monsoon (June-September), post monsoon (October–January), and Dry Winter (February–May) from three layer of the water column (surface, middle and 0.5 m above bottom). Significant tidal and seasonal variation of nutrient concentration was found (Table 1 and Figure 1).

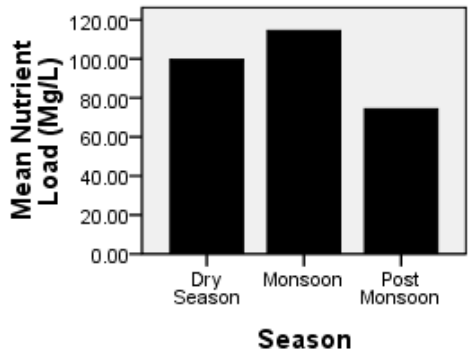

Fig. 1. Seasonal variation of nutrient load

Table 1. Seasonal and tidal variation of nutrients

Season	Tide	NH3–N (ppm)	NO_3–N (ppm)	PO_4 (ppm)	SO_4 (ppm)
Dry	High	0.038	0.169	0.165	104.20
	Low	0.032	0.107	0.091	94.41
Monsoon	High	0.361	0.154	0.134	108.41
	Low	0.319	0.181	0.125	119.16
Post Monsoon	High	0.036	0.145	0.107	72.20
	Low	0.043	0.164	0.122	75.78

The maximum nutrient concentration was found during monsoon while minimum in post monsoon season. But very irregular tidal variation of nutrients was observed during the study period. All the nutrient concentration found within the EQS limit indicates very suitable hydrological environment for aquatic organisms. The average value of physical parameters such as Dissolved Oxygen (DO) of 5.00 mg/L, temperature of 27.17 ^{0}C, pH of 7.6, Electric Conductivity (EC) of 26.15 mS was found at the study period. The salinity ranged from 7 to 24 ppt from monsoon to dry season.

Rural aquaculture: Way to poverty alleviation and livelihood security in Patiya, Bangladesh

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Aquaculture has gaining importance in Bangladesh to compensate the declining fish production from capture sources and as a main alternative for the management of sustainable fish production output. Present study was carried out at Patiya Upazilla under Chittagong district and aimed for identifying potential adaptation in the changed climate through community-based aquaculture practices for protein food production. Data was collected through the questionnaire survey, focus group discussion, participatory field observation and key informant interview. Data analyses revealed that the extensive, improved extensive and semi-intensive aquaculture systems with carp and tilapia polyculture has been practiced in 438 ha, which covers about 6% of the study area. Average carp and tilapia production was recorded 1800 and 1100 kg/ha/yr with local market prices of Tk 130/kg and Tk 110/kg respectively. Total yearly production was recorded about 1270 MT with economic value of Tk 155 million (1 US$=Tk 74) from the study area. The respondents reported that about 10% of the production has been consumed by farmers household. It was amazing that 96% fish farmers improved their life style with cash income, intake protein food, bought good cloths, school-going children, and repaired houses; where disease outbreak and social disputes hindered other farmer's progress. Shortage of quality fish fry and lack of loan facilities are the main operational barriers for rural aquaculture at Patiya. Extension services with farmers training, disease monitoring, and arranging loan facilities in time can stimulate aquaculture production several folds that can contribute malnutrition control and improve rural livelihoods (Figure 1).

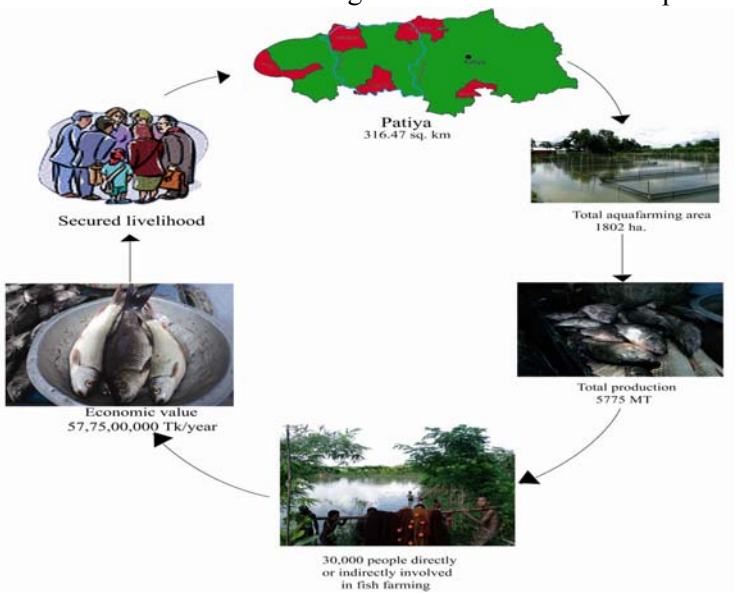

Fig. 1. Impacts of rural aquaculture on livelihood at Patiya

Managing without managers: Climate change adaptation at Ramgati coast, Bangladesh

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Climate change impacts on human are often considered as the regular social fabrics in Bangladesh. The present study explored climate change disasters and subsequent impact of extreme events on the livelihood of local community in Ramgati coast under Lakshmipur district. At the same time indigenous adaptation options with climate change have also been analyzed. The study relied on a questionnaire survey of household heads by utilizing 125 random samples, focus group discussion and participatory observation from the study area, and collected data were feed into SPSS software for analysis. The study identified tropical cyclone, river bank erosion and tidal surge as extreme events of climate change. The vector of effectiveness (Figure 1) indicated that continued change made people's livelihood fragile by making homeless, landless, income less, food crisis, water crisis, cattle death, disease outbreak and migration. Analyzing the survey data revealed that going to the shelter center and neighbors/relatives house, formation of temporary cluster house on embankment, buy land in upward areas and migrate to nearby urban districts are options for settlement. In addition, take loan from money lender, selling liquid assets, borrow money from relatives, utilize previous saving, mortgage land are mentioned by the interviewee as immediate solution of financial requirement. Travel long distance for drinking water collection, use water purification tablets, exercise herbal medicine, visit village doctor and depend on religious superstition are parts and parcel of their daily life. The coastal residents have been surviving their existence with generations-old innovative indigenous adaptation mechanisms.

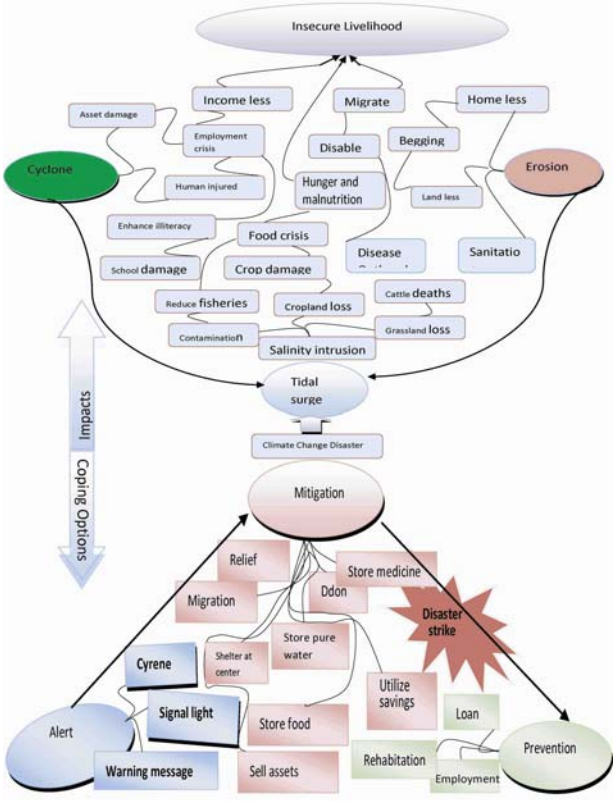

Fig. 1. Impacts and adaptation with disasters at Ramgati

A study on livelihood status of fishermen and icthyodiversity of Hail *haor*, Sreemangal upazila, Sylhet

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The present study was carried out to assess the livelihood status of the fishermen of Boruna and Haziganj (around hail haor) of Sreemangal upazila under Moulvibazar district to explore the livelihood status of the people and also to assess icthyodiversity of hail haor and their dependency on its resources. Hail haor is a large floodplain basin surrounded by hills on three sides. The major source of water in the haor is local rainfall and hilly stream flows. The water area of the haor varies from a maximum of 12,00 - 14,00 hectares in the wet season to a minimum of 4,009 hectares in the dry season. The study carried out from September, 2010 to July, 2011. Data were collected using well designed structured questionnaire. Total 55 fishermen directly involved in fishing were selected. Most of the fishers were 31 to 47 years age group; 80.7% of them were Muslims and 19.3% Hindus. Of them 63% have kacha house, 28% and 11% have tin-shade and other types of house respectively. Mean income of majority of fishermen were > Tk. 63,000 per year. About 49% fishermen used kacha sanitary latrin, 42% used semi-pucca sanitary latrine and 9% had no sanitatary latrine. Of the fishers 68% used own tube-well, 25% i used neighbor's tube-well and 7% use other sources of water. Forty two percent fishermen received health service from village doctor, 28% have access to upazila health complex, 26% consulted with professional doctor however, 4% of them did not take any treatment due to lack of money.
The outcomes of the study showed 8 species of barbs in Cyprinidae family, 3 species of snakeheads in Channidae family, 8 species carp in Cyprinidae family, 2 species of eels in Mastacembelidae family, 5 species of catfishes, 5 species of Perch and 10 Miscellaneous fishes are recorded from hail haor.

Population dynamics of *Gudusia chapra* in the Pagla river

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The population structure, age, growth, mortality and exploitation status of Chapila *Gudusia chapra* were estimated for first time in the Pagla river, Bangladesh between August 2004 – July 2005. Monthly length frequency data of *G. chapra* were analyzed by FiSAT software for determination of population parameters like asymptotic length (L∞), growth co-efficient (K) and recruitment pattern to evaluate the status of the stock. Asymptotic length (L∞) was 128.33mm and growth co-efficient (K) was 1.2 yr^{-1} respectively. The growth performance index (φ/) was 4.30. The growth pattern showed isometric (b= 3) with an asymptotic weight (W∞) 18.28 g obtained. Total mortality (Z) by length – converted catch curve was estimated at 2.27 yr^{-1}, fishing mortality (F) .97 yr^{-1} and natural mortality (M) 1.30 yr^{-1}. The exploitation level (E) of *G. chapra* was 0.43 that of the maximum allowable limit of exploitation (E_{max}) was 0.463. The recruitment pattern was continuous with two major peaks in a year. The exploitation level (E<0.50) indicated that the fishing pressure on *G. chapra* was lower than optimum level (E=.50) and the status of stock might be under-exploited in the Pagla river of Bangladesh.

Development of tilapia hatchery and employment opportunities: A micro-level analysis in Mymensingh region

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The impacts of aquaculture along with its value chain are versatile such as nutrition supply to human diet, foreign currency earnings, poverty alleviation and employment generation. The fisheries statistics of Bangladesh shows a gross statistics of employment being generated by fisheries and aquaculture. This statistics does not show the disaggregated data of employments with their typologies and other dimensions. The present study was conducted to assess employment generation in a mono-sex tilapia hatchery located at Bailor under Trishal Upazila, Mymensingh with respect to the type of employees, salary structure, socio-economic characteristics of employees and the livelihoods impacts of hatchery based jobs. Overall, it was found that a large number of employees were found working in the hatchery (Table 1). The majority of the employees were from the localities working in the hatchery. The employees were working with different category of works of which some were technical. The majority of them had low level of education with no previous working experience and training in aquaculture.

Table 1. Employment structure in the mono-sex tilapia hatchery

Employees category	No. of employee	Gender	Responsibility	Education	Previous aquaculture experience	Monthly salary (BDT)
Farm owner	1	Male	Control the farm	MS in Social Science	No	25,000
Farm manager	1	Male	Manage the farm	HSC	No	8,000
Administration officer	1	Male	Manage the pond	SSC	No	5,000
Feed distributor	3	Male	Distribute feed	SSC	No	4,200
Skilled technician	1	Male	Preparing feed	SSC	No	8,000
Semi-skilled technician	1	Male	Packaging	Class 8	No	6,000
Unskilled technician	6	Male	Fry handling	Class 5-8	No	3,500
Water supplier	1	Male	Supply water	Class 8	No	3,500
Cook	1	Female	Cooking food	Illiterate	Yes	2,000
Guard	3	Male	Ensure safety	SSC	Yes	3,500
Driver	1	Male	Car driving	SSC	Yes	4,000

The employees were found to be paid with salaries equivalent to the categories of national pay-scale. All the employees have developed their livelihood conditions considerably compared to their previous occupation before employed in the hatchery. Along with basic livelihoods benefits from hatchery based jobs, employees were found to be experienced different incentives such as living in the farm residence, eating fish, vegetable from the farm ground at free of cost. Tilapia hatchery acts as an effective sector to reduce poverty by crating employment for the poorest people in rural areas.

Presence of nitrofuran and chloramphenicol in the farmed prawn, shrimp and feed in the southwest coastal region of Bangladesh

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Presence of nitrofuran and chloramphenicol in farmed prawn and shrimp is a major concern in the export sector in Bangladesh. Rejections of consignments by the foreign buyers have been recurrent for the last couple of years due to detection of these banned antibiotics. The increasingly complex requirements for food safety assurance and traceability set by major export markets represent a threat to the trade of this significant sector. In this study, the status and trends of the presence of nitrofuran and chloramphenicol in freshwater prawn *Macrobrachium rosenbergii* and marine shrimp *Penaeus monodon* and in their feeds in the Southwest coastal region of Bangladesh were analysed. The prawn/shrimp farmers, feed manufacturers and feed sellers were interviewed with pre-tested questionnaires. Antibiotic residues present in the animal muscles, feeds and feed ingredients were detected through LC-MS-MS by the Fish Inspection and Quality Control Wing of the Department of Fisheries.

Field study revealed that farmers did not deliberately use those banned antibiotics, but these chemicals were detected in many *M. rosenbergii* and *P. monodon* samples in 2008, 2009 and 2010, in both fresh muscles, pre-export and post-export consignments. Various feeds and feed ingredients were also contaminated with nitrofuran metabolites. Antibiotic residue detection data of 2008, 2009 and 2010 when compared with the questionnaire interview results, major findings observed were- i. contamination of nitrofuran and chloramphenicol was more in *M. rosenbergii* than *P. monodon*; ii. among 4 nitrofuran metabolites, nitrofurazone was found more frequently but in smaller quantities in 2009 and 2010; iii. contamination of nitrofuran metabolites was more in prawns fed with commercial feed than those with home-made feed; and iv. there has been a decreasing trend of presence of nitrofuran and chloramphenicol in prawn and shrimp in Bangladesh.

Crab fattening as livelihood option for the poor community in Shyamnagar, Satkhira

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The study was carried out to analyze the present livelihood status of the poor community of farmers engaged in crab fattening and related activition using the capital assets framework in Shyamnagar Upazilla under Satkhira district. A total of 100 households were interviewed with a semi structural questionnaire. About 40% of the total sample households were only able to sign. Almost 60% of the respondents pursue agricultural activities as their secondary occupation. 44% of the respondents were functionally landless. Almost 90% the total land was operated by the better off and middle class household. Out of 12 unions in Shyamnagar Upazilla, mud crab business was found in 6 unions. There were variations in price according to grade. Average maximum selling price for male of SM, L, XL, XXL were 110±31.81981 Tk./kg, 135±31.81981 Tk./kg, 225±63.63961 Tk./kg, 325±98.99495 Tk./kg respectively in winter. While the average minimum prices of SM, L, XL, XXL were 65±31.81981 Tk./kg, 90±31.81981 Tk./kg, 135±63.63961 Tk./kg, 185±98.99495 Tk./kg respectively in summer. For female crabs the average maximum prices of F1, F2, F3, KS1, KS2, KS3, were 375±70.71068 Tk./kg, 160±35.35534 Tk./kg, 125±31.81981 Tk./kg 400±88.38835 Tk./kg, 130±28.28427 Tk./kg, 130±28.28427 Tk./kg, respectively in winter. While the average minimum prices of F1, F2, F3, KS1, KS2, KS3, were 275±70.71068 Tk./kg, 110±35.35534 Tk./kg, 80±31.81981 Tk./kg, 275±88.38835 Tk./kg, 90±28.28427 Tk./kg, 90±28.28427 Tk./kg, respectively in summer. All the harvested crabs were marketed abroad through airfreight in live condition. The peak harvesting season is June to August from shrimp *ghers* and November to January from the mangrove areas and tidal rivers. Mortality rate of crabs captured from the forest (20%) is higher than *gher* (10%) during transportation. The study revealed that increasing the facility for crab fattening can develop the socio-economic condition of the poor farmers.

Effects of salinity and pH on the rate of oxygen consumption in female mud crab *Scylla olivacea*

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The mud crab industry has been expanding satisfyingly in Bangladesh in the recent years and playing an important role in the export earnings from the fisheries sector. The present study was carried out to evaluate the consequence of salinity and pH on the rate of oxygen consumption in different life stages (juvenile, adolescent and adult) of female mud crab (*Scylla olivacea*). Four different salinity regimes *viz*., 0, 4, 15, 30 ppt and 3 different pH levels *viz*., 5.5, 6.5 and 8.5 were tested in the Fish Physiology Laboratory of Fisheries and Marine Resources Technology Discipline, Khulna University. The highest O_2 consumption rate (0.38 $mgO_2/l/h$) was observed at 30 ppt and the lowest (0.31 $mgO_2/l/h$) at 15 ppt salinity. Juvenile mud crab showed higher O_2 consumption rate compared to the adolescent and adult crabs at all different salinity and pH levels. Juvenile crabs were also more vulnerable to different salinity and pH levels compared to adolescent and adults. Different pH levels treatment revealed the highest O_2 consumption rate at pH=8.5 and lowest at pH=6.5. Results of the present experiment support the maintenance of 15 ppt salinity and around 7 pH levels for both crab culture and fattening in Bangladesh.

Seasonal and tidal variations of major nutrients (No_3-n, Po_4, NH_4-n, So_4) in Rupsha-Passur river system of the Sundarbans

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The Rupsha-Passur river system is one of the biggest and important river systems flowing through the middle part of the Sundarban mangrove forest and serves as the source of essential nutrients for millions of aquatic life inhabiting the mangrove dominated ecosystem of the Sundarbans. Unplanned rapid expansion aquaculture including shrimp industry, industrialization, urbanization, agricultural land and other settlements in the upstream zone has changed the characteristics of the aquatic sub-system. This research provides information about the variation of major nutrients under different tidal and seasonal conditions. Water samples were taken between 2010 and 2011 at five fixed stations in different tidal conditions, covering three seasons: monsoon (June-September), post monsoon (October–January), and dry winter (February–May). Samples were collected from discrete layers of the water column (surface, mid and 0.5m above bottom) and were poured into the 250 ml plastic bottles, immediately preserved in icebox and carried to the laboratory for analysis.

Table 1. Concentration of nutrients under different tidal and seasonal conditions

Seasons	NH_3-N		NO_3-N		PO_4		SO_4	
	High	Low	High	Low	High	Low	High	Low
Dry	0.554	0.469	0.554	0.469	0.191	0.178	28.035	26.886
Monsoon	0.833	0.816	0.833	0.816	0.207	0.206	35.583	72.078
Post monsoon	0.691	0.616	0.691	0.616	0.525	0.629	8.342	7.709

Monsoonal runoff increases the concentration of nutrients in the estuarine river water (Figure 1). Tidal water temperatures during the sampling period were on average 30.5, 30.0 and 20.8 ºC in monsoon, post-monsoon and dry winter respectively. Average salinity values were measured as 5.42, 8.2 and 11 ppt in monsoon, post-monsoon and dry winter respectively while NO_3-N, NH_4-N, PO_4 and SO_4 concentrations ranged from 0.08 to 1.23, 0.013 to 0.080, 0.045 to 1.35 and 7.30 to 126.92 ppm respectively. The variations of nutrient concentration were significant between high and low tides. These considerable tidal variations of nutrients (Table 1) is the net effect of freshwater flow from the upstream regions that bring contributions from the industries, shrimp and other aqua farms, tourism facilities, fish landing centers and other agricultural lands.

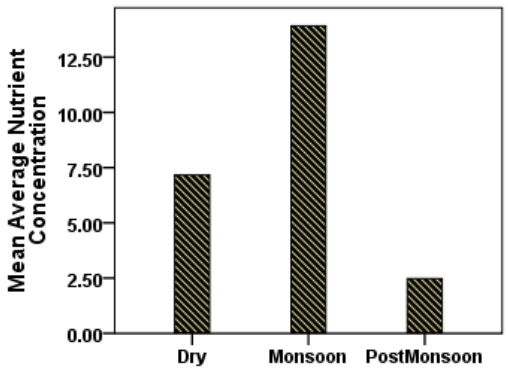

Fig. 1. Seasonal variation of nutrient concentration

Mud crab (*Scylla serrata*) fattening in Bangladesh: present status and future prospects

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In Bangladesh, as an exportable fishery, mud crab is playing an important role in national and international market. It can generate employment directly and indirectly in terms employment in the farming, marketing and other associated business. Two mud crab fattening seasons were identified; one is dry season from October to May and another one is the wet season from June to September. Fattening is mostly involved in stocking wild stock. There is obvious need for crab hatchery for crab farming however, no one ready to take the challenge. Most of the mud crabs are exported particularly to East and Southeast Asian countries. Considering the total export earning from the mud crab the fishery showed future potentialities. From 1997-1998 to 2006-2007 Bangladesh earned US$21,064,000 (excluding local sales) by exporting crabs to 23 countries around the world. More than 96% of total export earnings came from Asian countries. Among them, the East Asian and Southeast Asian countries are playing significant role in the foreign export earning for Bangladesh. Development supports from government and different non-governmental organizations need to be increased to improved for sustainable mud crab farming and marketing in Bangladesh.

PCR-based detection of *Pseudomonas fluorescens* isolates collected from diseased fish

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Studies were conducted for rapid detection of *Pseudomonas fluorescens* isolates associated with 'Bacterial Hemorrhagic Septicemia' disease of carp and catfish by Polymerase Chain Reaction (PCR) method. *P. fluorescens* specific and highly conserved forward and reverse primers were designed after alignment of 16S rDNA sequences available in the database. The forward primer (225F) was 18 bp in length and the reverse primer (1265R) was 17 bp in length. Percentage of Genus/Species specific conserved region of the PCR primers was calculated by base pair specific calculation. The Forward primer (225F) possess 27.78% conserved region compared with *Aeromonas* spp., 27.78% with *Edwardsiella* spp., 50% with *Flavobacterium* spp. and 38.89% with *Vibrio* spp. whereas reverse primer hold about 58.82% unique sequence with *Aeromonas* spp., 41.17% with *Edwardsiella* spp., 64.70% with *Flavobacterium* spp., and 42.12% with *Vibrio* spp. A total of seven isolates viz. $PuKL_2$, $PuKL_{22}$, PFK_{13}, Cla_1B_8, Cla_1B_{10}, Cla_1B_{18} and P_2F_2 collected from hemorrhagic septicemia infected carp and catfish and identified to be belong to *P. fluorescens* gave the expected 1040 bp PCR product. Isolates belonged to *Aeromonas* spp, *Edwardsiella* spp., *Flavobacterium* spp. and *Streptococcus* spp. did not amplify in the PCR method. Thus the PCR method was found selective for *P. fluorescens*. This PCR based detection of *P. fluorescens* could be used for rapid and specific detection of *P. fluorescens* pathogen form disease infected fish and waterbody.

Concentrations of DO, BOD and COD in the Sundarbans mangrove aquatic ecosystem, Bangladesh

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The biodiversity, especially the aquatic lives are depended on the quality of the waters of the creeks, rivers, estuaries, khals and channels of' the Sundarbans. Based on in situ observation during October 2010– February 2011DO was found to vary between 4.5 and 8.9 mg/L with an average value of 6.05 mg/L. Higher level of DO was noticed at Rupsha-Posur river system, but a decline was evident from Malancha-Arpangachia river system. The oxygen concentration improved in Baleswar-Bhola river system. The basis of the results of this study are the analyses of a total of 30 water samples collected from 15 measuring stations in post monsoon and winter season. Maximum BOD (2.98 mg/L) was recorded in October while minimum (0.65 mg/L) around November to December. The overall range is found to be from 0.3 to 3.9 mg/L, having an average BOD of about 1.62 mg/L, which is much lower than the upper limit of EQS (10 mg/L), Bangladesh (DOE, 1991). COD is the measure of pollutants, containing bio-degradable and non-biodegradable organic matter, thus not fully degradable biologically. The observed range of COD is 20 –200 mg O_2/L with an average of 109.2 mg/L, exceeding the permissible range of 4–8 mg/L (DOE, 1991). Again, higher COD is found to occur in February. The relative value of COD is higher in the dry season than in the wet season because rain causes dilution in the stream. It is revealed that organic pollutions are being existed in the studied river systems, which is dangerous to aquatic organisms.

Spatial and temporal variation of phytoplankton abundance and diversity within the sundarbans mangrove forest

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The present study was conducted to understand spatial and temporal variation of phytoplankton abundance and diversity in the Sundarbans mangrove forest, Bangladesh. For this study samples were collected from 15 spots of three major river systems (Rupsha-Pashur, Malancha-Arpangachia, & Bhola-Baleswar). Temperature, pH, DO, salinity, transparency, phytoplankton diversity and abundance were analyzed using standard methods. Results showed that phytoplankton abundance and diversity were strongly variable with seasonal changes. A total of 132 phytoplankton species were identified, dominated by Diatoms, some Dinoflagelates, and fewer Cyanobacteria and Chlorophytes. Ninty nine species from 41 genera of Bacillariophyta; 18 species from 6 genera of Pyrophyta; 12 species from 9 genera of Chlorophyta; 4 species from 4 genera of Cyanobacteria; and 1 species of Ochrophyta were present. The most diverse genera observed were *Coscinodiscus* with 12 species; *Thalassiosira* with 10 species; *Chaetoceros* and *Paleurosigma* with 7 species; *Protoperidinium* with 11 species and both *Cyclotella & Actinocyclus* with 4 species. Species abundance varied within the range 3112 to 525283 individuals/l. Highest abundance was observed in Bogi in pre-monsoon period and lowest in Nildumur in post-monsoon period. Species diversity ranged from 11 (post-monsoon) to 60 (winter). Species Richness Index, Diversity Index, and Equitability Index varied from 1.19 (Supati, post-monsoon) to 5.84 (Arpangachia, winter); 2.03 (Harbaria Canal, post-monsoon) to 4.64 (Karamjol, winter); and 0.71 (Sharankhola, winter) to 1.50 (Karamjol, winter) respectively. Water temperature, pH, DO, transparency, and salinity were found to vary from 20 to 31°C; 6.7 to 7.87; 3.93 to 7.37mg/L; 7.5 to 60 cm; 2 to 23‰ respectively. The study will provide an ecological baseline for the Sundarbans mangrove forest area and serve as a basis for establishing monitoring programs to predict changes with high hydrological variation and in developing an early alert system for ecosystem disturbances.

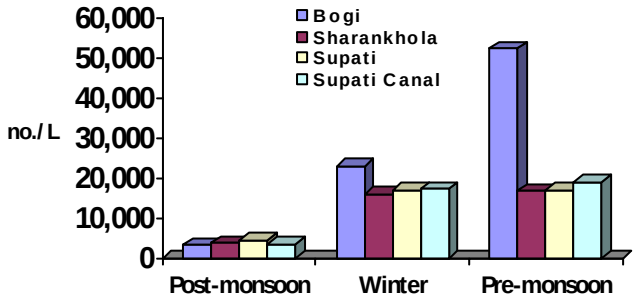

Fig.1. Spatial and temporal variation of abundance in Rupsha-Pashur river

Mud crab *Scylla serrata* fattening as an adaptive measure for the climatically stressed coastal fisher-folks of Potuakhali district

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Crabs are commercially important, commending high prices in local and international markets and used as source of income for coastal fisher-folks and also for domestic consumption. The study was carried out to analyze the technique of mud crab fattening in cage at Kalapara upazila of Potuakhali district of Bangladesh. Cages were grouped into six sets for the experiment and tested in different areas. Lean crabs were collected from rivers, estuaries and sea. The maximum catching attained during spring tide and neap tide.

The cage size was 1.83m in length, 0.91m in width and 0.30m in height. The size of each cell was L×W×H: 0.2m×0.2m × 0.3m in the trial for crab fattening. One individual lean crab was stocked in each cell i.e. 50 individual per cage. Feeding rate was about 8-10% of the total body weight. The salinity at Kalapara ranged from 0 to 12 ppt over the period of March-September, 2011. The highest salinity was found in April but the lowest values were 0 ppt after the month of August. The pH value ranged between 7.1 and 8.4 during the study period. Average gonad maturation (%) in the Cage-1, Cage-2, Cage-3, Cage-4, Cage-5, and Cage-6 was 79.29, 83.57, 82.14, 78.57, 86.43, 87.14 respectively with maximum 95% and minimum 60%.The highest mortality (15%) was observed in Cage-2.The average profit for all sample units was found in the range of 593.00 to 1058.00 taka. The average net profit was maximum for Cage-5 and minimum for Cage-1. The study demonstrates that fattening in floating cages is an economical, powerful and sensitive experimental tool for crab fattening studies.

Shark fishery management in the Bay of Bengal, Bangladesh

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Shark fishery is not a target fishery in Bangladesh water rather regarded as by-catch. A total of 30 species of sharks and 39 species of rays were so far recorded from Bangladesh waters but no skates and chimaerids. Catch records reflect that catches are declining (Table 1) and bulk of the catch is small sized ones. Prime fishing grounds in the south-west region are Kuakata, Sonar char (island), Ruper char, Fatrar char, Char Gongmoti and Dublar char in Patuakhali and Asar char, Patharghata areas of Barguna and coastal areas of the Sunderbans. In the south-east fishing grounds are Sandwip, Kutubdia, Moheshkhali, Cox's Bazar and Teknaf coasts.

Table 1. Year-wise catch records of sharks and rays in Bangladesh*

Year	Catch (t) of sharks and rays
2009-10	4,044 (0.78)
2008-09	3,933 (0.76)
2007-08	4,767 (0.96)
2006-07	4,790 (0.98)
2005-06	4,448 (0.93)
2004-05	4,085 (0.86)
2003-04	4,946 (1.09)
2002-03	5,063 (1.17)
2001-02	6,234 (1.50)
2000-01	5,162 (1.36)

Figures in the parenthesis are percentages of total marine catch.

Sharks are mainly caught by artisanal fishery with drift gill nets used for catching hilsa and Indian salmon, set bag nets, long lines and trammel nets within 10-80 m depth ranges (Fig. 1). Mostly small sized sharks and rays are caught because of gear limitations. Fish Act has no restriction on harvesting of sharks, while Forestry Act restricts it in and around the Sundarbans. Hence indiscriminate harvesting is depleting their stocks. Iced and slated dry flesh, sun-dried hide, bones, fins, tails, teeth and shark liver oil is traded in Bangladesh. Export earnings of shark products are decreasing rapidly since 1999-2000 (Table 2) and significant amount of shark products are straddled through transboundary movement from Bangladesh to neighboring countries.

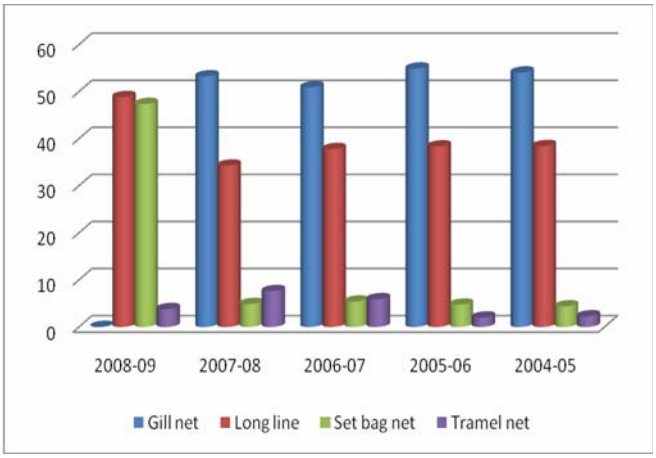

Fig. 1. Gear-wise exploitation (%) of sharks and rays.

Study on the biology of elasmobranch fishes of Bangladesh is very insignificant and this is probably because of the difficulty in getting adequate statistics and samples. Review of stock assessments and present stock status of sharks is essential with a National Plan of Action (NPOA) for a regional fishery management plan which would help in introducing and promoting collaborative fisheries management approaches in the BOBLME region. Fishery Act should be updated with strong rules and strong monitoring, control and surveillance (MCS) should be implemented for restricting indiscriminate exploitation of elasmobranch fishes.

Gate way of adaptation to coastal fishing community in an erosion-prone island of Bangladesh

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Erosion is one of the major climate change disasters along the coastal zone of Bangladesh. Present study was conducted at Rahmatpur union of Sandwip upazila, a vulnerable coastal island of Bangladesh. The objective was to assess the extent of erosion and identify its impact on the livelihood of fishing community with their adaptation options. Data were collected through extensive field survey based on structured questionnaire, focus group discussion, key informant interview and participatory observation. A total of 150 questionnaire surveys were conducted and data were analyzed using MS Excel and SPSS software. The study revealed that 37.5% area of the Rahamatpur union had been eroded during the period of 1978-2010. Loss of houses, cropland, towns, trading centers, road networks, educational institutions and wet meadows were the major affected zones. The study recorded lots of instances of shifting individual family in every 5-6 years interval due to ongoing erosion. Data analyses (Table 1) found that heightening of dike, bamboo revetment, concrete pole structure, retreat and homestead plantation were the indigenous adaptation options for local fishing community. Yearly household expenses averaged Tk 9,156 (1 US$= Tk 74) as the climate change adaptation cost that equaled about 20% of the annual household income.

Table 1. Expense of particular adaptation cost

Adaptation Coast BDT		Minimum	Maximum	Mean	No. of respondents
Heightening of dike	Monthly	600	800	715	75
	Annually	7200	9600	8580	
Bamboo revetment	Monthly	800	1000	895	18
	Annually	9600	12000	10740	
Concrete pole Structure	Monthly	1000	1200	1090	17
	Annually	12000	14400	13080	
Plantation	Monthly	500	600	550	20
	Annually	6000	7200	6600	

Status of *Tenualosa ilisha* culture with tiger shrimp, tilapia and carp: a case study in farmers' pond at Batiaghata Upazilla

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A survey was conducted to know the status of *Tenualosa ilisha* culture in pond ecosystem of Batiaghata upazilla, Khulna during April-December, 2010. There were 3 ponds and each of these was 0.20 ha in size. Farmers conducted polyculture of *Penaeus monodon, Tenualosa ilisha, Labeo rohita* and *Oreochromis mossambicus* where *Penaeus monodon* was the main crop and others *were* the additional crops. The initial average weight of the PL of *P. monodon* and fry of *T. ilisha, L. rohita* and *O. mossambicus* were 0.5, 10, 20 and 10g respectively. The PL of *P. monodon* and fry of *O. mossambicus* were stocked in April, when the salinity was 10.0 ppt. The fry of *T. ilisha* and *L. rohita* were stocked in early June and late June when the salinity was about 5 ppt. The stocking densities were 1, 5, 1 and 1/ m^2 for *T. ilisha*, *P. monodon*, *L. rohita* and *O. mossambicus* respectively. Hand made mixed feed containing a protein

Table 1: Growth, Survivility and production of the four specie

Species name	No. of stocked	No. of survived fish	Final weight (g)	Production (kg)	Total Production (kg/0.6ha)	Total Production (Kg/ha)
T.ilisha	2000	500	215	108	381	635
	2000	560	230	129		
	2000	600	240	144		
P.monodon	10000	6500	28	182	552	920
	10000	7500	26	195		
	10000	7000	25	175		
L.rohita	2000	1100	400	440	1228	2046
	2000	1000	350	350		
	2000	1200	365	438		
O.mossambicus	2000	1200	250	300	1127	1878.33
	2000	240	300	372		
	2000	1300	350	455		

Mud crab (*Scylla serrata*) fishery in Patuakhali and Barguna district

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A study was executed to obtain an overview of crab marketing at 2 Upazila namely Patharghta of Barguna District and Kalapara Upazila of Patuakhali District. The overall sex ratio of male to female was found to be 1:0.94 and 1:0.95 in Patharghata and Kalapara Upazila respectively. The total number of depots and manpower involved in crab business in the depots were estimated to be 52 and 137 respectively. Manpower involved in crab business was maximum in Kalapara sadar in Kalapara Upazila and minimum in padma union in Pathorghata Upazilla. Grading system was different in Kalapara Upazilla from Patharghta. In Pathorghata the average selling prices of female from depots was found to be highest in January for F1, KS-1, F2 and in February for F3. The prices were highest for XXL and XL in January, L in October, M and SM in November. But in Kalapara the average selling prices of female from depots were found to be highest in October for F1, KS-1, in January for F2 and F3 in September. The prices were highest for XXL in December, XL in February, L in November, M and SM in November.

Average boat size in Pathorghata was found in length 226.366±61.006 inch, width 59.7533±4.9938 inch, and high 33.12±2.237 inch. Each boat collects per 7 days in neap tide 60.3333±14.326 kg per week. On the other hand in Kalapara average boat size was found in length 237.66±40.083 inch, width 60.009±4.3386 inch, and high 33.28±2.015 inch. Each boat collects 60±10.856 kg per week. Rate of mortality was found high in case of soft shell male and goandally matured female. It was found that mortality rate of crabs which comes from forest is higher than *Gher* & it is 20% per day. All the harvested crabs were marketed in the foreign country through airfreight in live condition. Major export markets of mud crab are Singapore, Hong Kong, China and Malaysia. The research work is supported by Regional Fisheries & Livestock Development Project, funded by DANIDA.

Performance of PCR tested WSSV negative *Penaeus monodon* seed in different culture system in Bangladesh

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White spot syndrome (WSS) caused by WSS DNA virus has seriously affected farmed penaeid shrimp. WSSV is an extremely virulent to cultured shrimp, which causes 100% mortality within a few days from the onset of symptoms and are notoriously hard to predict. This virus causes catastrophic economic losses on shrimp farms. Its presence is considered as a potential threat to shrimp industry and thought to be transmitted vertically from broodstock to the offspring in the hatchery and horizontally through water or infected hosts to the healthy animals in the farm. Protection against this disease needs PCR tested WSSV negative seeds and stocking in ponds that is free from WSSV sources.

A study was conducted to assess the performance of PCR tested WSSV negative postlarvae of *Penaeus monodon*. Four culture systems namely Closed System Technology (CST), Modified Traditional Technology (MTT), Best Management Practice (BMP) and Traditional System Technology (TST) were investigated. All of these culture systems except TST were stocked with WSSV-PCR negative postlarvae of *P. monodon*. TST ponds were stocked with non tested seeds. It was revealed that 80% shrimp ponds of the CST were un-affected by WSSV during the study period (10 months) followed by MTT (72%), BMP (57%) and TST (39%). Higher shrimp production was obtained from the CST (1744 kg/ha/year) followed by MTT (402 kg/ha/year), BMP (269 kg/ha/year) and TST (223 kg/ha/year). Net profit from the CST was also higher (Tk. 220925/ha/year) followed by MTT (Tk. 61175/ha/year), BMP Tk. 37850/ha/year) and TST (Tk. 27350/ha/year). It was evident from the study that PCR tested WSSV negative shrimp seed with relatively better culture practice minimized the crop loss and gave better profit.

Table 1. Shrimp production and net profit analysis

Culture System	Total number of pond	Number of non affected pond	Percentage of non affected pond	Investment (Taka) /ha/year	Return (Taka) /ha/year	Net profit (Taka) /ha/year	Production (Kg) /ha/ year)
CST	52	42	80	271230	492155	220925	1744
MTT	35	25	72	113825	175000	61175	402
BMP	105	60	57	56650	94200	37850	269
TST	100	39	39	51400	78750	27350	223

Microalgal polyunsaturated fatty acids (pufa) determine survival and development of marine calanoid copepod *Acartia tonsa*

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Copepods are the primary consumers in aquatic ecosystems and thus provide an important link between primary producers and higher trophic levels such as fish. The biochemical food quality of microalgae is one of the key factors that determine copepod abundance. Of particular importance are the essential fatty acids (EFAs) that are vital for cell functions but cannot be synthesized *de novo* by animals and must be taken up through diet. In aquatic ecosystems, microalgae are the sole producers of EFAs that are stored and transferred to the higher tropic levels by zooplankton, mainly copepods. However, our understanding on the relative role of each of the EFAs on copepods is extremely limited. Here, we tested the survival and development of copepod *A. tonsa* fed separately with four different taxa of marine microalgae that varied greatly in the concentration of two EFAs, docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) (Table 1).

Table 1. The presence or absence of DHA and EPA in the algal taxa tested

Algal taxa	DHA	EPA	Treatment
P. lutheri	+	+	DHA+EPA
I. galbana	+	−	DHA only
N. salina	−	+	EPA only
Dunaliella sp.	−	−	None

A. tonsa nauplii stage-I (N-I) were stocked and were grown up to N-VI stage (3 replicates) and copepodite-VI (C-VI) stage (3 replicates) separately on each diet. Next, N-I stage copepods were reared on *P. lutheri* (DHA+EPA) for five days to produce N-VI stage; then they were reared either on *N. salina* (EPA only) or on *Dunaliella* sp. (no DHA, no EPA) for six days to produce C-VI stage. The algae were grown at 18°C under 16:8 hours light:dark regime in enriched (f/2) filtered seawater. Eggs of *A. tonsa* were incubated in filtered seawater. Copepods were reared in 1.25 L glass bottles at densities of 3 nauplii ml^{-1}. Algae were fed to the copepods at ~2.5 mg carbon $L^{-1}d^{-1}$. Copepod survival rate (SR) was computed as the final density ml^{-1} of culture water. Developmental rate (stage day^{-1}) was calculated by assigning value to each stage as 1−6 for N-I to N-VI and 7−12 for C-I to C-VI and by dividing the mean stage by the time in days of culture. Copepod survival and developmental rates were analysed by one way analysis of variance (ANOVA) followed by post hoc analyses using Tukey test. Naupliar survival was significantly ($p<0.01$) lower in treatment that received *Dunaliella* (SR 4.7%) having no DHA and no EPA but did not differ significantly among the other three treatments (SR 45.7−49.7%). Only copepods that received *Pavlova* (DHA+EPA) or *Isochrysis* (DHA only) survived to C-VI stage and no copepods in the other two treatments survived to C-VI stage. However, developmental rates were not significantly different among treatments. In the second experiment where copepods received DHA throughout the naupliar stages (fed with *Pavlova*) but deprived of DHA (fed with either *Nannochloropsis* or *Dunaliella*) during copepodite stages, SR were better than the first experiment but were still very poor (5.6−9.1%) compared to the treatments that received either 'DHA+EPA' or 'DHA only' alga. Our study suggests that DHA is the critical molecule for copepod survival and must be supplied throughout the naupliar as well as copepodite stages and perhaps beyond.

Early embryonic development of the mangrove crab *Perisesarma bidens* by artificial insemination from the Okinawa Island, Japan

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There are few studies on the embryonic development of brachyuran crabs, whereas other groups of decapod crustaceans have received much attention, and their embryology is better documented. Studies on the embryology of brachyuran crabs are recent and have included only a few species from different habitats. On the other hand, studies on artificial insemination and early embryonic development of a dominant mangrove crab *Perisesarma bidens*, as well as most other crabs are almost completely lacking to date. The aim of this study was to explore a technique of artificial insemination and document the early embryonic development of the mangrove sesarmid crab *P. bidens*. The female extruded the eggs into the abdominal cavity within 24-48 hours after copulation. The unfertilized eggs were collected from the pleopods of the female immediately after laying and were stored in 80% filtered sea water (FSW). Sperm were removed from the spermatheca of the same female and diluted in 80% FSW. The unfertilized eggs and sperm were shaken well in a glass beaker for artificial insemination. The eggs were rinsed 3-5 times with 80% FSW after 5 minutes of mixing of sperm with ova. Eggs were incubated in 100ml flat cylindrical culture bottles containing 70ml of 80% FSW at 25°C in a water bath. The fertilization membrane was observed 3-5 minutes after insemination. An average of 65% of fertilized eggs hatched as first zoeae after 17 days of incubation.

The present work is the first report on the successful artificial insemination of *P. bidens*. Results strongly suggest that the fertilization of *P. bidens* is of the moderately internal type that occurs in the abdominal cavity. Females store sperm in the spermatheca, and their release was induced by internal stimuli after egg extrusion into the pleopods of the female. Thus the findings of the present study add a new avenue for managing mangrove ecosystems and biodiversity conservation using artificial insemination of this species. However, more research is necessary to explore the induction of mating so that gametes can easily be collected for artificial insemination in order to facilitate large scale seed production in crab farming.

Growth and economic performance of tiger shrimp in organic culture system: a case study in DOF demonstration pond at Batiaghata Upazilla

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The present study was conducted to observe the growth and economic performance of tiger shrimp (*Penaeus monodon*) in organic culture system. The study was conducted in DoF demonstration farm of Batiaghata Upazilla, Khulna from May to August 2010. The average pond size was 0.2 ha each. Three different treatments (T_1, T_2, and T_3) were tested with three replications for each. PL 20 was stocked with number of 8, 10 and 12/m^2 for T_1, T_2, and T_3 treatments respectively. All the ponds were prepared in standard way and no inorganic substances, chemicals and antibiotics were used during the culture period. Salinity, pH level, dissolved oxygen and temperature was within the culture range. CP feed containing a protein level of about 38% was used in the study pond. PL20 size was fed CP feed (Feed code-2001) 100% of the body weight and feeding frequency 4 times per day.

Effect of supplementary feeds on growth and survival of striped mullets *Mugil cephalus* in outdoor cistern ponds

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Striped Mullet locally called as Khorul bata/Bhangan bata (*Mugil cephalus*, family Mugilidae) is a commercially important high priced fish in Bangladesh and throughout the world.. It is a euryhaline species found in estuarine and coastal regions of Bangladesh throughout the year. Less work on monoculture of Striped Mullet in Bangladesh conducted with little success so, it is more important to investigate the culture technique of the fish to get higher production. Considering this a study was undertaken in BFRI, MFTS, Cox's Bazar to find out the effect of feeding on growth, survival and production of Striped Mullets (*Mugil cephalus*) in pond based culture system.

Good aquaculture practices for the shrimp in Bangladesh

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With its high class protein, essential vitamins and micronutrient contents, the crucial role of fisheries in achieving global or regional food security is well recognized. While global demand for fish is increasing with growing population, marine and inland open water fish production is either stagnated or declining due particularly to overfishing and varied changes in the aquatic environment. The situation has triggered quick expansion of aquaculture. From just three percent contribution in 1950, aquaculture currently contributes an estimated 45% to total global fish production of over 145 million MT. In Bangladesh, aquaculture in 2009-10 accounted for 47% of the total fish production and 80-85% of all fisheries export by value of US$635 million. According to the Fisheries Road Map, aquaculture is to produce 57% of total projected fish production by 2015. Aquaculture employs several million people directly in the aquaculture farms and indirectly in the aquaculture-based industry chain.

Despite its significant economic contributions, aquaculture, particularly coastal aquaculture is often negatively assessed by environmental and social activists. Their main concerns are indiscriminate clearances of mangrove covers, water quality degradation, social problems stemming from forcible obstruction of common property wetlands and flowing rivers and canals for establishing fish or shrimp farms by powerful individuals, salt water intrusion in agricultural crop lands, non-compliance with Labour Law, etc. Besides, many farmers often use various chemicals including pesticides, antibiotics, growth hormones, dyes, etc as disease preventive or curative drugs or growth promoting agents in an effort to increase farm productivity. Many of these medicines and drugs are hazardous to human health. The national and international consumers demand hygienically safe shrimp and fish as per HACCP practices with reliable traceability records. They also demand that the shrimp is produced, processed and marketed in environmentally sustainable and socially responsible manners.

Having given due consideration to the above complaints and consumers' demands, FAO/UN has suggested a number of management principles for responsible aquaculture. Some organizations or countries have designed specific approaches fashioned as Good Aquaculture Practices (JIFSAN), Best Aquaculture Practice (Global Aquaculture Alliance,) etc. Suitably integrating the above management approaches, EU, US FDA requirements, international buyers' preferences and Bangladesh's own rules, BSFF has customized and published a management approach - Good Aquaculture Practices (GAqPs) for the shrimp in Bangladesh carefully incorporating local conditions. Appropriate compliance with the suggested practices may increase farm production in a socially responsible, environmentally sustainable and hygienically safe manner. This will increase access of Bangladeshi shrimp to EU, US and other potential markets and ensure sustainability of the Bangladesh shrimp aquaculture based industry.

Isolation of indigenous probiotic bacteria for application in shrimp aquaculture in Bangladesh

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The emergence of drug-resistant pathogens as a result of uncontrolled use of antibiotics for the treatment of bacterial infections is a major concern for shrimp industries. Probiotics-friendly bacteria with a host of benefits can be an alternative to chemicals and antibiotics uses urging us to isolate some probiotic bacteria from shrimp niches. Six isolates were identified as putative probionts from 96 isolates obtained from rearing environment of shrimp aquaculture in the coastal areas of Bangladesh by using different culture media, both selective and non selective as a rudimentary method. The potential six isolates were selected through a series of methods analyzing their antagonistic activity to target pathogens isolated beforehand and non hemolytic properties to make them safe for mammalian system at least in vitro and cytotoxic effect in vivo using brine shrimp *Artemia franciscana*. They exhibited higher LD50 values compared with others. Four of the isolates, identified as *Pseudomonas* sp. and *Bacillus* sp. exhibited the lowest inhibition against *Artemia* and were considered as safe. Subsequently, in a co-culture experiment it was apparent that the isolated probiotic bacteria were shown to inhibit the growth of target vibrio pathogens due to their antagonistic properties. Considering this, isolated probionts had the capability to exert outcompeting nature against the shrimp pathogens which might have important, economic implications for our shrimp industries that frequently face heavy losses owing to the bacterial infections, and overuse of antibiotics. However, the findings need to be tested in outdoor shrimp ponds of Bangladesh so as to realize the true efficacy of microbial control of bacterial disease in shrimp.

CHARACTERIZATION OF WATERS FROM SHRIMP FARMS IN SOUTHWEST BANGLADESH

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Marine shrimp are cultured supplied with saline water in several nations including Bangladesh. Traditionally it has been conducted in ponds near coastal areas with seawater or brackish water from estuaries. Although this water has adequate salinity for shrimp culture, there may be imbalances of major ions that negatively effect survival and growth of shrimp. There is a general consensus that problems associated with coastal shrimp culture can be avoided. Calcium, magnesium, potassium, sodium, chloride, and sulfate are the most important for shrimp culture. This study was originated to investigate water quality issues of shrimp farms from Khulna and Satkhira district of Bangladesh.

The study area was sited within randomly selected 24 aquifers used in shrimp farming from eight villages of four upazillas in Khulna and Satkhira district. The data was found through field research and chemical analysis of collected water samples. All the data was statistically analyzed where level of significance $p<0.05$ was considered.

The levels of salinity, magnesium, potassium, sodium, chloride and sulfate concentration detected in the water samples of Satkhira district were significantly higher than those of Khulna (Table 1). Conversely, no privileged ion concentration was found in water from Khulna. Conductivity of Satkhira district was observed notably higher than that of Khulna. In relation to this, the salinity intensity was ultimately privileged in Satkhira district. Again, the nutrient indicator phosphorus was also found considerably higher in Satkhira.

The studied ions are involved in shrimp osmoregulation. In comparison the ions to those of seawater held at the same salinity, potassium, and sulfate appear to be deficient. But the results show high cation exchange capacities of water where pH>7 usually where all the factors favor potassium adsorption in water.

TABLE 1. Physico-chemical properties of water samples (mean ± SEM) drawn from Khulna and Satkhira (P<0.05).

Variables	District	
	Khulna	Satkhira
p^H	8.4 ± 0.02	8.06 ± 0.01
EC (mS/cm)	7.51 ± 0.59[b]	10.03 ± 0.61[a]
Salinity (mg/L)	3.71 ± 0.29[b]	5.0 ± 0.31[a]
Ca^{+2} (ppm)	182.13 ± 8.63	199.14 ± 10.51
Mg^{+2} (ppm)	196.81 ± 14.10[b]	249.42 ± 18.26[a]
K^+ (ppm)	20.75 ± 1.82[b]	27.05 ± 1.61[a]
Na^+ (ppm)	639.74 ± 49.09[b]	1181.24 ± 19.49[a]
Cl^- (mg/L)	669.57 ± 55.81[b]	1451.33 ± 294.53[a]
SO_4^{-2} (mg/L)	20.40 ± 1.63[b]	23.70 ± 1.46[a]
PO_4^{-2} (mg/L)	0.56 ± 0.02[b]	0.79 ± 0.02[a]

The data show that highly mineralized waters exist in several shrimp farms. So although shrimp farming is hailed as a possible great source of income for those areas, it presents a risk of salinity intrusion in water.

CHLORIDE CONCENTRATIONS OF COASTAL SHRIMP AQUIFERS IN SOUTHWEST BANGLADESH

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Shrimp farming in Bangladesh traditionally has been conducted in coastal areas supplied with seawater or brackish water from estuaries. Many conflicts have arisen between shrimp producers and other stakeholders because of mangrove destruction, water pollution, and other negative impacts of shrimp culture. Moreover, impaired water quality has had disastrous effects on coastal shrimp farming. Shrimp producers in southwest Bangladesh need assistance with several issues related to water supply and water quality. Chloride concentration is an indicator of the degree of mineralization of water. This study was initiated to explore chloride ion status in surface water used in shrimp farming in Khulna and Satkhira district of Bangladesh.

The study area for this research was located within randomly selected 24 aquifers used in shrimp farming from eight villages of four upazillas in Southwest Bangladesh. Chloride concentrations of sampling water were analyzed following modified Griess-IIosvay method (Banrnes and Folkard, 1951) by visible spectrophotometer at 530 nm.

There was large variation in chloride concentrations of saline water across the twenty four shrimp farms. The calculated average (mean ± SEM) chloride concentration of 999.46 ± 75.23 mg/L for Khulna district and 1353.39 ± 103.41 mg/L for Satkhira district ($p<0.05$), and the data had a range of 237.49 to 1831.23 mg/L (Figure 1). Variation in chloride concentration was extremely great for Khanpur, Noabaki of Shamnagar, Golkhali of Kaligonj and Soladana of Paikgacha upazilla with ranges of 1554.16 to 1831.23 mg/L, 1158.33 to 1424.27 mg/L, 1029.14 to 1187.47 mg/L and 1029.14 to 1266.64 mg/L, respectively. Village Paikgacha had the lowest chloride content saline aquifers with a range of 237.49 to 474.99 mg/L.

In terms of chloride concentration, the villages can be divided into four groups as: 1) Khanpur; 2) Noabaki, Golkhali and Soladana; 3) Kakshiari and Shopalakathi; and 4) South Chakundia and Village Paikgacha. The saline aquifers in Soladana, Golkhali, Noabaki and Khanpur occurred in a narrow band extending from northeast to southwest through the three upazillas.

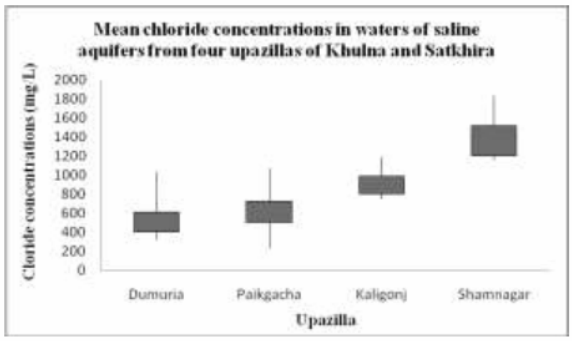

FIGURE 1. Mean chloride concentrations in surface water of saline aquifers from four upazillas of southwest Bangladesh.

Chloride concentrations in some of the studied aquifers suggest that waters would be too saline. As other ionic proportions are not changed, the saline water should be diluted before using for shrimp culture.

Present status of good aquaculture practices (GAP) in shrimp ghers of Satkhira, Bangladesh

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The present study was conducted to assess the current status of Good Aquaculture Practices (GAP) in shrimp ghers of Shyamnagar and Kaliganj upazila in Satkhira district, Bangladesh. Data were collected from randomly selected 54 shrimp farmers by interview using a well structured questionnaire, arrangement of Focus Group Discussion (FGD) and Crosscheck Interviews (CI) with Key Informants. The study reveals that in Shyamnagar upazila, 61% shrimp farmers use the land for rice cultivation using alternative method. During the culture period, most of the farmers use many types of chemicals. Among the farmers, 81% treat their land with chemicals before shrimp culture. In Kaliganj upazila, 75% farmers use the land for rice cultivation and 29% shrimp farmers treat their lands with chemicals before shrimp culture. Among the shrimp farms, 42% of located near ring toilets in Shyamnagar the figure for Kaligonj is 18%. Due to the presence of excessive bushes on the dike, various types of pesticides used for controlling in which 35% (Shyamnagar) and 25% (Kaliganj) used banned chemicals eg. Sumithine and Thiodine. For disease control in Shyamnagar and Kaliganj upazila, 19% and 18% farmers use chemicals (lime, Sumithine and Thiodine) respectively. In Shyamnagar, 92% farmers use formulated brand feed (Aqua-P) whereas only 18% farmers use it in Kaliganj. In both Shyamnagar and Kaliganj upazila, no farmers know the proper way of harvesting, scientific holding system of shrimp and appropriate ration of shrimp and ice for preservation. They do not preserve the harvested shrimp for long time transportation to depot. Most of the farmers are unconscious about their personal hygiene and good management plan. No farmers were found to have any knowledge about Good Aquaculture Practices (GAP), which is a prerequisite condition in HACCP implementation at cultural stage. The study reveals that the shrimp farmers do not follow the EU recommended rules and regulations of Good Aquaculture Practices (GAP) properly which is a prerequisite for HACCP implementation at culture stage.

Mangrove and aquaculture: aspects of climate change adaptation in the central coast of Bangladesh

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Coastal aquaculture has been expanded rapidly over recent decades representing an increasing percentage to meet the growing fish protein demand. Present study was carried out at Feni-Noakhali coastal area, a centrally exposed coastal part of Bangladesh and aimed to assess the aquaculture area, measure the spatial distribution of mangrove forest with analyzing the role of mangrove forest in mitigating climate change vulnerability. Data was collected by using structured questionnaire, focus group discussions and field observations. ASTER satellite image was analyzed for geo-spatial distribution of mangrove forest and aquaculture ponds. ENVI and ArcGIS software's were used for satellite image interpretation and land use mapping. The study identified 3451 ha mangrove forest and 1694 ha aquaculture ponds which was consistent with field verification. Intensified aquaculture of carp, tilapia and shrimp has been practiced with 2-3 crops/year. Calculated yearly total production was about 15,300 MT with good economic return. The goods and services of mangrove ecosystem have been recognized by the local residents in the form of building materials, fuel wood, grazing land, foot bridge, fishing pole, fencing materials and household furniture. Moreover, mangrove is referred as natural barrier against natural disasters, particularly it reduces the wind and wave driven power of tropical cyclone and tidal surges as mentioned by the elderly people. Fish farmers prefer mangrove sheltered zone and reluctant to exposed zone to develop new fish ponds. Presence of mangrove ecosystem provides better way of life to fish farmers with climate change adaptations.

GIS and remote sensing database for spatial decision support for sustainable shrimp culture in southwest Bangladesh

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Southwest coastal region of Bangladesh has experienced a rapid expansion in shrimp farming. Availability of coastal land and water, successful transfer of hatchery technology and increased export demand led to this expansion. The rapid development of shrimp culture has been accompanied by many controversies and it demands a closer look at the environmental and socio-economic impacts including large-scale degradation of agricultural areas, acidification, salinization of ground water, pollution of agricultural land and coastal waters by farm effluents, loss of hundreds of indigenous species and subsequent loss of goods and services generated by natural resource system. Shrimp culture has itself been affected adversely by poor water, seed and feed quality, disease etc. that lead to reduced productivity and in some cases abandonment of shrimp farms. The major step for scientific and sustainable development of shrimp culture is better site selection. Remote sensing integrated with GIS can play a major role in sustainable shrimp culture development. These tools help proper site selection by considering the impact of other land use activities like agriculture, protected areas like sanctuaries, human uses, etc. that are part of the same ecosystem. A systematic and scientific research work had been undertaken in three coastal districts of Bangladesh, and GIS, remote sensing and ancillary data were collected. Base map was prepared and visual interpretation of the images was performed using the most important diagnostic characteristics. Through this study a spatial (GIS) database has been prepared and most, moderately and less suitable areas of shrimp culture were calculated for Shyamnagar as 9309, 19257, and 9104 ha respectively while the areas for Paikgacha and Rampal were 9954, 8919 and 6776 ha, and 6403, 8617 and 8867 ha respectively.

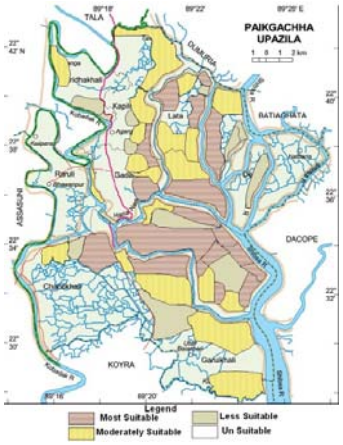

Fig. 1. Suitable areas of shrimp culture

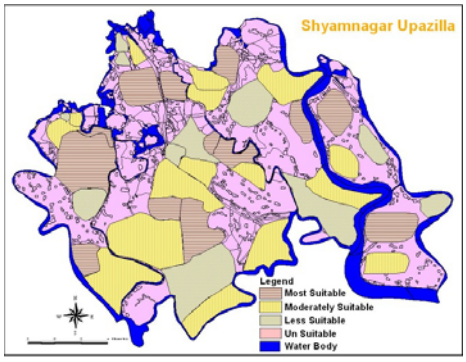

Fig. 2. Suitable areas of shrimp culture in Shyamnagar, Satkhira

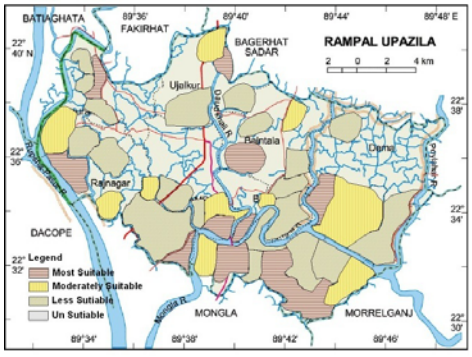

Fig. 3. Suitable areas of shrimp culture in Rampal, Bagerhat

Catch composition for main marine shrimp species in Bangladesh

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Yearly total catch and trends of catch composition for major marine shrimp species were evaluated from the landing data by the commercial shrimp trawlers fishing in the four major fishing grounds within the exclusive economic zone (EEZ) of Bangladesh. Data set were collected from the landings for the year of 1986-87 to 2010-11 and total catch, catch per unit effort (CPUE), and percent contribution and tendency of catch composition and amount of finfish as bycatch were calculated accordingly. Total numbers of shrimp trawler engaged in shrimp catch and finfish as bycatch were varied between 31-48 and also fishing days fluctuated from 4,581 to 7,866. The total shrimp catch fluctuated from 2138 to 4830 MT for the year of 2006-07 and 1988-89, respectively and finfish bycatch fluctuated from 1836 to 6157 MT. The contribution of brown shrimp was highest for entire study period and varied between 53-72% of the total catch. On the other hand white shrimp contributed lowest portion (1-13%) of the total catch. The CPUE for tiger shrimp, brown shrimp and Indian white shrimp varied between 23-89, 191-465 and 7-65 kg d^{-1}, respectively. The highest CPUE of 465 kg d^{-1} (65.4% of the total catch) was observed in the year of 1990-91 by the contribution of the brown shrimp. The percent contribution of tiger shrimp was decreased slowly but increased in case of brown shrimp and for Indian white shrimp the contribution was stable. The total shrimp and fish catch decreased from the beginning to the end of time period. Policy measures can now take into account these values for sustainable fisheries resource management in the Bay of Bengal and justify a sufficient investment in this sector in the interest of current and future generations.

Physico-chemical characteristics of river sediments of the Sundarbans mangrove forests, Bangladesh

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The study was carried out to determine the physico-chemical characteristics of sediments of the three major river systems Rupsha-Passur (R-P), Malancha-Arpangachia (M-A) and Baleswar-Bhola (B-B) of the Sundarbans Mangrove Forests, Bangladesh during September 2010 to May 2011. Bottom sediment samples were collected from intertidal zones during low tide condition. During analysis, pH of the sediments was from 6.48 to 7.79. Electrical conductivity ranged from 1.34 to 30.14 dS/m. Sodium (Na) showed unusual concentration ranging from 9.9 to 74.45 meq/100g soil. Organic matter of the sediments was 0.36% to 2.84% and total nitrogen concentration was from 0.02 to 0.14%. Cation Exchange Capacity was 6.16 to 18.9 meq/100g soil. Among heavy metals Cu, Zn and Mn was found in the range of 2.26 to 6.98, 0.46 to 0.97 and 11.2 to 59.5 µg/g soil respectively. Silt loamy, clay loamy and sandy clay loamy soil was found dominant in the eastern, central and western river system respectively. The concentrations of different parameters were significantly higher in the downstream than the upstream. The tendency follows post monsoon < dry winter <Pre-monsoon. Study result suggests that the physico-chemical properties of bottom sediments of the major river systems of the Sundarbans are influenced by seasonal and spatial variations. The data generated from this study will guide potential restoration and management of river ecosystems of the unique Sundarbans Mangrove Forests, Bangladesh.

Promoting sustainable coastal aquaculture in Bangladesh (ProsCAB)

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Through DFID funded projects, technologies for crab fattening, mollusc culture, seaweed culture, improved fish icing and drying and associated value chain analysis, storage and transportation were developed with community partners. The five technologies such as crab fattening, mollusc culture, seaweed culture, fish icing, and improved fish drying are easily manageable and affordable by poor coastal communities and there are potentials for up-scaling. Using these simple technologies, the livelihoods of coastal low-caste Hindu *Jaladas* (fishers), poor Muslim fishers and ethnic tribal (*Rakhaing*) communities depended mainly on fishing, and fish related activities may be improved. The potentials of upscaling of the technologies through community participation and their impacts on poverty alleviation and employment generation were looked into through a Research Into Use (RIU) project. During the ProSCAB initiative of three years from July 2008 to June 2011, more than 5000 community partners from four agro-ecological zones along the coast were addressed. An initial core of 1000 households were trained and equipped with technical, and business skills. All partners tested and improved five technologies in 34 villages of 11 Upazilas under 5 coastal districts within the first 2 years. Thus, the production and marketing practices were extended to an additional 4000 households. Through the efforts of the ProSCAB research team, crab culture was introduced into the Southeast Cox's Bazar region and it was expanding there rapidly. Crab cages with large multi compartments have been giving better results compared to small multi compartments. Therefore, designs of cage have been modified from small multi compartment to big multi ones.

ProSCAB has been supporting crab fattening in the project areas at southeast and southwest coast of Bangladesh. Hundreds of HHs people, particularly women have taken up the technology and have been getting benefits from crab fattening. In most of the cases, the juveniles and adults crabs for fattening are the by-catches of fishermen's catch. However, collection of seeds for crab culture is becoming a concern for nature and the natural stock may suffer over-exploitation. It is now the peak time to establish crab hatchery in the crab fattening areas. While three popular mollusc species are available in this country and technologies of their culture are available, there are risks of poaching of mollusc rafts in the coastal pockets that inhibited further expansion. Under the ProSCAB, production of seaweed was initiated. The partner NGO – COAST and a few others - PKSP, CWE, COAST successfully promoted uses of seaweeds in the Cox's Bazar and Teknaf areas through panel test and exhibition. The ice box designed and promoted by ProSCAB received wider appreciation among the fish retailers, depot holders and other intermediaries because of its durability and cheaper value. The retailers outside OGs (occupational groups) are using ProSCAB-designed ice box for fish preservation and transportation. Local manufacturer are producing the ice box according to the design of ProsCAB. Pesticide-free fish drying technology using solar dryer have been taken up by a number of private entrepreneurs in both regions. The product produced through ProSCAB OGs has received greater acceptance by the consumers in Dhaka and Chittagong. Several linkages have been developed with affluent outlets of local and city based exporters to market the products. Largely through the three and half years activities of ProSCAB, coastal people are now highly motivated towards crab fattening, pesticide-free fish drying and fish transportation with icing with cheaply made baskets.

Food and feeding habit of *Plotosus canius* in the coastal water of Bangladesh

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Plotosus canius, commonly known as 'Sagar Magur', 'Samudra Magur', 'Kaoir', 'Koir Mach', etc., is found in different coastal areas of Bangladesh, especially in the mangrove estuarine area. For the food and feeding habit study of *P. canius,* a total of 96 individuals were collected from commercial behundi jal, long line and hook line catches of the Southeastern part of the Bay of Bengal. Monthly sampling was done from July **2009** to June **2010**. Study showed *P. canius* to be a predatory carnivore right from its fingerling stage. The major food items found in the stomach was crabs, shrimps and diatoms. Crab was found to be the prime food of *P. canius* by occurrence, volumetric measurement and index of preponderance. The food and feeding habits revealed that *P. canius* was a mangrove habited species.

Production of chitin and chitosan from shrimp shell wastes

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Chitin is a macro-molecular linear polymer of anhydro N-acetyl glucosamine (N-Acetyl, 2-Amino 2-Deoxy D-Glucose) and chitosan is deacetylated chitin. Both chitin and chitosan have very wide industrial applications in more than 200 different fields in Bangladesh like paper, textiles - sizing, dyeing and printing, chromatography, water purification, effluent treatment, cosmetics, drugs, pharmaceuticals, surgery and many others. The demand of these chemicals is fulfilled by import from other countries. Present study explains the production and purification possibility of chitin and chitosan from indigenous sources.

For production of chitin, fresh shells of *P. monodon* having initial bacterial load of $>10^5$ CFU/g sample and peroxide values of >10 mmol free iodine liberated /kg of oil were washed with dilute sulphuric acid. Adhered proteins were removed by washing with low strength alkaline solution and rinsed with water. Crude chitin thus prepared was treated with concentrated hydrochloric acid and purified chitin was obtained after treating with low strength alkali solution. Water soluble chitosan was prepared by performing a deacetylation process using 50% NaOH (w/w) at 100^{o}C for 4-5 hours. Finally, chitosan was washed, dried and ground.
For purification of chitin and chitosan, a series of experiments were conducted to optimize the level of NaOH concentration and time and temperature schedule of demineralization and deproteinization / deacetylation. A high temperature-short time schedule obtained best quality chitin and chitosan. Quality of chitin and chitosan and their purity was tested by both subjective and objective methods.

Comparative studies between the quality of products from different components of the shell and from different shrimp/prawn species showed that both chitin and chitosan obtained from *M. rosenbergii* shell were better compared to those of *P. monodon* in terms of extractibility, deacetylation and colour. Shells obtained better product compared to shrimp appendages. Processes developed for chitin and chitosan were refined and field validated in the shrimp/prawn processing plants of Khulna and Cox's Bazar. A simple cost of production and profit analysis was done at factory production level. Study suggests that chitin and chitosan could be produced in existing shrimp/prawn processing plants of the country with simple renovation.

Nutrient enrichment of popular food products utilizing shrimp processing plant wastes

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The fish processing industry produces a huge quantity of shrimp/prawn shell wastes in Bangladesh during processing the exportable frozen products. Presently, these wastes are dumped outside the plant causing serious environmental pollution. The proximate compositions of these shrimp shell wastes were determined and the dried forms of wastes were incorporated in some popular food products, *viz.*, crackers, loaves and croquettes, in order to investigate the possibility of nutrient fortification. Shrimp/prawn processing wastes (head, shell, appendages, antenna, etc.) transported in ice were thoroughly washed with cool freshwater, dried at 45^{o}C in a hot air electric oven, pulverized and kept refrigerated and used as nutrient supplement to the products. Standard recipes were used for the preparation of crackers, loaves and croquettes and variable levels (3, 5, 10, 20%) of dried shrimp shell powders (SSP) were incorporated. The quality of the products was evaluated by sensory (texture: crispiness for crackers, softness/firmness for loaves and chewiness/rubberiness for croquettes; mouth-feel; colour and flavour), biochemical and microbiological methods. Increasing the quantity of SSP in the products increased the protein and lipid contents but the quality in terms of texture, taste, color and flavor was decreased. Using of 10% SSP obtained the best quality shrimp crackers, in terms of both protein enrichment and sensory quality. Best quality shrimp loaves and shrimp croquettes were obtained with incorporation of 5% SSP. Crackers made with 10% SSP and packaged in air-tight polyethylene zip-loc had an acceptable bacterial load at 4^{o}C up to 45 days but in room temperature (28±1^{o}C) up to 30 days, while shrimp croquettes made with 5% SSP had an acceptable bacterial load in refrigeration (4±1^{o}C) for up to 10 days and in frozen storage (-20^{o}C) for more than 30 days.

Consumers' acceptance tests for shrimp loaves, crackers and croquettes were conducted with a total of 75 rural, coastal and urban people. Percent response of people in terms of taste, flavour, colour and overall acceptability were slightly higher ($p>0.5$) in case of loaves compared to crackers and croquettes. The taste, overall acceptability, colour and flavour of loaves were preferred ($p<0.5$) by the people irrespective of age, sex and occupation. Among the occupational groups, students and service holders liked the products much compared to other occupations ($p<0.5$). In-vitro digestibility test of SSP with standard enzyme-mix found 90-93% digestibility of these shell components. The study revealed that nutrient-enrichment of shrimp crackers, loaves and croquettes could be possible by utilizing dried powders of shrimp/prawn antennae and appendages.

Assessment of post harvest quality loss in four fish species

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Small-scale fisheries sector in Bangladesh suffers from serious post-harvest loss every year due to ignorance and negligence of the people involved in different steps from the harvest to retail distribution. A method was proposed for direct estimation of the quality loss of wet fish using a sensory based fish freshness assessment tool. The sensory assessments were conducted on four fish species (ruhu, *Labeo rohita*; ilish, *Tenualosa ilisha*, Thai pungus, *Pungasius stuchi*; and tilapia, *Oreochromis niloticus*) in different steps of their major distribution channels throughout the country for a year from March 2009 to February 2010 to find out the seasonal and spatial variations of quality loss. In order to standardize the sensory defect points (DPs) of fishes obtained at the field, some biochemical and microbiological quality indicators of wet fish post-mortem were studied corresponding to each sensory DPs. A quality loss index was determined to estimate the percent quality loss of fish at any step of distribution channel.

Most of the fishes did not loss their quality when they were in the fishermen, landing centers or commission agents in primary fish market, except *T. ilisha* destined for consumer market, where a 2% and 5% losses were recognized in landing centers and commission agents, respectively. *T. ilisha* used for salting during glut catch suffered a substantial loss while they were in the fishermen (14%) or in landing centers (43%). Most of the quality losses were found to be initiated at the transporters/wholesalers, from 4% in *P. stuchi* to 11% in *O. niloticus*. When the fish comes to retailers, very high degree of losses, as much as 16% was recognized in *L. rohita* and *O. niloticus*, while it was 7% in *P. stuchi* and 9% in *T. ilisha*. An extreme qualitative loss was however observed in fish vendors, as much as 10-19% in 4 species examined.

Fish vendors are found mostly in cities in small numbers. Therefore, if we consider the retailers as the end point stake in the fish distribution chain, present findings amplify that the range of fish quality loss is 7-16% in 4 major consumed species, in addition to various quantitative losses occurred in wet fish value chain. Quantitative losses should be included in the assessment model to understand the total loss of fish. Based on the results, it is understood that the post-harvest loss in fish is still enormous in Bangladesh that should be addressed with priority.

Efficacy of electrolyzedwater in keeping the freshness of fish

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Eelectrolyzed water (EW) has been used in food industry of USA, Japan and other countries as an effective disinfectant and sanitizing agent to kill bacteria and molds. Common disinfectant of the food industry, chlorinated water (CW), has recently been reported to form carcinogenic trihalomethane when comes in contact with animal cell and for that it is not encouraged to use in fresh food products. EW is produced by a electrolysis device adding 0.1-0.2% NaCl to pure water, and conducting a current across an anode and cathode. The cathode area produces alkaline (pH: 9-11) reducing water while the anode area produces acidic (pH: 2.3-2.7) oxidizing water. Bamboo and garlic are also considered to have bactericidal and preservative properties. In this experiment the efficacy of EW and two herbal extracts, *viz*, bamboo and garlic, on the freshness quality of Pacific mackerel (*Scomber japonicus*), horse mackerel *(Trachurus trachurus)* and oil sardine (*Sardinella longiceps Valenciennes)* was investigated.

Fishes were treated with EW, EW-mix (electrolyzed water - bamboo extract - garlic extract), bamboo extract and garlic extract. Various combinations of mixture were used. To compare the efficacy of EW as replacement of chlorine compound, treatment effects of sterile distilled water, plain tap water and CW were investigated. Fishes were dipped in either of the mixtures or individual liquid for variable time period (0, 1, 3, 5, 10, 15 up to 30 minutes) with agitation (150 rpm) and then rinsed with sterilized distilled water for 1 min. Treated fishes were kept under different temperature-time schedules. Bacterial samples were taken by wet sterile cotton from 1 cm^2 area on the back surface behind the pectoral fin, along the lateral line. Aerobic plate count was done as per standard procedure. Physical quality of the muscles and the freshness of fish were measured through sensory based fish quality assessment tool.

Three disinfectant solutions *viz*, EW (50 ppm Cl^-), CW (50 ppm Cl^-) and EW-mix (EW : bamboo extract : garlic extract :: 60 : 1 : 1) were found to be very effective in reducing aerobic plate count (APC) in wet fish at 25^oC. Fishes treated with EW and CW showed similar level of keeping quality and freshness in terms of bacterial load, physical appearance, texture and colour compared to other disinfectant solutions. The skin of the fish was damaged by EW-mix and garlic extract, while the physical and sensory qualities of fish were lost when compared to those treated with EW and CW. The results suggest that EW can be effectively used as a replacement of CW to extend the shelf life of wet fish during distribution and marketing in both ambient and refrigerated temperatures post-mortem.

Application of two herbal pesticides as the replacement of harmful chemical pesticides in dry fish

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The efficacy of turmeric and neem on repelling a dry fish beetle, *Dermestes sp*. was investigated and field doses were determined on the basis of insect repellency, insect occurrence and sensory qualities of treated dry fish. Turmeric and neem extracts were applied to the dry fish at the rate of 2, 3 and 4%, and 3, 5 and 7% respectively. Both powders were applied at the rate of 1.0, 1.5 and 2.0% and pellets at the rate of 1, 2 and 3 pieces per 100 g dry fish. Adult beetle showed highest repellency, while larvae showed mere resistance upon the two herbs. The order of repellency among three products were: extract> powder> pellet. Turmeric in all forms were more repellent than those of neem. The color, odor, texture and general appearance of the control and treated dry fish were almost similar within 2 month of room temperature storage. After 4 month, sensory quality and occurrence of insects in control dry fish fell down significantly ($p<0.05$) but those in treated dry fish were mostly unchanged. Turmeric extract at the rate of 3%, turmeric powder at the rate of 1.5% ($p<0.5$) and neem extract at the rate of 5% and neem powder at 1.5% ($p<0.5$) were found to be effective field doses for repelling dermestid beetle in dry fish.

Traditional fish drying activities and socio-economic status of dried fish processors of Chalan *beel* area, Sirajganj

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Present study was conducted on traditional fish drying activities at different fish drying points of chalan beel area at Tarash upazila under Sirajganj district from July 2009 to December 2009. There were nine fish drying points in the study area and twenty one fish species were identified for drying in the study area. Most of the fish drying points were operated seasonally (from July to March). Raw fishes were collected from local fish market or landing centers. Transportation of raw fish was done by non-mechanized van, rickshaw, or by head load of the labour. The peak period for drying was September-October. The rate of mixing salt in the study area was found as 1kg salt for 13 kg of raw fish. At normal weather, the drying duration was recorded as 2-6 days depend on the size of the raw fish. Plastic, jute sack and sometimes bamboo baskets were used for packaging purpose. All the dried fish products of the study area carried to the Sayadpur dry fish wholesale market in Nilphamary district. Among the dried fish processors 44.19% were genuine and 48.57% were belonging to age group above 40 years. 85% dried fish processors were Muslim and remaining 15% were Hindus. Literacy level was found poor (37.15%, from primary education to higher secondary). 12.50% dried fish processors were found landless whereas majority 30% were found with 0.001-0.668 ha land. Average monthly income was found to be varied between BDT 2000 and BDT 15000. About 70.50% respondents invest their own capital for fish drying purpose.

Post-harvest loss in traditionally smoked shrimp in south western region of Bangladesh

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Post-harvest loss in the pre-processing, production, distribution, marketing and storage of traditionally smoked shrimp in the South Western region of Bangladesh was determined through a loss assessment tool based on questionnaire interview of the people involved in raw material handling to product marketing and storage and physical and chemical properties of the raw materials and products. Smoked shrimp from three different species *viz.* Horina (*Metapenaeus monoceros*), Chaka (*Penaeus indicus*) and Chali (*Metapenaeus brevicornis*) were studied. The overall quality of the traditional smoked shrimp products available in the markets was very poor. The moisture content of traditionally smoked shrimp ranged from 14.54 ± 1.08 to 32.34 ± 0.26 % with the highest value found in Horina. The protein contents in the smoked Horina, Chali and Chaka were between 41.22±0.042 and 60.81 ± 0.031 %, 45.83±0.038 and 65.16 ± 0.031% and 44.37±0.043 and 62.42 ± 0.031%, respectively, while the lipid content were ranged from 8.18±0.031 to 8.94±0.031%, 7.74±0.037 to 8.62±0.038 % and 9.29±0.031 to 9.34±0.036%, respectively. The TVB-N value of traditionally smoked Horina, Chali and Chaka were ranged from 15.75±0.37 to 36.48±0.37 mg/100g, 17.58±0.42 to34.61±0.36 mg/100g and 16.03±0.02 to 35.29±0.36 mg/100g respectively.

Qualitative loss in raw material shrimp was 5.8%. Other qualitative losses (pre-process and in-process loss) were also very little. Therefore, this type loss in final product was also very less (10%). Most of the quantitative loss was found in the storage (18.7%) and during marketing (7.9%). Simultaneous drying and smoking process made product fragile and susceptible to breakage. Rostrum, legs and appendages were found to be broken down and lost during storage and marketing. One of the major losses encountered during storage was discarding due to mold infestation caused by reabsorption of water from the air. This also happened during marketing, because both production and marketing of smoked shrimp are done in monsoon months. In combination of such losses, the total quantitative loss in smoked shrimp was calculated to be more than 30%.

Table 1. Post-harvest quality loss in Smoked shrimp

Quality loss during processing (%)			
Raw material	Pre-process	In -Process	Final product
5.8±0.5	9.0±0.6	10.2±0.6	10.0±0.3

Table 2. Post-harvest quantitative loss in smoked shrimp

Quantitative Loss (% weight loss) during distribution & marketing				Total quantitative loss (%)
Packaging	Transportation	Storage	Marketing	
2.0±0.3	2.3±0.3	18.7±1.4	7.9±1.8	30.9

Investigation on chloramphenicol and nitrofuran metabolites in fish feed and feed ingredients

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Shrimp culture is of central importance to the fisheries sector in Bangladesh particularly in the context of export earnings. In recent years, EU has rejected many shrimp consignments from Bangladesh, since the products were found to have metabolites of banned nitrofurans and other health hazardous chemical contaminants. The presence of nitrofurans and other chemical contaminants in shrimp/fish products is of great concern to Bangladesh export sector. The study was conducted to identify nitrofuran metabolites and harmful chemicals like chloramphenicol in shrimp, fish, poultry feeds and feed ingredients through analysis of samples in LC MS/MS machine.

A total of 86 feed and 74 feed ingredients from different commercial fish feed companies in Bangladesh were analyzed for detecting nitrofuran metabolites (AMOZ, AOZ, AHD and SEM) and chloramphenicol. It was found that (38) thirty eight samples were non-compliant among which (11) eleven were shrimp feed, (10) ten were fish feed, (8) eight were poultry feed and (9) nine were feed ingredients. The highest amount of 8.25 ppb SEM was detected in "Shrimp feed starter-Saudi-Bangla Fish Feed" followed by SEM 6.73 ppb in Quality feed-golden grower and 6.23 ppb for Sunny fish feed. For poultry feeds, highest level of SEM 2.82 ppb was detected in Kazi Poultry Feed collected from Fakirhat of Bagerhat district. In case of feed ingredients 3.89 and 2.89 ppb of SEM were detected in imported "Indian oil cake-1" and protein concentrates Croatian Super Meat and Bone Meal, respectively. Samples collected from Bagerhat, Khulna and Jessore districts showed 50, 29 and 11% non-compliance, respectively.

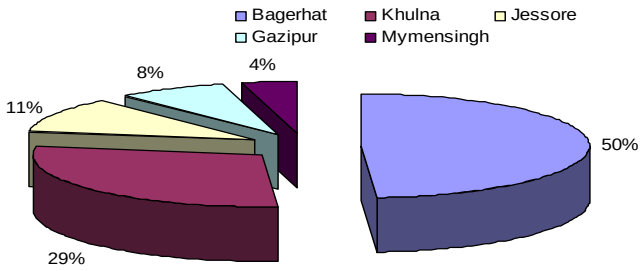

Fig. 1. Percentage of non-compliant feed and feed ingredients in study areas.

INVESTIGATION ON SUITABLE SALT CURING METHODS FOR HILSHA *Hilsha ilisha* AND OLIVE BARB *Puntius sarana*

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In Bangladesh dried salted fish is an important source of low-cost dietary protein. Salting and drying are the most common methods of fish preservation. Sun drying is difficult during continuous spell of rain particularly in the sub-tropical zones. In addition, sun drying is not suitable for fatty fishes due to rapid development of rancidity on being exposed to the sun. Therefore, salting is the only available method to preserve fish in Bangladesh.

Dry, pickle, brine and combination of dry and brine-salting methods were applied to hilsha (*Hilsha ilisha*) and olive barb (*Puntius sarana*) for 8 days and 2 days respectively and data was statistically analyzed where $p<0.05$ was taken.

The other nutrients except moisture were higher in salted products than those of fresh ones for both fish. In hilsha, the fat content decreased significantly after salting but it was more or less similar in fresh and salted sarpunti. The average percentage of moisture, protein and fat contents of mixed salted hilsha were significantly higher than those of commercially salted fish but drastically lower than raw hilsha, while the average protein and fat contents in mixed salted sarpunti were appreciably higher than those of commercially salted fish but considerably lower than raw fish.

In hilsha, Ca contents was maximum in mixed salted (114.45 ± 1.45 mg/100g) and slightly higher fish than that of commercially salted (105.47 ± 1.16 mg/100g) product, whereas P and Fe contents (mg/100g) were more or less similar in both laboratory (193.2 ± 1.40 and 1.37 ± 0.13) and commercially (192.8 ± 1.75 and 0.69 ± 0.12) salted hilsha. On the other hand, in sarpunti, P and Fe contents (mg/100g) were more or less similar in both laboratory (124.09 ± 1.37 and 2.19 ± 0.27) and commercial (122.09 ± 1.42 and1.18 ± 0.26) scale whereas Ca content was significantly higher in salted laboratory products (444.13 ± 0.83 mg/100g) than commercially (348.52 ± 32.22 mg/100g) salted sarpunti.

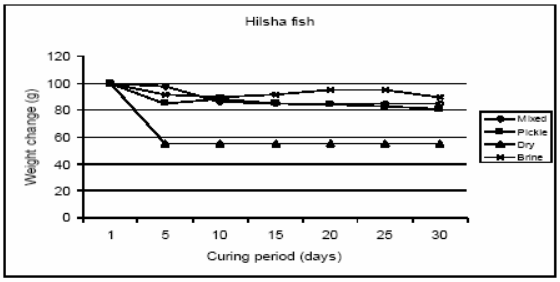

Figure 1. Line diagram of weight change during the period of different salt curing of hilsha fish.

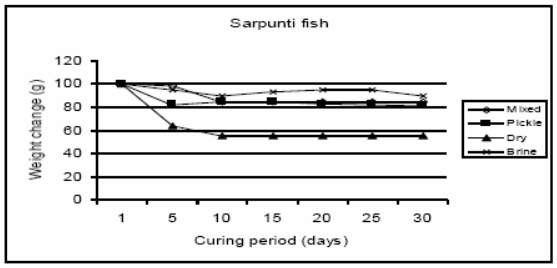

Figure 2. Line diagram of weight change during the period of salt curing of sarpunti fish.

The time required for producing the products of four salt curing methods which was considered determining their performances (Figures 1 and 2). On the basis of quality and performance the four salting methods can be arranged as follows: Mixed > Dry > Pickle > Brine.

Comparative analysis on microbiological status between raw and frozen freshwater prawn (*Macrobrachium rosenbergii*)

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The present study of microbiological assessment was carried out to detect the health hazard microbiological status in raw (head on, shell on) and frozen product of freshwater prawn (*Macrobrachiam rosenbergii*) and to make comparison between them on the point of microbiological load at fish processing plant "ARK Sea Foods Ltd." in Chittagong, Bangladesh during June to November, 2011. The microbiological quantity of total bacterial load, total coliform, faecal coliform, *Salmonella* spp., *Vibrio cholerae* were determined with three different samples of raw and frozen product of freshwater prawn (*Macrobrachiam rosenbergii*). For this purpose, microbial status of raw freshwater prawn (head on, shell on) and frozen freshwater prawn were assessed. In the present study, total bacterial load (Aerobic Plate Count) of raw freshwater prawn (head on, shell on) was $4.37 \times 10^5 \pm 0.328 \times 10^5$ CFU/g whereas in frozen freshwater prawn was $1.42 \times 10^5 \pm 0.187 \times 10^5$ CFU/g respectively (Table, Figure-1). However total coliform of raw freshwater prawn and frozen freshwater prawn were 37.65 ± 13.32 MPN/g, 4.23 ± 0.95 MPN/g, respectively (Table, Figure-2). In raw samples of freshwater prawn, the MPN count of total coliform per gram of sample ranges from 21 to 64, the values varied too much. That's why the mean value of raw samples in case of total coliform is varied largely more than others. Meanwhile, faecal coliform of raw freshwater prawn (head on, shell on) and frozen freshwater prawn were 3.33 ± 1.85 MPN/g, 2.20 ± 1.11 MPN/g, respectively (Table, Figure-2). Furthermore *Salmonella* spp. and *Vibrio cholerae* were totally absent from raw and frozen freshwater prawn (Table). The above mentioned data were under the limit of international standard. The result of the present study revealed that the raw lots of freshwater prawn be bought which were processed finely and the frozen prawns were excellent for exporting.

Table-MPN/g (Mean ± SEM) count of Aerobic Plate Count, total coliform, faecal coliform, *Vibrio cholerae* and *Salmonella* spp. detected in three samples of raw and frozen product of freshwater prawn.

Types of microbial assessment	Sample(Frozen Prawn) (Mean ± SEM)	Sample(Raw Prawn) (Mean ± SEM)
Aerobic Plate Count (CFU/g)	$1.42 \times 10^5 \pm 0.187 \times 10^5$	$4.37 \times 10^5 \pm 0.328 \times 10^5$
Total Coliform (MPN/g)	4.23 ± 0.95	37.65 ± 13.32
Faecal Coliform (MPN/g)	2.20 ± 1.11	3.33 ± 1.85
Vibrio cholerae	Nil	Nil
Salmonella spp.	Nil	Nil

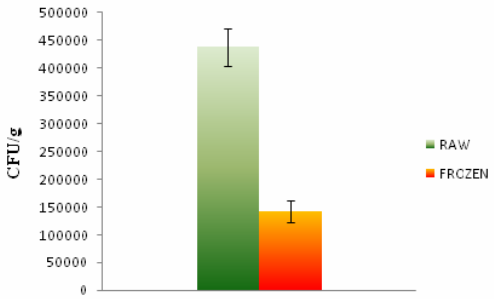

Figure-1. Difference on Aerobic Plate Count (Mean ± SEM) between raw and frozen samples.

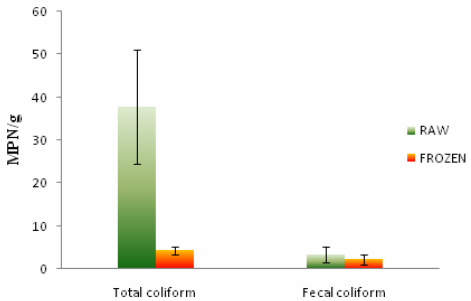

Figure-2. Difference on total coliform and faecal coliform between raw and frozen samples (Mean± SEM).

Microbiological quality assessment of raw and frozen product of sea bass (*Lates calcarifer*) in a fish processing plant

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The investigation was carried out to detect the health hazard microbes in fish processing plant at "Chowdhury & Co. (BD) Ltd." Chittagong, Bangladesh. The abundance of total bacterial load (Standard plate count), total coliform, fecal coliform, *Vibrio cholerae* and *Salmonella* were determined in raw and frozen product of coral, *Lates calcarifer* in Bangladesh. The extensive of microorganism (standard plate count, total coliform, fecal coliform, *Vibrio cholerae* and *Salmonella sp.*), growth promoters, residues of pesticide and dioxin, antibiotics etc. make fear and unease to consumer about what they eat. Moreover, Bangladesh export fish to developed countries and they are very conscious to their food quality rather than price. As a result, many consignments have been rejected by the EU countries, Japan and USA for not maintaining the EU recommended rules. Therefore, the current study was undertaken to evaluate effectiveness of Hazard Analysis and Critical Control Point (HACCP) in the investigated processing plant. For the microbial analysis, samples were collected from raw and frozen coral fishes. To enumerate Standard Plate Count (SPC), selected samples were investigated at different stages of sample surfaces. In case of raw product of sea bass (coral), the SPC was 3.15×10^5 cfu/gm, 2.80×10^5 cfu/gm and 2.15×10^5 cfu/gm in sample-1, sample-2 and sample-3 respectively whereas in finished product of coral, the SPC was found 1.95×10^5 cfu/gm, 2.05×10^5 cfu/gm and 1.85×10^5cfu/gm, respectively in collected sample. While total coliform observed in coral were 75 MPN/gm, 43 MPN/gm and 28 MPN/gm in sample-1, sample-2 and sample-3 respectively, in finished product of coral total Coliform were found 15 MPN/gm, 20 MPN/gm and 18 MPN/gm, respectively. Fecal coliform in raw and finished product of coral was <3 MPN/gm (Table 1). In case of *Salmonella* sp. and *Vibrio cholera*, both were absent in raw and frozen product of coral (Table 2). All data of each processing stage of the processing plant were under limit of international standard. The result of the present study implies that the hygienic condition of the investigated fish processing plant was good and the quality of coral was excellent for export.

Table 1. MPN/g count of faecal coliform observed in different samples of different process

Sample name	Raw product	Finished product
Sample 1	<3	<3
Sample 2	<3	<3
Sample 3	<3	<3

Table 2. *Salmonella* and v. *cholera* in different samples

Sample name	Raw product (*Salmonella* in 25 gm)	Raw product (*V. cholera* in 25 gm)	Finished product (*Salmonella* in 25 gm)	Finished product (*V. cholera* in 25 gm)
Sample 1	Nil	Nil	Nil	Nil
Sample 2	Nil	Nil	Nil	Nil
Sample 3	Nil	Nil	Nil	Nil

Proximate composition and microbial assessment of smoked hilsha (*Tenualosa ilisha*) with salt, garlic and coriander treatment in laboratory condition

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The present study was conducted to investigate the proximate composition and microbial assessment of smoked hilsha (*Tenualosa ilisha*) with salt, garlic and coriander treatment in Fish Technology Research Station, Institute of Food Science and Technology, Bangladesh Council of Scientific and Industrial Research, Dhaka, Bangladesh during May to October 2011. For making a better flavored ready food item, Hilsha were smoked with different combinations of salt, garlic and coriander and the fishes were grouped into three clusters. One cluster composed of 10% salt, 10% garlic and 10% coriander and treated as Treatment 1 (T-1). Treatment 2 (T-2) composed of 10% salt and 10% garlic. Other part composed of 10% salt only and treated as Treatment 3 (T-3). After smoking and treating with food additives different compositions were found. The compositions are shown in the TABLE. Total viable count was 2.0×10^4 cfu/g for treatment 1, 2.1×10^3 cfu/gm for Treatment 2 and 2.2×10^3 cfu/g. Total coliform was <3 MPN/g for all the three treatments. *Escherichia coli* were found <3 MPN/g for three treatments and salmonella was absent in three treatments. The less moisture percentage of T-2 indicated the less number of bacterial loads. Again the lipid, Calcium and Phosphorus content were the highest in T-2 where TVN value was the lowest. Generally moisture and lipid content shows inverse relationship which is similar to T-2. Among the three treatments, T-2 was found found to be the most palatable after taste. It can be said that T-2 was the best among the three treatments. So, smoked Hilsha with salt and garlic may be the potential food item for national and international market.

TABLE. Bio chemical composition of the smoked Hilsha with food additives

Name of the Treatment	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Salt content (%)	TVN (mg/100g)	Ca (mg/100g)
T-1	39.99 ± 0.16	24.26 %±.39	24.50 %±.39	3.54 %±.29	22.53%±.16	3.80±.21	1.29 ±.11
T-2	39.65 %±.19	25.69 %±.18	24.86 %±.17	3.50 %±.30	23.67(%)±.16	2.58±.10	3.42 ±.11
T-3	40.60 %±.32	25.95 %±.29	24.78 %±.42	3.42 %±.27	16.20%±.14	3.12 ±.20	2.78±.11

BACTERIAL PROFUSION IN INDIAN WHITE SHRIMP *Penaeus indicus* OF TWO DIFFERENT MARKET CONDITIONS FROM DHAKA CITY BANGLADESH

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Shrimp quality might be deteriorated due to improper handling and responsible for causing food borne diseases. Food borne infections and intoxication is a major concern to fish consumer and public health authorities. The use of antimicrobial agents for preventing and treating diseases as well as promoting growth is an important factor in the emergence of antibiotic-resistant bacteria that are subsequently transferred to human via food chain. This study was conducted to assess the microbial profusion in the muscle of frozen Indian white shrimp from different conditions and their susceptibility resistance with a view to provide potential approaches for food safety in regards to food borne diseases.

Frozen shrimp samples were collected 12 in number from three departmental shops and 12 iced shrimp samples from three local markets of Dhaka city 4-5 shrimps were taken in each sample to perform the microbial assessment and data analyzed statistically where $p<0.05$.

The TBC ranged from $2.1 \pm 0.20 \times 10^4$ to $4.7 \pm 0.50 \times 10^5$ CFU/g for departmental chain shop frozen shrimp and $4.2 \pm 0.45 \times 10^6$ to $1.3 \pm 0.50 \times 10^8$ CFU/g for local market iced shrimp. The total coliform count ranged between $1.6 \pm 0.20 \times 10^2$ and $2.1 \pm 0.25 \times 10^3$ CFU/g for the chain shop frozen shrimp and $2.8 \pm 0.30 \times 10^3$ and $7.8 \pm 0.50 \times 10^5$ CFU/g for the retail market iced shrimp. Furthermore, the *Salmonella-Shigella* (SS) count for departmental shop frozen and local market iced shrimp varied from $0.5 \pm 0.0 \times 10^2$ to $1.3 \pm 0.10 \times 10^2$ CFU/g and $0.7 \pm 0.0 \times 10^2$ to $2.1 \pm 0.25 \times 10^2$ CFU/g, respectively. Presence of *Vibrio* spp. was confirmed in 11 samples (5 from departmental chain shop and 6 from local market). In case of antibiotic sensitivity pattern, all of them were resistant to penicillin and bacitracin. Most of the isolates were sensitive to streptomycin, chloramphenicol and kanamycin (Table 1).

TABLE 1. Sensitivity of *E. coli*, *Salmonella-Shigella* (SS) and *Staphylococcus* isolets to different antibacterial drugs.

Strains	Resistant	Intermediate	Sensitive
E. coli-1	P, AMP, E, AML	PG, CN	C, K, S, TE
E. coli-2	P, B, E, PG	AMP, TE	K, CN, S, AML
E. coli-3	E, PG, B, P	AMP, TE	K, C, CN, S
E. coli-4	P, B, PG, E	C, CN, AML	K, S, TE
SS-1	E, PG, CN, TE, S, P	AMP	K, S, B
SS-2	P, S, CN	AMP, AML	PG, TE, K, C, B
SS-3	P, PG, B, TE	Nil	AMP, K, C, CN, AML
SS-4	AML, PG, P, B, TE	AMP, E	CN, K, C
Staphylo-1	AMP, AML, P, B, TE	Nil	C, S, PG, K, E
Staphylo-2	AML, AMP, B, P	TE, K, E	S, K, PG

The results confirmed that the samples of local markets contained high pathogenic bacterial load which are supposed to be threat to food safety creating food borne diseases.

MICROBIAL QUALITY ASSESSMENT OF INDIAN WHITE SHRIMP *Penaeus indicus* FROM SOUTHWEST BANGLADESH

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Shrimp export market of Bangladesh is threatened for low quality of processed shrimp products which might be deteriorated due to improper handling and responsible for causing food borne diseases. Due to the presence of different types of bacteria in frozen shrimps, they may lose their exportability. This study was objected to determine the microbiological abundance in the muscle of Indian white shrimp collected from shrimp farms of southwest Bangladesh where the major share of exported shrimp is produced.

Shrimp samples in fresh condition were collected from Bagerhat, Khulna and Satkhira districts where 4-5 shrimps were taken in each sample to perform the microbial assessment. All the data was statistically analyzed where level of significance $p=0.05$ was considered.

The results show that total bacterial count of all the samples was beyond the acceptable limit 10^5 CFU/g according to International Commission on Microbial Specification for Foods. The shrimps from Satkhira were significantly loaded with bacteria in comparison to other two districts (Table 1). But no substantial difference was found for *E. coli* and total coliform among the districts.

The presence of total coliform indicates the contamination during handling and processing and also from water. In case of *Vibrio* spp, it was found as whole shrimp with gut was taken for analysis. Incidence of *Staphylococcus* and *Salmonella* in shrimp was due to external and environmental contamination. The total fascal coliform counts of normal shrimp indicate that the water or processing vessels were somehow contaminated fascally. The presence of *Salmonella-Shigella* and *E. coli* were detected in all the samples which indicate their unacceptability according to ICMSF.

TABLE 1. Bacterial density (mean ± SEM) of Indian white shrimp from southwest Bangladesh ($p^{=0.05}$).

Bacterial count (cfu/g)	Sources		
	Bagerhat	Khulna	Satkhira
TBC	$6.37 \pm 0.38 \times 10^{5bc}$	$1.88 \pm 0.02 \times 10^{5b}$	$5.83 \pm 0.12 \times 10^{5a}$
TC	$2.83 \pm 0.44 \times 10^{3}$	$4.80 \pm 0.81 \times 10^{3}$	$3.00 \pm 0.95 \times 10^{3}$
Vibrio spp.	$7.47 \pm 0.39 \times 10^{5b}$	$1.70 \pm 0.05 \times 10^{6b}$	$1.59 \pm 0.04 \times 10^{6a}$
Staphylococcus spp.	$3.00 \pm 0.36 \times 10^{5b}$	$3.07 \pm 0.32 \times 10^{5b}$	$4.77 \pm 0.58 \times 10^{5a}$
SS	$2.40 \pm 0.23 \times 10^{4a}$	$2.70 \pm 0.10 \times 10^{4a}$	$1.19 \pm 0.10 \times 10^{4a}$
FC	$1.50 \pm 0.15 \times 10^{4a}$	$2.17 \pm 0.38 \times 10^{4a}$	$2.03 \pm 0.43 \times 10^{4a}$
EC	$3.10 \pm 0.30 \times 10^{3}$	$3.95 \pm 0.46 \times 10^{3}$	$2.05 \pm 0.27 \times 10^{3}$

The results confirmed that high pathogenic bacterial abundance in the samples of shrimp farms from southwest Bangladesh supposed to be threat to food safety and deteriorate the export quality.

Microbiological quality assessment of chapila (*Gudusia chapra*) and tengra (*Mystus vittatus):* a potential export item

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The present study was conducted to determine and quantify the occurrence of various types of micro-organisms in raw and final product of Chapila, *Gudusia chapra* and Tengra, *Mystus vittatus* useful to to enhance food safety with a view to promote international trade and sustainability of indigenous species, SIS and marine fish species of Bangladesh. The abundance of total aerobic bacteria, total coliform, faecal coliform, *Salmonella* and *Vibrio cholerae* were determined in raw and frozen product of Chapila and Tengra. In each process, three different samples were examined. The density of total aerobic bacteria detected in all the samples of raw fishes was relatively higher than the frozen samples. APC of raw product of Chapila in sample 1, 2 and 3 were 3.10×10^5 CFU/g, 2.12×10^5 CFU/g and 2.52×10^5 CFU/g, respectively. Furthermore, APC of final frozen product of Chapila in three samples were 1.19×10^5 CFU/g, 0.97×10^5 CFU/g and 1.01×10^5 CFU/g, respectively (Fig.). Again, APC of raw Tengra in sample 1, 2 and 3 were 2.51×10^5 CFU/g, 1.62×10^5 CFU/g and 1.94×10^5 CFU/g, respectively and APC of final frozen product of Tengra in three samples were 0.91×10^5 CFU/g, 0.75×10^5 CFU/g and 0.87×10^5 CFU/g, respectively (Fig.). While Total coliform observed in raw Chapila was 36.00 ± 2.3 MPN/g, it was 7.2 ± 1.01 MPN/g in frozen product of Chapila. In raw product of Tengra, MPN count of total coliform per gram of sample was 27.00 ± 5.57 and in frozen product, it was 9.4 ± 3.75 MPN/g. Furthermore, the MPN count of faecal coliform per gram of sample of raw Chapila in sample 1, 2 and 3 were 6.2 MPN/g, 3 MPN/g and 3.6 MPN/g, respectively. Again, MPN count per gram of faecal coliform observed in sample 2 and 3 of raw Tengra was 3 MPN/g, while in sample 1 it was 6.1 MPN/g. *Salmonella* spp. and *Vibrio cholerae* were not detected in any of the raw and frozen samples of Chapila and Tengra (Table). In conclusion, the findings of the present study suggest that investigated processed frozen fishes of the fish processing plant were qualified enough for export and frozen fishes was much better than raw fishes from the microbiological point of view.

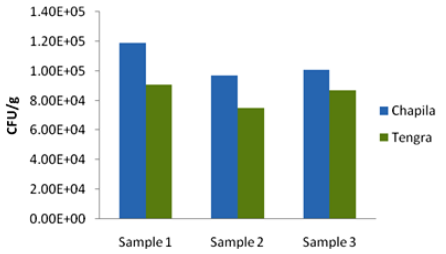

Fig.- Density (CFU/g) of total aerobic bacteria detected in 3 samples of frozen product of Chapila and Tengra.

Table- Amount of *Salmonella* spp. and *Vibrio cholerae* per gram sample observed in 3 samples of raw and frozen product of Chapila and Tengra

Product Name	Condition	Sample 1	Sample 2	Sample 3
Chapila	Raw	Nil	Nil	Nil
	Frozen	Nil	Nil	Nil
Tengra	Raw	Nil	Nil	Nil
	Frozen	Nil	Nil	Nil

Comparative analysis of microbiological status between raw and frozen product of black tiger shrimp (*penaeus monodon*)

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The present study was undertaken on comparative analysis of microbiological status between raw and frozen product of black tiger shrimp (*Penaeus monodon*), and to make a comparison between them on the point of microbiological load in the laboratory of ARK SEA FOOD LTD, Chittagong, from June to November, 2011. During the study period, quantity of total bacterial load, total coliform, faecal coliform, *Salmonella* spp., *Vibrio cholerae* were determined with three different samples. The study represents that, raw (head on, shell on) shrimp contains more microorganisms than frozen shrimp because in raw shrimp, elimination of head and shell was not occurred which contains maximum number of microorganisms of the total body. Total bacterial load (Aerobic Plate Count) of raw black tiger shrimp (head on, shell on) was 4.34×10^5 CFU/g and in frozen black tiger shrimp it was 1.50×10^5 CFU/g (Table, Fig.1). Total coliform of raw (head on, shell on) and frozen black tiger shrimp were 40.00 MPN/g and 4.27 MPN/g, respectively (Table, Fig. 2). Faecal coliform of raw (head on, shell on) and frozen black tiger shrimp were 3.33 MPN/g and 2.00 MPN/g, respectively (Table, Fig. 2). Furthermore, *Salmonella* spp. and *Vibrio cholerae* were totally absent in all the samples of raw (head on shell on) and frozen black tiger shrimp (Table). All mentioned data were under the limits of international standard. From the study it was found that the concentration of bacterial load was below the permissible level and presents no harm to human health.

Table- MPN/g count of Aerobic Plate Count (CFU/g) ,total coliform, faecal coliform , *Vibrio cholerae* , *Salmonella spp.* detected in three samples of raw and frozen product of black tiger shrimp.

Types of microbial assessment	Frozen sample (black tiger shrimp)	Raw sample (black tiger shrimp)
Aerobic Plate Count (CFU/g)	1.50×10^5	4.34×10^5
Total Coliform (MPN/g)	4.27	40
Faecal Coliform (MPN/g)	2.00	3.33
Vibrio cholerae	Nil	Nil
Salmonella spp.	Nil	Nil

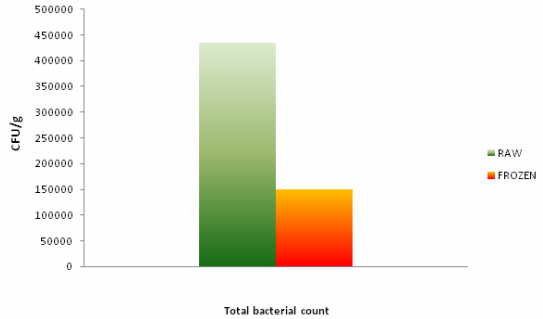

Fig.-1. Comparison of Aerobic Plate Count between raw and frozen samples.

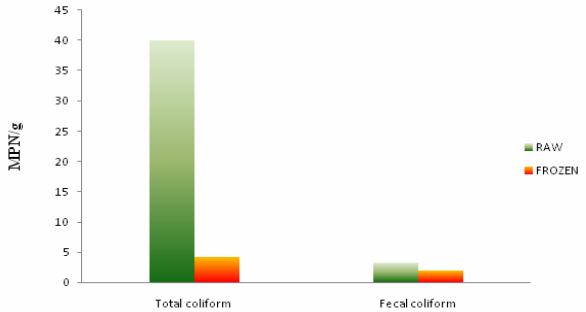

Fig.-2. Comparison of total coliform and faecal coliform between raw and frozen samples.

Fishbasebd: the fisheries and aquaculture information database of Bangladesh

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The literatures on fisheries and aquaculture of Bangladesh are scattered and so far, there is no electronic, either offline or online, database is available in Bangladesh. Therefore, to fulfill this gap and to offer a repository of available literatures on fisheries and aquaculture of Bangladesh, the current work has been designed to compile most of the available literatures on fisheries and aquaculture of Bangladesh into a single bundle, to create an offline repository of these compiled literatures, to create online literature database and to offer different stakeholders instant and free access to information on fisheries and aquaculture of Bangladesh. Both the online and offline database were named to be 'FishBaseBD'. The offline FishBaseBD software was designed using Visual Basic 6.0 and Microsoft Access 2010 and the online version was built using Joomla! 1.5, version 4.0. The online version is available at www.fishbasebd.com. Data input and linkage to the offline software was done using a data input form, and for online software the moderators can provide input, link and edit data. The offline database is storable in an attached storage (CD, DVD or pen drive). On the other hand, the online version is stored in an online registered domain. Running of offline FishBaseBD requires prior installation in a computer; whereas online version does not require any such installation and is accessible via web browsing. For both the versions, any or all of the search options, *viz.* title, author, keywords, publication year, source/reference, can be used. It is expected that the FishBaseBD database will benefit the scientists and researchers, students, fishery managers, fishery extension workers and NGOs working on fisheries and aquaculture sector of Bangladesh.