

BOOK OF ABSTRACTS

2nd International Conference on Sustainable Fisheries (ICSF) 2022

"Fisheries for Achieving SDGs"

16-18 SEPTEMBER



Faculty of Fisheries
Sylhet Agricultural University
Sylhet-3100, Bangladesh
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Thematic Areas

Aquaculture and nutrition
Aquatic resource management and conservation
Climate change and fisheries
Fish biology, genetics and biotechnology
Fish health, pharamacology and pollution
Fishing, processing and value addition
Fisheries strategies, planning and policy
Oceanography and blue economy
Socioeconomics, livelihoods and gender



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Foreword

I am very much delighted to share that Faculty of Fisheries, Sylhet Agricultural University, Sylhet, Bangladesh has successfully organized the 2nd International Conference on Sustainable Fisheries (ICSF) 2022. On behalf of the conference organizing committee, I feel honor to welcome you all to the ICSF 2022 in Sylhet, Bangladesh.

The theme of this conference is "Fisheries for Achieving Sustainable Development Goals (SDGs)". Sylhet region is specially endowed with many wetland fisheries that has vast potential to support income generation, livelihood and food security for rural people. The 2nd ICSF will be an interactive platform for our honorable scientists, policy makers, environmental managers, industries and all concerns in Fisheries for Achieving SDGs to discuss and exchange their ideas, views and knowledge along with other concurrent issues.

The technical programme of the conference is enriched with two plenary and nine session keynote speeches, guest speeches and plenary speeches by the experts in the field of Fisheries. We received a total of 247 abstracts for oral and poster presentations from home and abroad. From these, 164 submissions have been accepted and distributed as oral presentations (164) under nine thematic areas and as poster presentation (22). The presentations cover many aspects in the field of Fisheries that will contribute to the future development of the field and will also be able to generate awareness of the increasing global interaction inherent in the sector. This greater awareness will hopefully boost up the global, regional and national cooperation to promote the sustainability in fisheries and aquaculture.

I am confident that the aim of the conference will be fulfilled through effective gathering and successfully having a dialogue among the participants from national and international communities. Finally, my sincere thanks and appreciation to the authors who have cordially responded to our call for abstracts, the Scientific Committee who ensured a very high quality program by their thorough and timely reviewing of the abstracts, the Publication Committee for editing the Book of Abstracts and the Organizing Committee who have worked extremely hard for the details of important aspects of the conference programs and relevant activities.



Professor Dr. Mrityunjay Kunda

Chairman

Conference

Organizing

Committee,

ICSF-2022

Faculty of Fisheries, Sylhet Agricultural University

Sylhet-3100, Bangladesh.

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HOW MUCH MORE FISH DOES BANGLADESH NEED TO PRODUCE AND WHY?

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As Bangladesh celebrates its 50 years of independence and the birth centenary of our Father of the Nation Bangabandhu Sheikh Mujibur Rahman, fisheries sector of the country can also boast of its notable achievements. Both in terms of aggregate production and productivity per unit of area, it has been showing a steady growth with little year to year fluctuations. The major source of the increased production came from inland culture fishery which has been growing in area, production and yield. This has surpassed production from inland capture fishery mainly due to loss of perennial water bodies such as rivers, beels and estuaries. Marine capture fishery has also demonstrated modest increase, while marine aquaculture remains an area for further exploitation. Apart from the increasing trend of inland fishery and a little progress in coastal fishery, a remarkable growth of Hilsha fishery has been recorded in the last decade. The country now produces more fish than required as per capita consumption of fish which has itself surpassed the prescribed requirements.

While the commendable growth performance in fish production contributes to human dietary nutrition, employment and household income, it has also created new potentials for fish export market, although the performance in fish export has stagnated in recent years. Now the major issues of interests need to be revisited to revise/ reorganize strategies for fishery sector. One issue is to ascertain with factual data how much fish the country has to produce in order to meet the protein requirement of its population. In other words, does Bangladesh need to enhance its fish production from its present level of 'self-sufficiency'?, albeit taking annual wastage of fish catch at different levels into consideration. Or in addition to meeting the domestic fish consumption demand, the country should also produce for export market. Then, the sector has to concentrate on the kinds of fishes that have more competitiveness in the international market, let alone the question of good practices. More important strategic issue is whether the desired level of fish production (for local consumption and export) will continue to come from the inland culture fishery at the cost of rice fields conversion into fish ponds (which is going to be limited by increasing lease value of land and imported input costs) or the renewed emphasis will be put on enhancing productivity per unit of inland pond area and gradually shift the incidence of pond aquaculture from non-coastal to coastal area where both land and water are far less intensively used than the theoretical potentials?

The other policy issues include leveraging the untapped potentials of rice-cum fish culture, spread of new carp culture with 'Super Rui', shift of emphasis from inland to coastal aquaculture, increased R&D support to nutritionally rich SIS culture, strengthening of current focus on Hilsha fishery with adequate attention to artisanal fisher's community development. Finally, profitability of fish cultivation or more broadly aquatic agriculture in a land and water scarce situation warrants more focussed orientation of science community to fishery research.



Technical Session 1: **Aquaculture and Nutrition**

Session Keynote Paper

SPECIES AND FEED RESOURCES DIVERSIFICATION WITH INDIGENOUS POTENTIAL ALTERNATIVES: IMPERATIVE FOR RESILIENCE, SUSTAINABILITY AND BLUE TRANSFORMATION OF AQUACULTURE

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Aquaculture is the fastest growing major world food sector. Indian Aquaculture also exhibited compound annual growth rate (CAGR) of 8.1% during 2016-20 compared to 2.6-2.8% of rice and wheat, and 4.8% of coarse cereals during the same period. More and more number of recognized aquatic “species items” are being farmed in the world which has now increased to 652 as per the latest report by FAO. Notably, however, only a small number of species dominate the world aquaculture production with only 24 species contributing 78.7% of inland aquaculture production of the world and 22 species contributed to 75.6% of all fin fishes of mariculture. Similarly, though patchy reports on more and more fish species been brought into the aquaculture fold Indian major carps namely *Catla catla* (catla), *Labeo rohita* (rohu) and *Cirrhinus mrigala* (mrigal) together overwhelmingly dominate and contributes 70-75% of national aquaculture production of India and Bangladesh, in particular the most dominant contributors to aquaculture production. Such a dominance of a narrow base of closely related species has serious implications for sustainability, especially considering great variability in agro-climatic, and topographic conditions, temperature regimes, photo-periods, soil types, pond sizes and water depths and local preferences. It is also notable that the region is blessed with abundant indigenous aquatic fish faunal biodiversity many of which appear to have high niche preferences and market prices. The incorporation of potential indigenous species which are better adapted to the local conditions into the aquaculture can aid to the resilience, sustainability and blue transformation of aquaculture by not only aiding the demand and ecological balance of culture system but also their conservation as many of these are under vulnerable or threatened category.

On the other hand, growth of world aquaculture is mainly driven by fed aquaculture which now contributes about 72% of the aquaculture production. As the push towards enhancement of productivity gains more impetus in wake of increasing fish demand vs. declining per capita land and water resources, the contribution of fed aquaculture is likely to grow even further. Notably, however, ingredient of aquaculture feed is narrow with dietary protein conventionally sourced from fish meal and newly emerged plant protein sources namely soybean meal, oil cakes etc. and dietary energy sourced from narrow base of conventional food and feed grains. Production of none of these ingredients are increasing at pace of Aquaculture and simultaneously being sought for growth of production of other animal meat proteins, eggs and milk production. While fish meal is exhaustible, trade of soybean is dominated by USA which contributes to more than 30-35% of global trade. On the other hand, production of conventional food and feed grains requires assured irrigation, fertilization and proper care and has substantially high environmental and water foot print during production, and as a result, many regions are greatly deficit in their production. This necessitates long distance transports covering 2000-3000 km in country like India often through the least energy efficient roadways covering treacherous serpentine mountain routs. Such a long distance transports increase not only prices and susceptibility to disruptions but also carbon foot prints of fed aquaculture. Accordingly, it is important to evaluate alternative feed resources w.r.t. to both dietary protein sources as well as dietary energy sources with our species of interest be it Indian major carps, minor carps or cat fishes under prevalent culture conditions.

In lights of above, I will share our experiences in the northeastern region regarding development of comprehensive technology development for mass scale seed production and grow-out technology of some of indigenous fish species vis-à-vis evaluation of local feed resources for species of our interests under prevailing field culture conditions.

PRESENT SCENARIO, ISSUES, AND POSSIBILITIES OF BIOFLOC FISH FARMING IN SYLHET REGION, SYLHET, BANGLADESH

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The purpose of the study was to learn about the current state, difficulties, and prospects of biofloc fish farming in Bangladesh's Sylhet area. Interviews and a well-structured questionnaire were used to collect primary data from September 2021 to November 2021.

In the study, twenty farmers who were directly involved in biofloc fish farming were included. The majority of the farmers were between the ages of 25 and 32. All respondents had received some form of education, with the majority (55 percent) having received higher secondary education. Seventy percent of the farmers polled had fewer than five family members, and forty percent relied entirely on biofloc fish farming. Eighty percent of the respondents put their own money into the biofloc fish culture. 100 percent respondents were exposed to biofloc technology through YouTube, either directly or indirectly, and 60 percent began without any prior training. Respondent 14 (1500 kg, 300000 Tk) had the most output and return per cycle, whereas respondent 19 had the lowest output and return per cycle (105 kg, 22000 Tk). The highest BCR was discovered to be 2.608, while the lowest was found to be 0.800, and the average mild BCR was found to be 1.789. Twenty percent of farmers in the study reported fungal disease, tail rot disease, and ten percent parasitic diseases.

Problems like in the absence of a nearby hatchery and a scarcity of good fingerlings were prevalent in the research area. To improve and deploy biofloc fish farming technology in the Sylhet district, the focus should be given to ensuring good quality fingerlings, need-based training, and the construction of a community-based fish farming system.

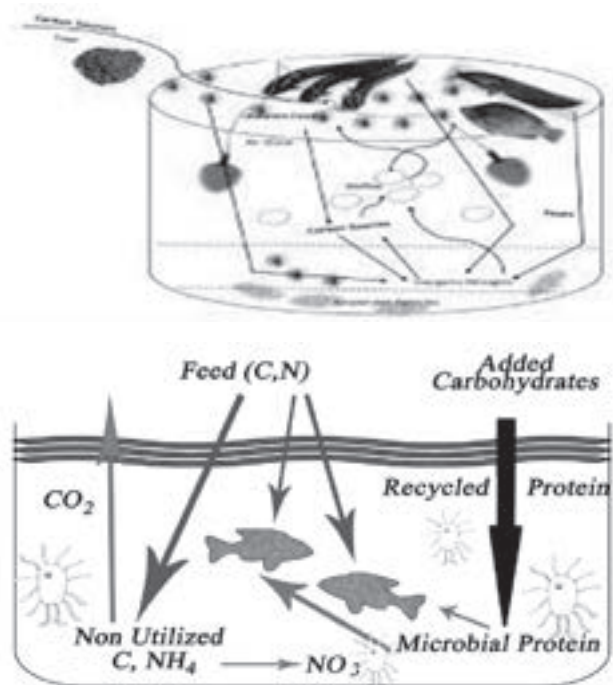


Figure : ইরডভষড়প ঙুংবস

SUITABILITY OF *Mystus cavasius* CULTURED IN BIOFLOC SYSTEM UNDER DIFFERENT STOCKING DENSITIES, BANGLADESH

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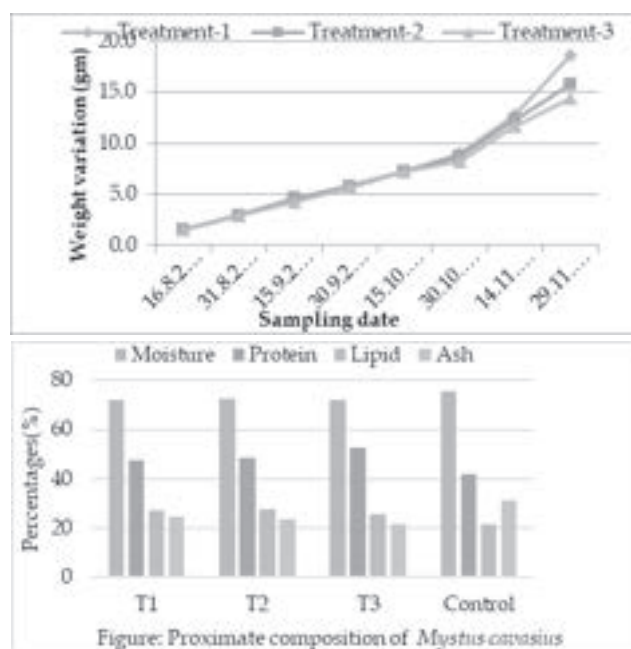
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The goal of this study was to see how varied stocking densities of Gulsha Tengra (*Mystus cavasius*) affected the fish's growth, proximate composition, and microbial colony count in a biofloc aquaculture system. Changes in growth performance, proximate composition, and microbial colony count were investigated using three different stocking densities: 400 ind./m³ (T₁), 500 ind./m³ (T₂), and 600 ind./m³ (T₃), each replicated three times in a biofloc tank. Species reached 1.52 to 18.55gm, in T₁, 1.51 to 15.79gm in T₂, and 1.51 to 14.37gm in T₃.

The survival rate was also high in T₁: 85.33% and the FCR was 1.45 in T₁ and 1.92 & 2.39 in T₂ & T₃ treatments respectively. Significant differences (P>0.05) were found in specific growth rate, food conversion ratio, and survival rate (%) of fish under the culture period of 120 days among the different stocking densities. A significant difference (P>0.05) was found in the mean value of weight gain among the three treatments and the highest value (17.02 ± 0.473) in T₁ and the lowest value (12.86 ± 0.132) in T₃ treatments. The average daily gain (ADG) of all treatments showed a significant difference (P>0.05) and the highest value (0.14 ± 0.003) in T₁ and the lowest value (0.10 ± 0.001) in T₃ treatments. There were no significant variations in Temperature, DO, Electro conductivity, TDS, Salinity, PH, Ammonia, Nitrite, and Floc volume among the treatments during culture. Comparatively, in the study, we found that moisture and ash percentages of *Mystus cavasius* from the biofloc tank were lower than the natural source (control) of *Mystus cavasius*. The protein and lipid percentages of *Mystus cavasius* from the

biofloc tank were higher than the natural source (control) of *Mystus cavasius*. The mean value of microbial colony count in experimental T₁, T₂, and T₃ treatment was lower than the control treatment. It is possible to conclude that Gulsha Tengra's decreased stocking density could result in increased production and be suited for maintaining higher water quality parameters in biofloc culture systems.



PROXIMATE COMPOSITION OF *Labeo calbasu* AT DIFFERENT SEASONS IN DEKHAR HAOR, SUNAMGONJ, BANGLADESH

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Fishes are rich source of protein and also contain essential elements (lipids, micronutrients, etc.) that help maintaining good health. This research work was carried out to determine the proximate composition of *Labeo calbasu* in Monsoon and Post monsoon seasons. A total of 65 *L. calbasu* fish were studied for a period of 6 months from June 2016 to November 2016.

The proximate composition of *L. calbasu* was found to be varied seasonally. Protein, lipid, ash and moisture content were 14.6 ± 0.43 , 2.84 ± 0.21 , 1.99 ± 0.08 and 77.27 ± 1.62 , respectively during Monsoon and 16.13 ± 0.49 , 3.65 ± 0.16 , 2.54 ± 0.21 and 74.82 ± 0.58 , respectively during Post-monsoon (Table 1). Protein, lipid and ash contents were noticed higher in post

monsoon season; however, the water content was higher in Monsoon. This research work provides valuable knowledge on proximate composition and nutritional value of the fish species which helps consumer to choose fish seasonally.

Table 1. Seasonal variation in proximate composition of *Labeo calbasu*

Season	Protein	Lipid	Moisture	Ash
Monsoon	14.60 ± 0.43	2.84 ± 0.21	77.27 ± 1.62	1.99 ± 0.08
Postmonsoon	16.13 ± 0.49	3.65 ± 0.16	74.82 ± 0.58	2.54 ± 0.21

MACRO AND MICRO MINERAL MATTER AND LIPID QUALITY INDICES OF FRESHWATER CRAB *Paratelphusa lamellifrons* FROM PADMA RIVER NEAR RAJSHAHI CITY, BANGLADESH

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Totally 10 mineral elements including 5 macro (Na, K, Ca, Mg and P) and 5 micro (Cu, Fe, Zn, Mn and Se) were analyzed in this study, where Sodium, Potassium and Magnesium were found to be maximum in cephalothorax, Calcium and phosphorous in LP while cheliped and legs content same quantity of Mg. Both macro and micro mineral elements were present in CTP, ChP, LP and WhP in the following order Ca>Na>P>K>Mg and Fe>Mn>Zn>Cu, whereas in whole crab (WhP) macro elements as Ca>Na>P>Mg>K respectively. Calcium was the predominant macro mineral element, whereas Iron was the predominant micro elements, observed maximum in cephalothorax and were present in the following pattern CTP>ChP>LP.

Among the different body parts of crab presence of minerals in cephalothorax were found to higher compare to cheliped and legs. The mineral analyses showed that crab species *P. lamellifrons* are nutritious and rich in the essential macro Na, K, Ca, Mg, P and micro elements such as Fe, Cu, Zn and Mn. To evaluate the nutritional value of fat present in the different organ of freshwater crab *P. lamellifrons* the ratios of PUFA/SFA, -6/ -3 and -3/ -6 PUFA, H/H, and atherogenic and thrombogenic indices was calculated and ranged between 0.58 to 0.73; 1.883 to 5.2; 0.19 to 0.53; 1.7222 to 2.0518; and 0.38 to 0.5; 0.62 to 0.78 respectively in different body parts of *P. lamellifrons*, while IT and IA value in CTP was observed somehow higher than other

organ and whole crab specimen. We suggest that daily intake of these essential mineral rich foods in sufficient quantities can prevent or reduce the risk of mineral deficiencies.

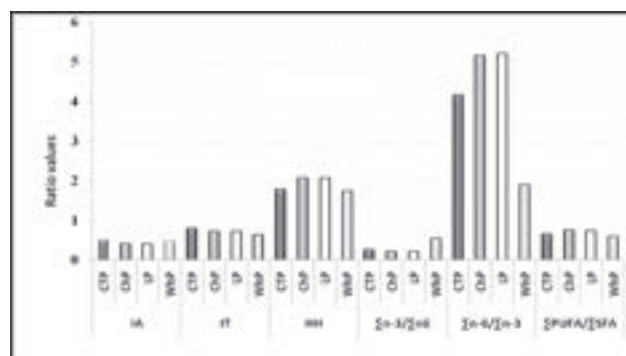


Figure: Comparative indexes of the nutritional quality of the lipid fraction and their ratios of whole body and different organ of *P. lamellifrons*

EXPLORING THE NEW CANDIDATE OF FISH FEED INGREDIENT FROM THE HAOR AQUATIC WEEDS AND ITS IMPACT ON THE GROWTH PERFORMANCE, BLOOD BIOCHEMISTRY, LIVER AND INTESTINAL MORPHOLOGY OF ASIAN CATFISH (*Clarias batrachus*)

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The replacement of fish meal (FM) with haor based fermented aquatic weeds meal (FAWM) can be a sustainable approach for the development of aquaculture sector. This study investigated the different ingredients at 50% inclusion level to the experimental diet compared to fish meal diet to verify growth and health performance of Asian catfish. Three experimental diets were prepared such as Kutipana (D1-FAWMKu), Topapana (D2-FAWMT_o) and Kochuripana (D3-FAWMKo) and fish meal diet (D0-FAWM₀) as a control diet. The significant difference (p 0.05) were observed in D1 diets which showed the lowest FCR (1.08) and the highest WG (911.20%), SGR (2.5%), FCE (93.02%) compared with other diets. In conclusion, the replacement of 50% FM with D1-FAWMKu could be used for better growth and health performance of Asian catfish as well as other freshwater species.

ECONOMIC FEASIBILITY OF AN IN-POND RACEWAY SYSTEM FOR COMMERCIAL FISH PRODUCTION IN SOUTH-WESTERN BANGLADESH

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Based on the demand of fish for the increasing population, fish export potential and limited land and water resources in Bangladesh, it is inevitable to increase the productivity with efficient use of land and water through intensive aquaculture. Aligning with the context, the In-Pond Raceway System (IPRS), one of the modern and efficient intensive aquaculture technologies in the world, has been introduced in Jashore district of Bangladesh recently. The present research was conducted to study the suitability in terms of growth performance and overall cost-benefit of four commercially important fish species, namely striped snakehead (*Channa striata*), rohu (*Labeo rohita*), grass carp (*Ctenopharyngodon idella*), walking catfish (*Clarias batrachus*) in the IPRS of Afil Aqua Fish Ltd., Sharsha, Jashore during October 1, 2021 to December 30, 2021. The IPRS was set up in a pond of 2.23 hectare (ha) of which 880 m³ was used for four production cells (concrete chambers), each 220 m³ in size. A total of 7175/ha striped snakehead, 5830/ha rohu, 1793/ha grass carp and 68161/ha walking catfish were stocked in four different cells with initial average weight 300.46±3.66 g, 182.66±1.04 g, 285.81±1.19 g and 4.46±0.38 g, respectively. Fish growth, survival and water parameters, as temperature, pH, DO and ammonia were monitored on fortnightly basis. Cost-benefit analysis of IPRS was done in terms of capital cost, operating cost, revenue and net profit. Average weights of the final sampling were 1006.25±4.03 g, 399.6±1.67 g, and 3195.76±1.52 g and 170.34±2.11 g for striped snakehead, rohu, grass carp and walking catfish, respectively. Though the highest average weight increment 2909.95±2.07 was observed in grass carp, the highest production (11302.15 kg/ha) was found from walking catfish presumably its high stocking density. Grass carp and walking catfish had the best growth performance, whereas rohu had relatively less growth response in IPRS. Satisfactory survival rate was found in all species. The cost-benefit ratio for striped snakehead, rohu, grass carp and walking catfish were 2.07, 1.19, 3.11 and 3.20, respectively. It is revealed that growth and economic profitability of walking catfish was best whereas rohu stands last in terms of overall performance, and grass carp performed moderately. Therefore, based on the growth performance and cost benefit analysis, grass carp and walking catfish would be more suitable species for the adaptation and commercialization of IPRS in Bangladesh.

EFFECT OF BIOFLOC ON GROWTH, SURVIVAL AND WATER QUALITY MANAGEMENT OF STINGING CATFISH *Heteropneustes fossilis*

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The biofloc culture system is gaining extensive popularity for its high stocking-based culture for fish. This study was conducted to observe the effect of biofloc on growth parameters (average length, weight gain, feed conversion ratio, specific growth rate, relative growth rate and protein efficiency ratio) and survival of stinging catfish *Heteropneustes fossilis* and at the same time the water quality parameters for suitability of stinging fish culture in biofloc system was checked. The study was organized including four types of biofloc treatments with three replications (n=3) each where fish were fed with commercial floating powder feed (Mega feed; Spectra Hexa Feeds Ltd)

for 35 days. Four treatments with three replicas directed as; T1 (control): 100% standard feed (SD), T2: (75% feed + 25% floc), T3: (50% feed + 50% floc), T4: (25% feed + 75% floc) for 35 days period based on their body weight. At the end of the culture period, the fish groups of each diet exhibited significant improvement in growth parameters. The average weight of 2.82±0.14 g, final length of 9.0±0.40 cm, mean final weight gain 2.82±0.14 g, RGR of 589.67±55.70% were significantly (P<0.05) higher in Treatment 2. Survival rate (SR) 91.0% seen higher in Treatment 3. SGR 2.00±0.12%, FCR 1.05±0.05 and PER 2.98±0.12% gave a maximum value in Treatment 1 which were significantly (P<0.05) different from other treatments. All the water quality parameters were found to be in optimum range. The overall results indicate that Treatment 2 (75% BFT) supplementation enhances the growth and survival rate for larval *H. fossilis* in biofloc culture system.

Parameters	T ₁ (Control)	T ₂ (BFT 75%)	T ₃ (BFT 50%)	T ₄ (BFT 25%)
Initial weight (g)	0.31±0.02	0.52±0.03	0.31±0.03	0.33±0.03
Final weight (g)	3.11±0.10 ^a	3.34±0.13 ^b	2.91±0.07 ^a	2.85±0.06 ^a
Weight gain (g)	2.40±0.11 ^a	2.82±0.14 ^b	2.39±0.09 ^a	2.32±0.06 ^a
SGR (%/day)	2.00±0.12	1.98±0.17	1.96±0.16	1.93±0.19
RGR (%)	535.96±37.04	579.67±55.70	490.33±40.96	472.31±41.81
FCR	1.05±0.05	0.78±0.03	0.51±0.04	0.53±0.04
Survival rate (%)	87.0	86.0	89.0	85.0

Table 1: Growth performance of stinging catfish, (*H. fossilis*) at larval stage under different treatments of biofloc technology during 35 days culture period.

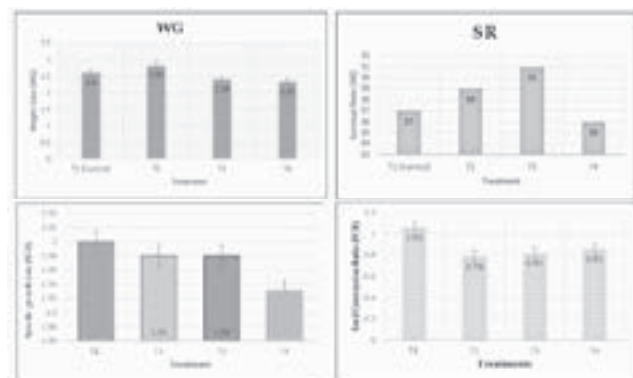


Figure 1: Specific growth rate (SR), Weight gain (WG), Specific Growth Rate (SGR), Feed Conversion Ratio (FCR).

EFFECTS OF SYNBIOTIC SUPPLEMENTATION ON THE GROWTH AND INNATE IMMUNITY OF GULSHA TENGRA, *Mystus cavasius* EXPERIMENTALLY INFECTED WITH *Aeromonas* sp.

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Synbiotics, conjunction between prebiotics and probiotics, have been used in aquaculture for over a decade. However, the mechanisms of how synbiotics work as growth and immunity promoters are far from being unraveled. The aim of this experiment was to evaluate the influence of a synbiotic on growth and immunity in Gulsha tengra (*Mystus cavasius*) fingerlings. The experiment was done in the laboratory condition with the fish with an initial average weight of 4.768 ± 0.2 g randomly assigned to four dietary treatments for 45 days. The dietary treatment (0.004, 0.006, and 0.008 g/kg of diet) was supplemented with a basal diet and a non-supplemented basal diet was used as a control. 5 fish samples were collected every other week from each replication which was used to collect blood samples from the caudal region and stored in appropriate chemicals for further analysis, blood smear slides were prepared to observe WBCs, and fish were gutted to collect viscera and liver samples and weighed. Further hematological analysis was done using a hemocytometer and prepared slides. After 45 days, all treatments supplemented with synbiotics showed a significant ($p < 0.05$) increase in final mean weight, weight gain, percentage, immunity, and survival rate compared to the control group. Among all supplemented treatments, the best result in terms of growth and innate immunity with the highest number of WBCs were observed in the treatment supplemented with 0.008 g synbiotic (20×10^4 CFU/ml) per kilogram of diet. This experiment showed an improved immunity against experimentally infected with *Aeromonas* sp. in the fish supplemented with synbiotics than that of the fish without synbiotic supplementation with zero mortality rate compared to the control group. This is an indication of the enhanced innate immunity of fish with the highest number of WBCs which are one of the vital components of the immunity system. These results revealed that a feeding regime with synbiotic for 1.5 months led to a significant increase in growth performance and survival rate of gulsha fingerlings. Synbiotics may provide an eco-friendly alternative to other commercial drugs although an extensive field study is required to elucidate the efficacy of synbiotics in pond conditions.

SYNERGISTIC EFFECTS OF CHITOSAN NANOPARTICLES AND VITAMIN-E SUPPLEMENT ON GROWTH AND BIOCHEMICAL RESPONSES OF PABDA FISH

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This research attempts to identify the synergistic effect of dietary chitosan nanoparticles (CNP) and vitamin E supplements on growth performances, haematological and biochemical responses of Pabda catfish (*Ompok pabda*). The experiments were designed with four treatments (T): fish fed with CNP (T2, 5g kg⁻¹ diet), vitamin E (T3, 500 mg kg⁻¹ diet), and combination of CNP and vitamin E (T4, 5g CNP and 500 mg vitamin E kg⁻¹ diet). Fish fed only basal diet was used as control (T1). Results showed that the length gain, weight gain, specific growth rate (SGR), daily growth rate (DGR), relative growth rate (RGR), feed conversion ratio (FCR) and feed conversion efficiency (FCE) were significantly higher in combination and CNP groups. The highest haemoglobin, haematocrit, RBC, platelet count and MCHC and the lowest MCV, MCH, and WBC were reported in combination group (T4). In case of serum biochemistry and liver function test, the highest level of albumin, cortisol levels, and alkaline phosphatase and the lowest bilirubin, ALT and cholesterol were observed in combination group. Glucose, total protein and triglyceride contents were higher in vitamin E containing diet (T3). In conclusion, combined supplementation of CNP and vitamin E provides a synergistic interaction in improving growth, health and immune status of fish under intensive culture.

EFFECTS OF SUPPLEMENTAL L-METHIONINE FOR TOTAL REPLACEMENT OF FISH MEAL BY SOYBEAN MEAL ON GROWTH, FEED UTILIZATION, AND HEALTH STATUS OF STINGING CATFISH, *Heteropneustes fossilis* fry

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A 14-week feeding trial was conducted to evaluate the effect of supplemental L-methionine for total replacement of fish meal (FM) with soybean meal (SBM) on growth and feed utilization of stinging catfish, *Heteropneustes fossilis*. Five diets were formulated, where diet 1 contained 15% fish meal and 45% soybean meal as a source of protein. The other four diets (2-5) contained 0% fish meal and 60% SBM with various percentages (0.5, 1.0, 1.5, and 2%) of L-methionine. The significantly highest mean final weight (g), weight gain (g), percent weight gain (%), and specific growth rate (%/day) were found in diet 4 containing 58.5% SBM with 1.5% L-methionine and there was no significant difference between diets 1 and 4. Feed conversion ratio (FCR), protein efficiency ratio (PER), and survival rate did not differ significantly among fish groups. However, the best FCR and higher PER were found in diet 4. The whole body carcass protein was significantly lower in diets 2 and 5 which contained 0.5% and 2% L-methionine, respectively might be below or above the requirements of stinging catfish. Significantly higher lipid content was found in diets 2 and 4. Dietary 1.5% supplementation of L-methionine for total replacement of fish meal with soybean meal increased Hb, RBCs, WBCs, and Glu, and 2% supplementation of L-methionine decreased these values significantly. Moreover, considerable morphological improvement of the intestine was observed in diet 4. Therefore, the results recommend that diet 4 containing 58.5% SBM with 1.5% supplemental L-methionine could completely replace fish meal without adverse effects on growth, feed utilization, and health condition of stinging catfish, *H. fossilis*.

VISUALIZING THE EMERGING PLATFORM OF USING MICROALGA, *Chlamydomonas reinhardtii* AS A SUSTAINABLE BIO-FACTORY FOR HEALTHY LIPID PRODUCTION THROUGH BIOCOMPATIBLE AGGREGATION INDUCED EMISSION PROBES

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Nowadays, a particular focus is using microalgae as the sustainable source of high-valued health beneficiary lipids production. The precise localization of the lipid droplets (LDs) and biochemical changes are crucial to portray the lipid production strategy in algae, but it requires an *in vivo* tool to rapidly visualize LD distribution. As a novel strategy, this study focuses on detecting lipid bioaccumulation in a green microalga, *Chlamydomonas reinhardtii* using the aggregation-induced emission (AIE) based probe, 2-DPAN ($C_{24}H_{18}N_2O$). As the messenger molecule and stress biomarker, hydrogen peroxide (H_2O_2) activity was detected with the AIE probe, TPE-BO ($C_{38}H_{42}B_2O_4$), in lipid synthesis. Distinctive LDs labelled with 2-DPAN have elucidated the lipid inducing conditions, where more health beneficiary -linolenic acid has been produced. TPE-BO labelled H_2O_2 have clarified the involvement of H_2O_2 during lipid biogenesis. The co-staining procedure with traditional green BODIPY dye and red chlorophyll indicates that 2-DPAN is suitable for multicolour LD imaging. Compared with BODIPY, 2-DPAN was an efficient sample preparation technique without the washing procedure. Thus, 2-DPAN could improve on traditional fluorescent probes currently used for lipid imaging. In addition, rapid, wash-free, multicolor AIE-based *in vivo* study opportunity of H_2O_2 and LDs under same assay condition with TPE-BO and 2-DPAN, respectively could broaden the horizon of these dyes to advance the research of lipid production in microalgae.

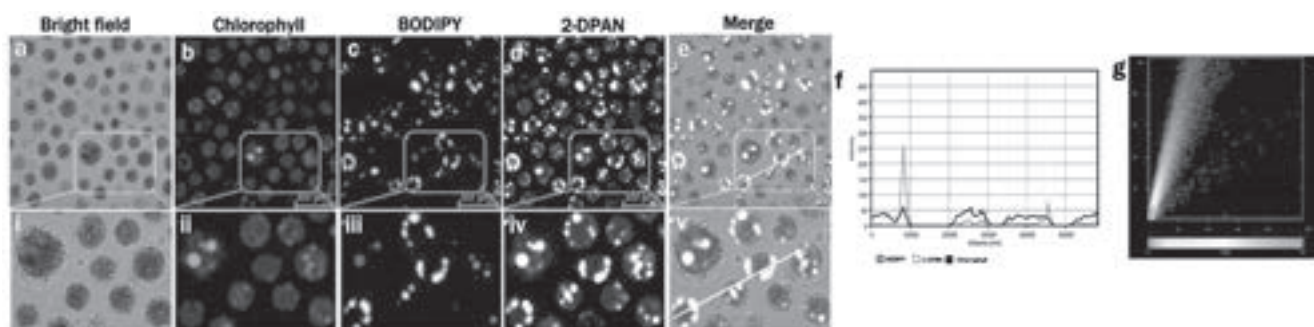


Figure 1. Visualization of lipid drops in *Chlamydomonas reinhardtii* with lipid-specific traditional probe, BODIPY and AIE probe 2-DPAN under confocal microscopy.

TAILORING CONDITIONS FOR IMPROVED GROWTH AND LIPID ACCUMULATION IN MICROALGAE WITH AGGREGATION INDUCED EMISSION-BASED LUMINOGEN

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Mass production of microalgae has become a focus of research owing to their promising aspects for sustainable biofuel feedstock, aquafeed, biofunctional compounds, and nutraceuticals. However, low lipid content in algal biomass is still a challenge that needs to be resolved for their commercial utilization. There is also a knowledge gap in improving the lipid accumulation in algal cells with a satisfactory growth rate. This research aims to determine the effect of light spectral shift on growth and lipid biosynthesis in a green microalga, *Chlamydomonas reinhardtii*. As a novel approach, an aggregation-induced emission (AIE)-based luminogen, TPA-A ($C_{21}H_{19}NO$) has been introduced into the culture media for tailoring the wavelengths to a specific range to enhance photosynthesis and lipid production. The absorbance and emission peaks of TPA-A have been found around 360 nm, and 488 nm, respectively. In compare to the control, almost a double algal growth has been observed at 10 μ M TPA-A exposure. Significant increase in the lipid production from the confocal analysis of the TPA-A exposed cells suggests increased growth and lipid

biosynthesis in TPA-A exposed algal cells. This AIE-based technology is expected to overcome the aggregation caused quenching effects of the conventional fluorophores by providing increased fluorescence with photostable AIEgen. Thus, this novel approach will strongly impact on algal biofactory development for sustainable food, eco-friendly fuel, and healthy lipids.

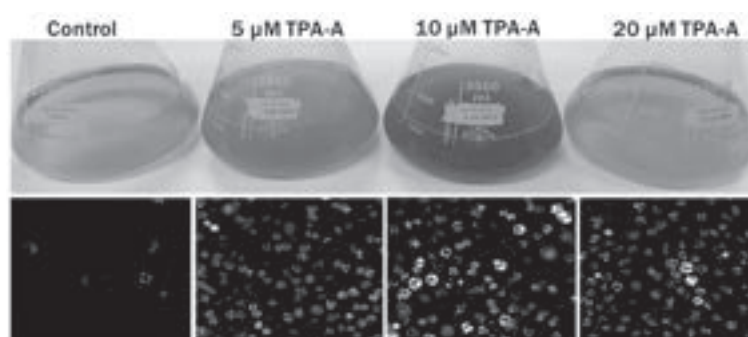


Figure 1. Growth and lipid production in *Chlamydomonas reinhardtii* cells at different concentrations of TPA-A.

EFFECT OF COMMERCIAL FEEDS ON GROWTH AND PRODUCTION PERFORMANCE OF SHRIMP (*Penaeus monodon*) IN BAGERHAT COASTAL PONDS OF BANGLADESH

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The experiment was conducted over 120 days from March to June 2019 in Bagerhat sadar upazila, Bagerhat. The study was categorized into four treatments indicated as T₁ (ACI feed), T₂ (Quality feed), T₃ (Mega feed) and T₄ (control) with three replicates. The experimental ponds were stocked with shrimp PL at same density of 4 nos./m². Ponds were treated with agricultural lime based on soil and water pH and fertilized with urea and Triple Super Phosphate depending on water transparency and depth. Different water quality parameters were determined at ten-day intervals. Parameters of water were within acceptable ranges of shrimp culture. Higher growth (30.36 g) of shrimp was achieved in T₂ compared to T₁ (28.53 g), T₃ (27.43 g) and T₄ (22.85 g). Growth and survival rate of shrimp were comparatively lower in T₄ at the same stocking density. Significantly (p<0.05) higher production of shrimp was obtained in T₂ (971.52 kg/ha) than those of T₁ (855.90 kg/ha), T₃ (757.07 kg/ha) and T₄ (566.68 kg/ha). Highest net profit (US\$ 2570.2/ha) of shrimp farming was found in T₂ than that of T₁ (US\$ 2105.7), T₃ (US\$ 1786.6) and T₄ (US\$ 1298.1). Results of the study indicate that among different commercial feeds Quality feed (T₂) is better than other feeds in respect of survival rate, growth, production and net profit. So, farmers may be encouraged to use Quality feed for getting higher production and significant return in a short period of time.

DEVELOPMENT OF SUSTAINABLE CLIMATE RESILIENT AQUACULTURE USING ASIAN WATERGRASS AS FISH FEED

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The price of commercial fish feed increased globally which threatens aquaculture as well as food security of the poor globally and creates problem for sustainable aquaculture development. Asian watergrass contains desired amount of nutrients and is a preferred food of some species of fish. An experiment was conducted using Asian watergrass as fish feed in comparison with commercial feed for reducing feed cost under three treatments for 5 months. In the treatment one, Asian watergrass was planted and grown as fish feed before 4 months of fish stocking and designated as T_0 (T_0 : no commercial feed for fish); in the treatment two, Asian watergrass was planted and grown at 50% area as feed and 50% commercial feed was applied and designated as T_{50} (T_{50}); and in the treatment three, 100% commercial feed was supplied as control and designated as T_{100} (T_{100}). Large sized fingerlings of grass carp, common carp, tilapia, mrigal and rohu were stocked at similar ratio of 6:2:2:1:1 with stocking density of 15000 fish ha^{-1} in all treatments. Important water quality parameters were measured throughout the study period those were suitable range for aquaculture. The survival, growth parameters and total production were calculated. The total productions were found significantly higher $5235.04 \pm 367.56 kg ha^{-1}$ in T_{100} followed by $4115.57 \pm 130.27 kg ha^{-1}$ in T_{50} and $3161.82 \pm 96.24 kg ha^{-1}$ in T_0 . But, the calculated highest benefit and benefit-cost ratio (BCR) were found USD 5436.53 ha^{-1} and 2.20 in T_0 whereas the lowest benefit and benefit-cost ratio were USD 1776.04 ha^{-1} and 0.16 in T_{100} . The total installation costs were same in all treatments, but the total operational costs were different due to the variations in the applying commercial feed cost. The operational cost was found highest USD 11191.98 ha^{-1} in T_{100} that was 4.77 fold higher from the lowest one (USD 2348.44 ha^{-1} in T_0).

GROWTH PERFORMANCE OF DIFFERENT FISH SPECIES DURING DRY PERIOD IN CHITWAN, NEPAL

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It is challenging to produce fish in dry period because water level drops in ponds and affects fish growth and survival. In order to assess the growth and yield of different fish species during dry period, an experiment was conducted in the Aquaculture Farm of Agriculture and Forestry University, Rampur, Chitwan from 1 April to 10 July, 2021. The experiment included three treatments: T₁ (Carp polyculture), T₂ (Common carp *Cyprinus carpio* monoculture) and T₃ (Nile tilapia *Oreochromis niloticus* monoculture), each with three replications. Silver carp (*Hypophthalmichthys molitrix* 7%), Bighead carp (*Aristichthys nobilis* 20%), Grass carp (*Ctenopharyngodon idella* 13%), Rohu (*Labeo rohita* 30%), Mrigal (*Cirrhinus mrigala* 10%) and Common carp (20%) were stocked at densities of 1,400, 4,000, 2,600, 4,000, 6,000 and 2,000 fish/ha, respectively. Stocking density of Common carp and Nile tilapia was 20,000 fish/ha. Fish were fed with sinking pellet (28% crude protein) at the rate of 3% of body weight.

The gross and net fish yield was higher ($p < 0.05$) in T₃ (9.89 ± 0.67 t/ha/yr and 8.16 ± 0.25 t/ha/yr) than in T₂ (4.88 ± 0.38 t/ha/yr and 4.05 ± 0.35 t/ha/yr) which was due to higher ($p < 0.05$) survival of Nile tilapia in T₃ ($72.5 \pm 11.3\%$) than that of Common carp in T₂ ($40.6 \pm 4.5\%$). Predation by bird in low water depth increased mortality of Common carp. Gross fish yield (6.62 ± 0.70 t/ha/yr) and survival ($59.0 \pm 6.2\%$) of carps in T₁ was on par with that of Nile tilapia in T₃. The total income and gross margin were higher ($p < 0.05$) in T₃ (1257482 ± 186600 NRs/ha/yr) than in T₂ (434250 ± 124753 NRs/ha/yr) due to higher yield of Nile tilapia. Based on higher survival rate, yield and gross margin, Nile tilapia culture is a suitable fish farming system for dry period.

AN OVERVIEW ON AQUAFEED PRODUCTION IN BANGLADESH: CURRENT STATUS, CHALLENGES AND FUTURE PROSPECTS

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The aquafeed industry in Bangladesh over the past 10 years has been remarkable, in line with the increasing population and the increasing per capita fish consumption. Feed costs commonly account for 70–75% of farm operating costs. Use of formulated feeds for fish farming is increasing in Bangladesh, associated with growth, intensification and commercialization of aquaculture. Till January 2022, there are 338 fish feed importer and 242 commercial mills that produce aquaculture feeds in Bangladesh. Production of commercial aqua feed raised by 32% per year from 2008-2012. A study reveals that in 2022, the sinking feed production reached to 1.9 MT and floating feed to 0.8 MT. The rate of expansion in the production and uptake of manufactured feeds has been so rapid that the industry has not yet matured fully. The main ingredients used for fish feed production are rice bran (20–50%), maize (5–20%), soybean meal (10–30%), mustard oil cake (10–25%), fish meal (5–15%) and meat and bone meal (10–20%). Among these, imported raw materials contribute more than 50% of the total cost of feed production in Bangladesh. More than half of the soybean meal (60–65%) and fish meal (67–72%) is totally dependent on imports. The use of more plant-based feedstuffs, rather than fishmeal and fish oil, is essential in the future development of aquaculture. However, plant products can have nutrient profiles that are not entirely suitable for fish and may contain anti-nutritional factors and can preclude the use of plant feedstuffs in diets at high concentrations. Blaming the rising costs of raw materials, aquafeed producers have announced a 50% hike in feed prices in the last 6 years, a move certain to increase the burden on farmers. An average of 20-taka rise was noted per kg feed. But to hold the market, the feed producers are rising the feed price to a lesser extent. As a result, the feed quality is eventually dropping. Importers and suppliers of raw materials and additives for feed are obliged to comply with the Feed Act. But a study found that only 20% of feed mills are aware of the Act's restrictions on antibiotic and chemical use. Again, the Feed Act, 2011 needs to be re-furnished according to the present needs. The aquafeed industry in Bangladesh is currently facing multiple challenges. So, to sustain, the industry needs to increase its productivity by lessening dependency on fish meal and imported raw materials, use of fermented meal containing single cell proteins, seek alternative source of native raw materials, adequate research on feed composition, proper use of feed enzymes and probiotics etc. for the future development of aquaculture.



QUALITATIVE AND QUANTITATIVE STUDY OF THE STATUS OF BIOFLOC TECHNOLOGY IN BANGLADESH

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Biofloc is an environment friendly farming method which requires lower input and returns higher yield. This technology is mostly practiced in a confined space—mostly in tanks and reservoirs in farms or courtyards. The technology gained a sudden popularity in Bangladesh early in the 2018. However, performance of this technology at farmer's level is still in question. To know the status of biofloc farmer's, this study was designed to find out the broader scenario of the biofloc fish culture system in Bangladesh. In this regard, a semi-structured questionnaire was developed to collect relevant information from farmers and they were selected via "snow ball approach". During the field survey, different information including demographic, pre-operational, operational and post-operational stages of biofloc farming were collected from 154 farmers from different regions. Most of the farms started their journey after 2020 when the activities were largely home-based due to the pandemic COVID-19. The collected data showed that

highest number of farms were surveyed in Dhaka district followed by Khulna and Rajshahi. Maximum survey participants (98.05%) were male. Higher percentage of Biofloc farmers were of young age (64.9%). Most of them are highly educated with 37.01% of them being graduates followed by higher secondary (30.5%) and primary. Most of the entrepreneurs (60%) took this venture as business purpose. In pre-operational stage, most of them used cemented tank with rectangular shape under a shed. Floc was developed by using only heterotrophic bacteria. Most of them (45.27%) used "Pond Care" as a probiotic. Besides, some farmers (3.48%) used their self-made probiotics. Most common cultured fish species were shing (25.81%), koi (22.87) and tilapia (19.06%). According to the economic analysis, 79.87% of farmers failed to make profit from their business. A small



percentage (1.95%) were still under running project. The main difficulties encountered by the enthusiasts were immature technology, lack of knowledge, lack of quality probiotics, seeds and test kits etc. The results revealed that the development of the commercial biofloc has hit the level of 'disillusionment', caused by the numerous challenges facing commercial food production.

EFFECT OF FISH PROTEIN HYDROLYSATES ON GROWTH AND REPRODUCTIVE PERFORMANCE OF PABDA (*Ompok pabda*) BROODSTOCK IN CAPTIVITY

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A marine-based fish protein hydrolysate (FPH) was used in this study as a supplemental feed ingredient in Pabda (*Ompok pabda*) diets. The present research aimed to examine the effects of different levels FPH treated diets on growth and reproductive performance of Pabda catfish in captivity. A 90-day feeding program with different percentages of FPH was conducted for four isonitrogenous diets containing 30% crude protein, namely 0% (basal diet), 5%, 7%, and 9%. Ovupin was given to the brood fish after feeding trials to induce breeding (0.5 ml/kg for females and half a dosage for males). The results confirmed that, butter catfish fed 7% FPH treated diets showed significantly ($p < 0.05$) higher percentage of spawning response (98.48 ± 2.4), egg fertilization rate (87.09 ± 0.14) than other test diets. Additionally, the hepatosomatic index (HSI), visceral somatic index (VSI), FCR, FCE, PER was significantly ($p < 0.05$) improved in 7% FPH -fed fish. The experimental diets exhibited an increasing trend in terms of SGR (%/day), live weight gain (%), fecundity (eggs.kg⁻¹), hatching rate (%) and ovulation time (h) while elevating the FPH levels. However, the survival rate (%) of Pabda broodstock was not significantly varied among the various groups of FPH incorporated diets. It can be concluded that, the 7% FPH incorporated diet contributes to the growth and reproductive efficiency of Pabda catfish.

EFFECT OF PROBIOTIC AND PREBIOTIC AS AN ALTERNATIVE TO ANTIBIOTIC ON GROWTH AND BLOOD PROFILE OF NILE TILAPIA (*Oreochromis niloticus*)

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The purpose of this study is to see how a commercial probiotic (Pond Care), prebiotic spirulina (*Arthrospira platensis*), and its synergistic effect on growth performance and hematology compare to the antibiotic (Cotrim vet) for a 75-day culture period of Nile tilapia (*Oreochromis niloticus*). The study was designed using five treatments (n= 3) in which T_{Con} (Control), T_{Ant} (Antibiotic; Cotrim vet), T_{Pro} (Commercial probiotic; Pond Care), T_{Pre} (Prebiotic; Spirulina), and T_{Syn} (Probiotic and prebiotic). The highest mean final growth was found in T_{Syn} (13.79±0.11^a) and then in T_{Pre} (13.61±0.02^a), T_{Pro} (13.22±0.12^a), T_{Ant} (10.04±0.7^b) and T_{Con} (8.89±0.19^b). The survival rate was not significantly (p<0.05) different among treatments. T_{Pro} had the lowest food conversion ratio (1.13±0.021^a), followed by T_{Pre} (1.22±0.01^a) and T_{Syn} (1.226±0.018^a), and then T_{Ant} (1.34±0.031^a) and T_{Con} (1.55±0.037^a). The highest protein efficiency ratio (PER) was in T_{Pro} (3.1±0.05^a) then in both T_{Pre} (2.93± 0.02^b) and T_{Syn} (2.91±0.04^b) followed by T_{Ant} (2.6±0.06^c) and T_{Con} (2.3±0.05^d). In blood profile analysis, the highest value of white blood cells (WBC) was found in T_{Syn} (126300±1100^a) followed by T_{Pre} (126000±2000^a), T_{Pro} (123250±1250^{ab}), T_{Con} (121650±1050^{ab}) and T_{Ant} (110350±4650^b). The values of red blood cells (RBC) and blood glucose were not significantly (p<0.05) different among the treatments. The platelet value of all five treatments was significant (p<0.05) compared to each other. In histological analysis, all treatments showed normal hepatocyte structure in liver tissue histology. T_{Syn} showed a higher number of lipid vacuoles and a bigger number of them, indicating improved growth. The blood profile of Nile tilapia did not differ much across treatments and all treatments had normal liver tissue structure. However, higher growth performance values were observed in probiotic, prebiotic and its synergism provided treatment than control and antibiotic. So probiotic, prebiotic and its synergism can be used as an alternative to antibiotics in fish culture.

Table 1 Growth performance and feed utilization data of Nile tilapia (*Oreochromis niloticus*)

Parameter	Treatments				
	T _{Con}	T _{Ant}	T _{Pro}	T _{Pre}	T _{Syn}
Mean Initial Weight (g)	0.57 ± 0.014 ^a	0.56 ± 0.014 ^a	0.53 ± 0.025 ^a	0.51 ± 0.014 ^a	0.51 ± 0.014 ^a
Mean Final Weight (g)	8.89 ± 0.19 ^b	10.04 ± 0.7 ^b	13.22 ± 0.12 ^a	13.61 ± 0.02 ^a	13.79 ± 0.11 ^a
Weight gain (g)	8.33 ± 0.18 ^b	9.48 ± 0.69 ^b	12.7 ± 0.13 ^a	13.11 ± 0.02 ^a	13.28 ± 0.11 ^a
% Weight gain	1470.12 ± 45.34 ^b	1696.46 ± 82.6 ^b	2422.54 ± 134.68 ^a	2579.62 ± 76.37 ^a	2614.45 ± 94.07 ^a
SGR (%.day ⁻¹)	3.67 ± 0.04 ^b	3.85 ± 0.06 ^b	4.3 ± 0.07 ^a	4.38 ± 0.04 ^a	4.4 ± 0.05 ^a
FCR	1.55±0.037 ^a	1.34±0.031 ^a	1.13±0.021 ^a	1.22±0.01 ^a	1.226±0.018 ^a
PER	2.3±0.05 ^d	2.6±0.06 ^c	3.1±0.05 ^a	2.93± 0.02 ^b	2.91±0.04 ^b
Survival rate (%)	93.3 ± 1.44 ^a	93.3 ± 1.44 ^a	94.16 ± 1.44 ^a	95 ± 0.00 ^a	95 ± 0.00 ^a

DIETARY MICROALGAE CAN IMPROVE GROWTH, IMMUNITY AND GUT MICROBIOTA DYNAMICS IN FISH

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Microalgae are photosynthetic heterotrophic organisms that contain essential amino acids, protein, minerals, vitamins, chlorophylls, and some antioxidants and bioactive substances. Because of their nutritional quality and positive effect on growth performances of aquatic species due to increased triglyceride and protein deposition in muscle, improved resistance to disease, decreased nitrogen output into the environment, omega-3 fatty acid content, physiological activity, and carcass quality, the use of microalgae could have significantly beneficial effects and could potentially replace or reduce common feedstuff for fish. Many compounds in algae supplements have been reported to act as non-specific immunostimulants, improving defense mechanisms in fish, providing enhanced resistance to pathogens, and thus improving immunity. In recent studies at BSMRAU, based on the growth performance, whole-body composition, blood parameters, gut microbiota and serum lysozyme values; it was concluded that dietary replacement of 7.5-10% fish meal with *S. platensis* improved the growth performance and immune response of Gulsha (*Mystus cavasius*) and Stinging catfish (*Heteropneustes fossilis*). It already seems that microalgae will play a significant role in the effort of formulating of aqua feed to a more sustainable way. This comprehensive review summarizes the most important and recent developments of microalgae use as a supplement or feed additive to replace fishmeal and fish oil for use in aquaculture. Furthermore, from this study, it would be possible to find out the effect of using microalgae as fish feed ingredients for enhanced growth and immunity of fish.

AQUACULTURE WASTEWATER AS A LOW COST MEDIUM FOR MASS PRODUCTION OF MICROALGAE AND IT'S UTILIZATION AS FEED FOR CULTURING SHRIMP POSTLARVAE

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Microalgal biomass has been widely reported as feed, food, biodiesel, and pigment source. Suitable microalgae species for particular industrial application are selected on the basis of its growth rates, productivity, adaptability to laboratory conditions, and proximate profiles. Suitable species with higher level of protein, easy to commercial culture and faster growth rates are the preliminary considerations for recommending that species to be used as animal feed. Here a standard protocol is maintained to cultivate purely isolated microalgae of marine water originated from different coastal water farms of Bangladesh. A total four (4) species were isolated from six (6) samples of different coastal farms. Among the four identified species three species were green microalgae (*Chlorella* sp.; *Nannochloropsis* sp.; and *Tetraselmis* sp.) and rest one was brown microalgae (*Chaetoceros* sp.). Growth curves of those microalgae were determined in terms of cell density to observe the growth rates and division per day.

Different media such as wastewater, Conway and Conway + wastewater was compared for the maximum production of biomass for the isolated species. Results showed that *Tetraselmis* sp. and *Chaetoceros* sp. obtained significantly higher ($p < 0.05$) growth when cultured in 50% Conway + 50% wastewater compared to 100% Conway and 100% wastewater. Finally through comparing growth rates and protein contents, potential microalgae candidates were identified for animal feed production. We have identified *Tetraselmis* sp.; *Chaetoceros* sp.; and *Nannochloropsis* sp. as suitable algae for feed production chronologically. These species are potential candidates as animal feedstuffs.

For the feeding experiment, selected microalgae such as *Chlorella* sp. and *Tetraselmis* sp. were used as feed supplement in rearing *Penaeus monodon* shrimp post larvae. A commercial diet was compared to diets containing at 25%, 50%, 75% and 100% replacement levels and fed to postlarvae to evaluate the survival, growth performance and nutritional composition. Results showed that PLs fed with 25% of *Chlorella* sp. and *Tetraselmis* sp. had significantly higher specific growth and survival rate compared to the other treatments. This study demonstrates that selected microalgae have potential to be used as a cost effective feed replacement for rearing shrimp PLs.

METABOLOMICS AND FISH NUTRITION: WITH REFERENCE TO SUSTAINABLE FEED DEVELOPMENT

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Aquaculture is facing a strategic challenge to improve feed suitability and support the global increase in fish production. Improvements in diet formulation for sustainable nutritional strategies have focused to date on the partial substitution of marine resources by plant resources but will now include other alternative feedstuffs. Growth trials and body composition data provide valuable indicators of fish nutritional status, while omics technologies may contribute to a better understanding of fish nutrition and help to demonstrate how feed and nutrients act in fish metabolism. Metabolomic approaches give an insight into fish metabolism through a non-targeted analysis of metabolites in tissues or biofluids that involve multiple factors affecting fish, such as nutrition. In this review, we highlight the outcomes of publications in metabolomics applied to fish nutrition. We explain the concept of metabolomics and discuss specific technical considerations related to sample type, sampling and sample preparation. We show how metabolomic studies help to elucidate the impact of nutrition on fish fillet composition and fish metabolism.

NURSERY REARING OF ORANGE MUD CRAB *Scylla olivacea* (HERBST, 1896): OPTIMIZING STOCKING DENSITY IN RICE-CRAB FARMING SYSTEM

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Utilizing the limited resources, poor peoples of the southwest Bangladesh employed varieties of production techniques in the dynamic rice-based farming systems. Orange mud crabs a potential mariculture species, whilst cannibalism is the major challenge for the nursery and culture of mud crab which hindered the survival and production. Provision of adequate shelter might reduce the cannibalism and ultimately enhanced the production. Thus, this study aimed to exploit the dynamic coastal rice-field as an integrated nursery for mud crab.

Potentiality of coastal rice field for mud crab nursery was assessed by conducting a field based trial in Paikgacha region, Khulna. Depending the variable stocking densities (SD), the trial was designed with three treatments *viz*, SD 1.25/m² (T₁), SD 2.50/m² (T₂) and SD 3.75/m² (T₃). Each of the treatment had three replicated plots with an area of 18m×6m of which 9m×6m was covered with rice. Each of the plots were prepared as according to integrated culture system and fetched with *bana* to prevent escaping of crabs. Stocking was done with 34.45±2.10 g sized crabs. Feeding was done with trash tilapia fish @4-5% of the total biomass daily and the experimental duration was 90 days.

Recorded all water quality variables were within the acceptable ranges for rice-crab farming system except the fluctuation of water depth that ranged between 22.0 and

48.0 cm in the canals. The recorded final BW of crabs was 150.88, 130.38 and 112.13 g in T₁, T₂ and T₃, respectively (Fig. 1.a). The survival was 41.18, 33.33 and 25.62% in T₁, T₂ and T₃, respectively (Fig. 1.b). The estimated production of crabs was 78.23, 108.65 and 107.97 g/m² in T₁, T₂ and T₃, respectively (Fig. 1.b). Both the BW and survival rate was significantly higher (p<0.05) in T₁ than T₂ and T₃, whereas, the production was significantly lower (p<0.05) in T₁ than T₂ and T₃. Meanwhile, the roots, number of tillers, stems and grain per panicles of rice showed no significant difference (p>0.05) among the treatments indicated symbiotic for rice-crab integration. The overall findings of this trial concluded that the stocking density of about 1/m² might be practiced efficiently to culture mud crab (*Scylla olivacea*) in rice-crab farming system to enhance survival, production and to maximize the profitability.

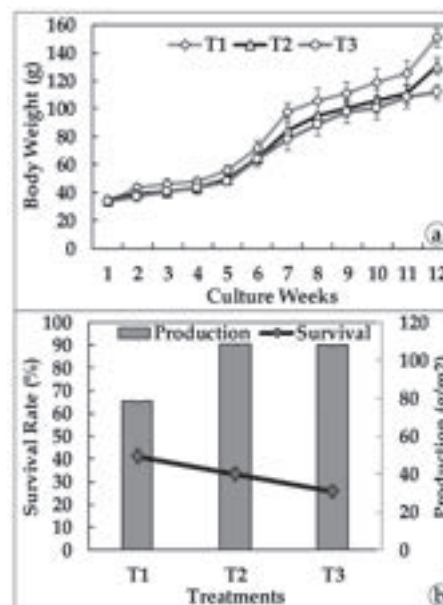


Figure 1: (a) Growth performance; (b) Survival and production of mud crab (*S. olivacea*) grown in rice-crab culture system under different stocking densities

ADOPTION OF IMPROVED SALT-SHRIMP (*Penaeus monodon*) INTEGRATED AQUACULTURE PRACTICES IN TRADITIONAL SALT PRODUCTION AREAS OF COX'S BAZAR

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Development of appropriate technologies to integrate aquaculture in salt farms are required to reduce risk, diversify income, increase food security and nutrition uptake and generate employment for the salt farmers in Cox's Bazar district. The baseline of shrimp aquaculture production in the area is 100 kg per ha. The objective of the study was to assess the production performance of shrimp monoculture in six newly constructed aquaculture ponds (218.7±124.2 m²) in the salt farms at Cox's Bazar Sadar and Teknaf sub districts. Specific pathogen-free (SPF) shrimp (*Penaeus monodon*) were stocked @ 4 post larvae per square meter and reared for 90 days during March-May in 2021 and 2022. Water quality including water temperature (°C) and salinity (g/l) were recorded daily, dissolved oxygen (DO) (mg/l), transparency (cm), water level (cm), water pH, ammonia (mg/l), alkalinity (mg/l), phosphate (mg/l), nitrite (mg/l) and nitrate (mg/l) were recorded weekly, and growth and health status (visual observation the clinical signs of diseases) were recorded fortnightly. Shrimp were fed with a commercial diet of a national fish feed company. Analysis of physical and chemical attributes of water quality in the ponds showed significant differences in temperature (°C), salinity (g/l), dissolved oxygen (mg/l) and transparency (cm) between the ponds at Cox's Bazar Sadar and Teknaf but were within the recommended ranges of shrimp culture. In 2022, a higher survival rate and production were found in both locations compared to 2021 (Table 1). The better results in 2022 could be explained by improved routine management including timely feeding, water quality monitoring and health status monitoring. The improved technologies showed a 500% increase in shrimp production compared to baseline. Further improvement and dissemination of technologies can be achieved through training of the farmers and availability of the resources to improve management and biosecurity (quality post-larvae, feed and water quality monitoring).

Table 1. Mean weight, survival rates, production and feed conversion ratio (FCR) of two production cycles both in Cox's Bazar Sadar and Teknaf (n=6)

Production year	Number of ponds	Days of Culture (DoC)	Mean weight (g)	Survival rate (%)	Production (kg/ha)	FCR
2021	6	90	21.1±2.3	45.8±12.3	402±174	2.1±0.5
2022	6	90	18.6±2.0	79.4±10.4	590±112	1.3±0.1

USING OF FERMENTED WATER SPINACH MEAL (FWM) AS A PROTEIN SOURCE IN FISH FEED FOR THE REPRODUCTIVE PERFORMANCE OF FEMALE SINGHI (*Heteropneustes fossilis*) BROODSTOCK IN CAPTIVITY

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The identification and development of the new candidate of plant-based ingredients from the haor as an alternative protein source to fish meal has received sustainable interest in the aquaculture feed industry. The aim of this study was to investigate the physical, biochemical and bacteriological properties of dietary fermented water spinach meal (FWM) diets and its impacts on the growth and reproductive performance of female Singhi (*Heteropneustes fossilis*) broodstock in captivity. Five isonitrogenous (30% crude protein) diets were formulated at different percentages of 0%, 25%, 50%, 75%, and 100% of FWM coated on the fish feed pellets. The physiological properties of FWM diets were evaluated by using various tools and formulae additionally to analyze bacterial quantification by bacterial plate culture method. The reproductive performance of Singhi broods was measured by using different formulae and histological tools. The mean value of the physical properties of test diets was highly significant ($p < 0.05$) among the treatments. The number of total bacteria and lactic acid bacteria were significantly ($p < 0.05$) increased with the increase of FWM inclusion in test diets. The growth performance, feed utilization, and reproductive variables of fish were significantly ($p < 0.05$) varied among the treatment groups. Moreover, the significantly ($p < 0.05$) highest oocytes weight, fertilization, egg ripeness, and ovipositor diameter were observed in the treatment of 50% of FWM diet hold brood fish. The spawning response was up to 100% in all treatments except for the control group (66.67%). The mid-intestinal histological tissue slides demonstrated that the 50% FWM diet-treated brood fish intestine had an unbroken epithelial barrier with more goblet cells and a very well-equipped villi structure, tunica muscularis in comparison with other brood fish fed treatments. These results, therefore, provided a novel insight into 50% of FWM inclusion level as a protein supplement for the aquaculture feed formulation for better growth and reproductive performance of Shing broodstock development in captivity.

EFFECTS OF FISH PROTEIN HYDROLYSATE (FPH) ON THE GROWTH PERFORMANCE, BLOOD BIOCHEMISTRY, LIVER AND INTESTINAL HISTOPATHOLOGY AND DISEASE RESISTANCE TO *Aeromonas hydrophila* OF PABDA (*Ompok pabda*) FRY IN CAPTIVITY

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This research was carried out to analyze the physiological, biochemical, and bacteriological study of FPH-treated experimental diets and its effects on growth, haematology, serum biochemistry, liver, and gut histology, and challenge study against *Aeromonas hydrophila* infection in catfish Pabda (*Ompok pabda*). Four isonitrogenous diets (35% crude protein) were formulated by adding FPH at levels of 0% (control diet), 0.5%, 1%, and 2% coated on feed pellets through the spray technique. The feed's physical properties especially feed diameter and pellet durability index were significantly ($p < 0.05$) varied among the treatment groups while expansion ratio, bulk density, floatability, and water stability of feeds were not significantly ($p > 0.05$) influenced by FPH diets. Furthermore, the diets containing 1% and 2% FPH were more palatable in comparison with other experimental diets. The total bacteria (TB) in test diets and fish guts followed an increasing trend with the increase of various levels of FPH on test pellets. The significantly ($p < 0.05$) highest body weight, specific growth rate, total biomass, survival rate, condition factor, hepatosomatic index, and intraperitoneal fat were noted in 2% FPH fed group fish when compared with those fed with other test diets. The feed intake of fish was significantly ($p < 0.05$) increased with increasing the FPH inclusion in diets. The mean value of platelet, procalcitonin, and blood glucose were significantly higher in the 2% FPH treated fish group. However, the lowest mean value of creatinine, serum glutamic pyruvic transaminase (SGPT), urea, serum glutamic oxaloacetic transaminase (SGOT), cholesterol, total protein, and globulin content of blood serum was found in the control diet but no obvious trend was followed among the test groups. The histopathological observation of mid intestine displayed that 2% of FPH diet-fed fish had a well-anchored epithelial wall with well-arranged goblet cells, long villus structure, stratum compactum, and tunica muscularis compared to other treatments. The inclusion of FPH in diets up to 2% significantly improved the liver health of fish. The fish fed with 2% FPH had a significantly higher ($P < 0.05$) relative percentage survival (76.19%) against *A. hydrophila* infection in the bacterial challenge test. Therefore, the present results recommended that using 2% FPH in the aquafeed industry improves the growth performance, health status, and disease resistance of Pabda catfish in captivity.

STATUS AND PROSPECTS OF CAGE CULTURE IN INLAND OPEN WATERS OF INDIA WITH SPECIAL EMPHASIS ON PANGAS (*Pangasianodon hypophthalmus*)

A.

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Fisheries and aquaculture are the sun rising sector of India, striding at a faster rate towards achieving 2nd Blue revolution by 2022 onwards accomplishing an overall production of 14.73 million metric tones (mmt) fish during 2020-21, where inland fish production occupies the lion's share (11.25 mmt; >76.37%) with 56 folds increase from 1950-51 (0.2 mmt). Pangus (*P. hypophthalmus*), a native of Mekong river in Vietnam, now well established in South-East Asia-Thailand, Malaysia, Indonesia, and China which was introduced in India during 1994-95 via Bangladesh (1989) through Thailand. Since last 20 years the culture of Pangus has been spread via West Bengal to undivided Andhra Pradesh to 20 States of India with a production of 0.85 mmt of which 80% comes from land based pond system and the remaining from cages specially in reservoirs. The culture of this species is a profitable venture because of their high stocking density, year-round production barring severe winter months in winter driven States, quick growth, and high productivity. The fish provides ample protein supplement to rural poor mass in this sector of the world because of low market price coupled with significant demand. Accordingly, a large number of rural people living below the poverty line find employment in production as well as marketing systems for this species. India is no exception to that. The fish is a very good candidate species in cage farming installed in Indian reservoirs of medium and large category covering >23 lack ha of which only 0.1% area will be brought under cage culture so as to save the ecosystem from being eutrophied keeping biodiversity intact, which showed immense scope of horizontal expansion of its farming. ICAR-CIFRI has been instrumental in disseminating the technology of cage farming of Pangus across India since 2010 onwards and engaged in providing technological support to 20 States with 25000 numbers of freshwater cages in functional mode installed in reservoirs and some deeper wetlands. It is estimated that >65,000 mt Pangus is being produced from cages in India. The PMMSY (Pradhan Mantri Matsya Sampada Yojana), a flamboyant scheme with budgetary allocation of 20,050 crores under Deptt of Fisheries, GoI has been in place since May, 2020 till 2025 to provide active financial support for all round development of fisheries and aquaculture sector has allocated 800 crores especially for cage culture in Indian reservoirs with 40% subsidies to the beneficiaries where additional 20,000 cages will be installed. New areas are coming under Pangus culture in sub-tropical part, where technological packages are being modified accordingly, as the species though very hardy in nature, can't withstand cold being susceptible to multipronged attack by different pathogens with the onset of winter. The package of practice has been modified accordingly befitting to the selective sites of different States. The need of the hour is to stabilize the fluctuations in prices of this species in the market imbibing post-harvest value chain, cold chain development, filleting, maintaining sustainable supply to Hotel & restaurants across India in a holistic manner involving other ICAR-Fishery Institutes besides Line Departments of different States. Because of tremendous domestic market potentials of this species right from Kerala to Dibrugarh, the fish is available in bulk quantities in >220 markets. So, it is high time for processing units to add value to this filleting as to overcome or combat import of this species from Vietnam to sustain its production. ICAR-CIFRI's endeavour in maintaining sustainable production of this species through cage culture across India with need-based modifications of package of practices including fabrication of low cost eco-smart cages would be of immense help in making the cage culture technology for this species acceptable and suitable in different regions.

The background of the page features a stylized, layered mountain range in shades of gray. The mountains are depicted with soft, rounded peaks and are arranged in a way that creates a sense of depth and perspective. The overall aesthetic is clean and modern, with a focus on natural elements.

Technical Session 2:
**Aquatic Resource Management
and Conservation**

AQUATIC RESOURCES AND DISASTER IN COLDWATER FISHERIES IN NEPAL

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Nepal is a landlocked country; hence, it has only freshwater resources. Water resources cover around 0.15% of the world's freshwater surface area and 5.6% of the total surface area of the country. About 48% of the wetland is occupied by a running river system, which drains 828,171 ha of land in Nepal. Nearly half of the wetlands (45%, standing water bodies) are located in the Himalaya due to the occurrence of a large number of glaciers and glacial lakes. The rest coverage of standing water bodies are located Terai and Siwaliks (DoFD, 2012). Distribution, types, water quality, quantity and fish diversity in the water bodies vary with geographical regions viz Himalayas in the north, hills in the middle and the Terai (plain) in the south. There are 252 fish species (236 indigenous, 16 exotic), 9 crab species, 3 prawn species, 5 mollusk species, 53 amphibian species, 47 reptile species, 193 bird species and 84 macrophytes. Aquaculture is done in approximately 1.5% water surface area and 11 fish species are cultured. Current fisheries production is 104,623 tons where captured fisheries contributes 20%. Habitat destruction, over fishing, water pollution, dam construction obstructing fish migration for spawning and use of harmful fishing gears such as electrofishing, poisons are the major reasons behind decreased fish population and catch. Aquaculture and capture fisheries contribute 4.2% to the national Agriculture Domestic Product and 1.6% to the Gross Domestic Product. Current fish consumption is 3.4 kg per caput (CFPCC, 2022) which is almost six times lower than global fish consumption.

Cold water local fish population and fish diversity is decreasing gradually. Twenty one fish species have been listed red by International Union for Conservation of Nature (IUCN). Out of which 15 are cold water fish and among them 3 are critically endangered, 1 is endangered and 4 are vulnerable. Disasters such as floods, earthquakes and landslides caused huge damage to Rainbow trout farm and incurred great loss. Mega earthquake in 2015 destroyed 52 Rainbow trout farms and 422 raceways in Nuwakot, Rasuwa and Sindhupalchok districts with loss of 1.04 million USD. Around 52 tons of Rainbow trout were lost from eight farms of Kaski and Sindhupalchok districts due to flood while the landslide washed out nine Rainbow trout ponds in Sindhupalchok in 2021. As the risks of future disasters remain high, there is an urgent need to work on preparedness and risk reduction urgently.

LIFE-HISTORY TRAITS OF ASIAN STRIPED DWARF CATFISH, *Mystus tengara* (BAGRIDAE) IN THE PAYRA RIVER, SOUTHERN BANGLADESH

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The Asian striped dwarf catfish, *Mystus tengara* (Hamilton, 1822), belongs to the family Bagridae is a commercially important small indigenous fish species of Bangladesh. This study offers first comprehensive explanation on life history traits of *M. tengara* specifically; length-frequency distribution (LFD), length-weight relationships (LWRs), length-length relationship (LLR), form factor ($a_{3.0}$), size at maturity (L_m), age at maturity (t_m), condition factors (Fulton's K_F and relative K_R), prey-predator status through relative weight (W_R), natural mortality (M_w) and optimum catchable length (L_{opt}) using multi-model indices from the Payra River in southern Bangladesh.

Total 345 individuals of *M. tengara* were occasionally sampled (ranging between 4.0 to 15.2 cm total length (TL), and 0.76 to 28.38 g whole body weight (BW)) through different fishing gears during January to December 2021. The maximum number (27.25%) of its population stands at 8.00 to 8.99 cm TL size group. Exponential (b) of LWRs exhibits negative allometric growth pattern ($b < 3.0$), with r^2 values ≥ 0.950 (Table 1). The calculated $a_{3.0}$ was 0.008, indicating this fish is elongated in body shape and the W_R indicates that the habitat was imbalanced with higher predators. The K_F value ranged from 0.65 to 2.25 and K_R varied from 0.62 to 1.93. The L_m and t_m for combined sexes of *M. tengara* were estimated as 9.19 (~9.2) cm TL and 0.85 year, respectively. Moreover, the estimated M_w and L_{opt} were 1.23 year⁻¹ and 10.74 cm TL (Figure 1) for *M. tengara* in the Payra River.

Thus, the results of the present study could be used in the future for improved management of this species in Payra River, as well as for linking ecosystems.

Table 1. Descriptive statistics and relationships of length (cm) and body weight (g) of *Mystus tengara*

Measurement	n	Minimum	Maximum	Mean \pm SD	95% CI	
TL (cm)	345	4.00	15.20	8.83 \pm 2.36	8.59-9.07	
SL (cm)		3.10	11.90	6.54 \pm 1.80	6.45-7.03	
BW (gm)		0.76	28.38	8.29 \pm 6.34	7.62-8.96	
Formula	a	b	a (r95% CI)	b (r95% CI)	r ²	GP
BW = a \times TL ^b	0.0159	2.79	0.0159 to 0.0182	2.73 to 2.86	0.959	A-
BW = a \times SL ^b	0.0346	2.76	0.0304 to 0.0393	2.69 to 2.83	0.950	A-
TL = a + b \times SL	0.2685	1.25	0.1525 to 0.3845	1.23 to 1.27	0.985	A*

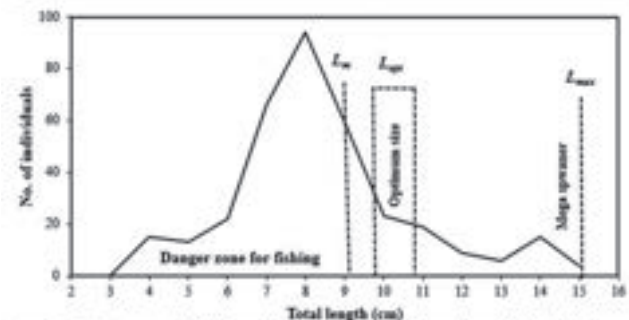


Figure 1. Optimum catchable length of *Mystus tengara* (Hamilton, 1822) in the Payra River (L_m = length of sexual maturity, L_{opt} = optimum catchable length, L_{max} = maximum length).

PRESENT STATUS OF FISH DIVERSITY, THREATS AND MANAGEMENT OF NOAKHALI COASTAL RIVER-CHANNEL

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This investigation was carried out from November 2020 to February 2021 to assess the fish diversity status of the fishing community of the Noakhali Khal region based on the spot data collections, Different PRA (FGD, GD, KI) tools were used to collect data among the target groups in the sampling sites. A total of 72 species were found in the study area. Among 26 families, Cyprinidae was the most dominant family comprising 22 species followed by Bagridae(5 species) and Clupeidae (5 species), Channidae (4 species), Ambasiidae(3 species), Gobiidae(3 species), Notopteridae (3species) Mastacembelidae (3 species) and Siluridae (3 species) were dominant. The Order Cypriniformes was found as the most diversified fish group regarding both the number of species and individuals and the order Perciforms ranked as the second. Among the collected species, most fishes have relatively high economic value in Bangladesh. Among the total number of species recorded according to local conservation status 1 species were critically endangered (CR), 5 species were endangered (EN), 7 species were vulnerable (VU), 41 species were the least concern (LC), 8 species were near threatened (NT) and 10 species were data deficient (DD). According to global conservation status, 2 species were vulnerable (VU), 44 species were the least concern (LC), 4 species were near threatened (NT), 11 species were data deficient (DD), and 11 species did not evaluate (NE). Maximum (61) species were recorded from Lala Nogor and a minimum (14) from Chowmuhni. For the sake of fish biodiversity conservation and the protection of the Noakhali Khal, the appropriate authority should place a high priority on enforcing existing fisheries laws and increasing the awareness of local people.

CHALLENGE OF AQUATIC RESOURCES MANAGEMENT IN BANGLADESH

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Ecosystem is an ecological unit consisting of a biotic community (an assemblage of plant, animal, and other living organisms) together with its abiotic environment (soil, precipitation, sunlight, temperature, slope of the land, etc.). An ecosystem includes indicators of habitat, species and resources, such as water and its physicochemical characteristics. Aquatic resources of Bangladesh belongs to a. Inland Open Water (Capture): River and Estuary, Sundarbans, floodplains, Beel, and Kaptai Lake b. Inland Close Water (Culture): Pond, Seasonal cultured waterbody (Paddy Field/ Floodplain and Boropit), Baor, Shrimp, Prawn and crab Farm, Pen Culture and Cage Culture c. Marine Fisheries Industrial and Artisanal. Data and information sources are used from the direct interview with individual, publication of the Department of Fisheries (DoF), internet and related non-published grey literature. The country has an inland water area of about 4.72mill.ha and about 710 km long coastal belt. Fisheries sector contributes 3.57% to the national GDP, 25.30% to the agricultural GDP and more than 2.0% to the total export earnings. The target of fish production was crossed by producing 4.621mil.mt in 2020-21, whereas in 2020-21, inland culture fisheries contribute 57.10% to total fish production. This sector has been contributing about 60% animal protein in daily dietary requirement comes from fish. Bangladesh is blessed with an enriched aquatic diversity, comprising almost 260 freshwater fish species and 730 marine water fish species with other aquatic lives. In recent years, the fisheries resources is faced with challenges posed by numerous natural and anthropogenic causes such as climate change, natural disaster, environmental pollution, industrialization, overfishing, using destructive fishing gears, pesticide and agrochemicals. So, some important national program and biological management technology is developed for fish production and open water management to restrict the declination of resources and enhance production.

DIVERSITY AND SEASONAL VARIATIONS OF MACRO-BENTHOS COMMUNITIES IN RELATION TO HYDROLOGICAL PARAMETERS OF PASUR RIVER ESTUARY, KHULNA, BANGLADESH

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The main purpose of this study is to gather a baseline database of the macro-benthic assemblages and using them as a biological index for coastal waters. Seasonal samples were collected from January' 2021 to December' 2021 including three different seasons. All the environmental parameters showed significant ($P < 0.01$) differences among seasons. Water temperature, transparency, salinity, alkalinity, TDS were significantly higher during pre-monsoon season, whereas the value of pH, DO, $\text{NO}_3\text{-N}$ and $\text{PO}_4\text{-P}$ were higher during post-monsoon season and lower during monsoon except DO. During the study period silt was dominated in the study area followed by clay and sand. For organic matter maximum and minimum value were observed during post-monsoon and monsoon season respectively. PCA biplot of the environmental parameters explained 49.4% and 39% variability of the data, thus accounting for 88.40% of cumulative data variability. A total of 47 species belonging to 35 families of macro-benthos were collected during the study period. Species accumulation curves by rarefaction showed post-monsoon to be more speciose (41) than pre-monsoon (34) and monsoon (27). Significantly higher species density was also recorded during post-monsoon season (545 ind./m²) followed by pre-monsoon (214 ind./m²) and monsoon season (63 ind./m²). Species diversity and evenness were significantly higher during post-monsoon season and the lowest during monsoon season. Analysis of similarity (ANOSIM) indicated significant difference in species assemblage of Pasur river estuary among the seasons ($R = 0.7222$, $P = 0.0005$) which was visualized in non-metric multidimensional scaling (NMDS) plot. SIMPER analysis detected *Dendronereisae stuarina* was the most contributory species for overall average dissimilarity among the seasons. Macro-benthos collected during study period was categorized into 4 Shreedrs (SH), 10 Scrapers (SC) and 5 Filtering collectors (FC), 10 Gathering collectors 3 Omnivore (OM) and 15 Predator (PR). GC represents the highest total density (221.83 ind./m²) and relative abundance (26.97%) among the other FFGs. Among the environmental variables, DO and percentage of silt concentration in the bottom were positively correlated with *Pristina acuminata*, *Lumbrinerissp.*, *Cossuracoasta*, *Capitellacapitata*, *Neritinaviolacea*, *Laccotrephesgriseus*, *Hydrometrabutleri*, *Gomphussp.* and *Libellulasp.* All the findings of the present study concluded that the assemblage of macro-benthos is largely influenced by environmental parameters.

SPATIAL AND TEMPORAL VARIATIONS OF ZOOPLANKTON ABUNDANCE AND DIVERSITY IN THE SHARI-GOYAIN RIVER

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The zooplankton community of freshwater bodies consist of an immensely diversified assemblage of organisms. Many Bangladeshi scientists' and researchers have carried out many extensive works on diversity and seasonal variation of zooplankton in different freshwater bodies of Bangladesh. But, acquaintance about the zooplankton present in Shari-Goyain River of Sylhet district, is not yet cognizant.

The present study was conducted during December 2018 to November 2019. Samples were collected monthly from five incoherent sites. It was more abundant in pre-monsoon (20333 ± 1470 individuals/l) and post-monsoon season (16667 ± 1538 individuals/l) (Figure-1). The highest and the lowest abundance was recorded in Jalurmukh and Sharighat respectively. A total 18 genera of zooplankton under 8 major classes such as Copepoda (2), Cladocera (5), Rotifera (5), Ostracoda (2), Branchiopoda (1), Tubulinea (1), Monogonta (1) and Euratoria (1) were recorded during the study period. Cladocera (37%) was highest in number comparing Rotifera (28%) (Figure-2). Analysis of the zooplankton community structure in the five sampling sites based on the abundance of the different genera revealed distinct differences in species assemblage seasonally. Present studies focused towards the understanding of the plankton diversity, ecology and their importance as fish food, bio-indicators of water quality and to assess the trophic status of the waterbody.

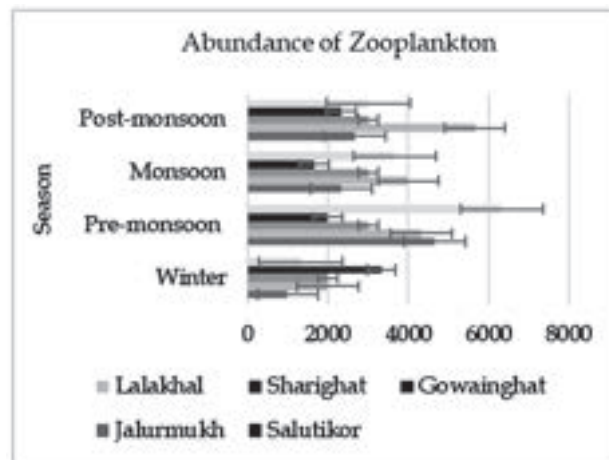


Figure 1: Comparative abundance (\pm SD) in different sampling sites and seasons

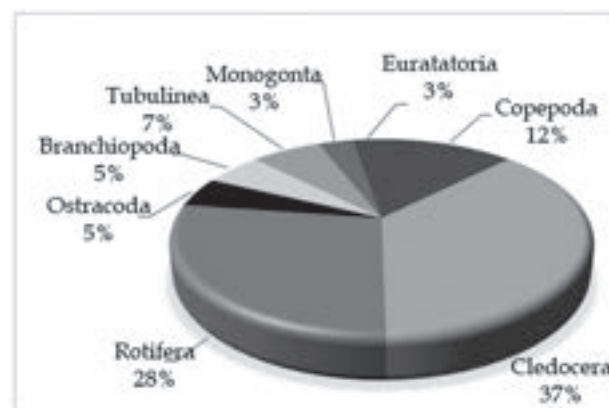


Figure 2: Percentage of zooplankton diversity under different classes in the Shari-Goyain River

MONITORING SPATIO-TEMPORAL CHANGES OF THE FLOATING VEGETATION IN BAIKKA BEEL BY USING LANDSAT 8 DATA

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This study aimed to monitor the Spatio-temporal changes of floating weeds in Baikka Beel by using Landsat images. The introduction of new generation sensors such as Landsat 8 which provide viable options for reliably detecting, mapping and estimating the distribution of floating vegetation in Baikka Beel. Landsat images from 2013-2020 were used, considering the month of January and February when cloud cover percentage was less than 10. Both supervised and unsupervised image classification are used to categorize distinct characteristics in the Landsat images. The result revealed a variable but a considerable amount of floating vegetation in Baikka Beel. The area covered by floating vegetation 0.7803 km² (79.47%) in 2014, 0.5022 km² (51.15%) in 2015, 0.3222 km² (32.81%) in 2016, 0.4995 km² (52.30%) in 2017, 0.3267 km² (32.27%) in 2018 and 0.5931 km² (60.40%) in 2020. The highest amount of floating vegetation was observed around 0.7803 km² (79.47%) in 2014 and the lowest amount noticed was about 0.3267 km² (32.27%) in 2018. These maps are shown the efficiency of remote sensing for detecting invasions, assessing infestation levels, monitoring speediness and measuring the efficacy of weed mitigation strategy.

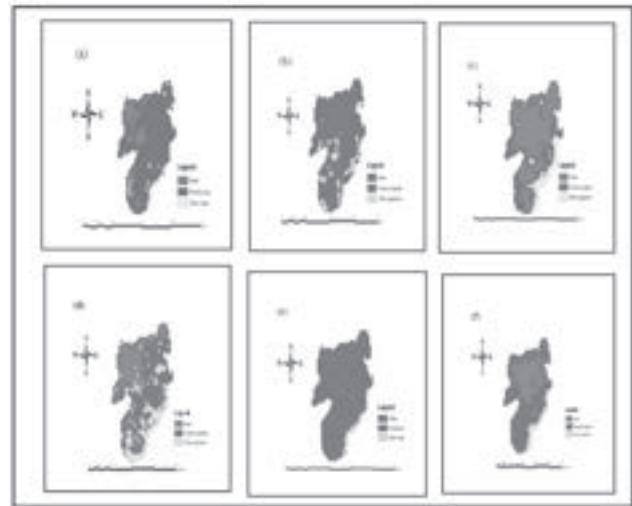


Figure01: Supervised Images (a) January, 2014, (b) February, 2015, (c) January, 2016, (d) January, 2017, (e) January, 2018, (f) January, 2020

WATER POLLUTION THREATENS FISHERIES RESOURCES IN THE SHARI-GOYAIN, A TRANSBOUNDARY RIVER BETWEEN INDIA AND BANGLADESH

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In Bangladesh, rivers are one of the main habitats for aquatic life, which are nowadays greatly polluted, causing changes in the riverine ecosystems. In extreme cases, fish mortality occurs when excess amounts of pollutants mix with the river water. In 2019, two mass mortality incidents of fish occurred in the transboundary Shari-Goyain River in the north-eastern region of Bangladesh. Data were collected from six sampling sites by direct catch assessment during those fish mortality incidences as well as by personal interviews, focus group discussions, and key informant interviews from March to May 2019. During the investigation, a total of 38 species of fish were recorded and categorized into three groups, where 14% of fish were dead, 56% were moribund, and the remaining 30% were less affected. Local fishers and other residents claim that coal mine pollutants from upstream are the primary cause of water quality deterioration and sudden fish mortality, and they have witnessed similar incidents in recent years, which have been accompanied by visible flushing of coal with flash flood water from upstream. Within three decades, many indigenous fish species of the river have disappeared, mainly due to coal mine drainage pollution. To support the findings, six water quality parameters, viz. water temperature, dissolved oxygen, conductivity, total dissolved solids, pH, and transparency, were measured throughout that river during those incidences. The parameters of the river water were found to be fluctuating and some of them, especially pH (3.87-6.61), were badly crossing the suitable limits for the survival of aquatic flora and fauna. Therefore, a few continuous water quality monitoring sites throughout the river should be put up, along with comprehensive ecological observations, to notice any repeat incidents and to precisely determine the source of such fish mortality outbreaks in the future. Finally, immediate steps should be taken to find a solution for conserving the Shari-Goyain River ecosystem by creating a joint team with a combination of researchers and administrators from both Bangladesh and India.

GEOSPATIAL ANALYSIS OF DEFORESTATION IN LAKSHMI BAOR FRESHWATER SWAMP FOREST OF BANGLADESH USING MULTISENSORY SATELLITE IMAGERIES

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The Lakshmi Baor swamp forest (LBFSF) is a freshwater swamp forest in Bangladesh's north-eastern region that is inhabited by a plethora of biodiversity, including a wide range of indigenous fish species. The objective of the study is to measure changes in land use/cover (LULC) in the LBFSF in order to illustrate forest degradation circumstances. To accomplish this goal, LULC changes within the LBFSF were discovered and categorized, and LULC maps were produced over a two-decade time span. The LULC was identified using the normalized difference vegetation index (NDVI) and Landsat 7 and 8 satellite data from 2000 to 2020. Using maximum likelihood supervised classifiers, images were classified into four LULC classes: forest, sparse vegetation, bare land, and water. A post classification change detection approach was used to construct LULC maps from 2000 to 2003, 2003 to 2018, 2018 to 2020, and 2000 to 2020. The NDVI-derived LULC classifications of the analysed years reveal that forest area has altered dramatically (59.68% to 43.77%) during the previous two decades. According to the categorization, the sparse vegetation area remained stable (24.28%), bare land expanded significantly (14.44% to 26.71%), and water area rose somewhat (1.60% to 5.24%). The overall accuracy of the NDVI-derived classification was 86%, and the kappa statistic was computed to be 80.81%. According to the findings, the LBFSF is suffering persistent forest degradation as a result of natural and human activities. The analysis of remotely sensed data in this work will help academics, policymakers, and development practitioners understand the magnitude and character of long-term LULC change in the forest. This one-of-a-kind environment may be safeguarded by designating it as a protected area and applying long-term sustainable resource management strategies.

A STUDY ON THE DIVERSITY OF REEF-ASSOCIATED FISHES OF BANGLADESH

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Saint Marin's Island (SMI), is the only sedimentary continental island in Bangladesh. We have conducted an ichthyological survey to assess the reef-associated fish species on this island. In this survey, we have identified and recorded 141 species of reef-associated fishes of 56 Families under 20 Orders. Among them, 37 species of reef fishes were recorded for the first time in Bangladesh and one is discovered as a new species to the science during the current study. In this study, we also obtained 221 DNA sequences from 100 species of which 179 sequences (96 species) were obtained from the COI gene and 42 sequences (26 species) obtained from the 16S rRNA gene region. The COI sequences of those 96 species comprised 145 haplotypes with 337 polymorphic sites. The mean genetic distances within species, genera, and families were 0.34%, 12.26%, and 19.03%, respectively. In the case of 16S rRNA sequences, 42 sequences of 26 fish species comprised 31 haplotypes containing 241 polymorphic sites. The mean genetic divergence within species, genera and families was 0.94%, 4.72% and 12.43%, respectively. This study is a significant contribution to the fisheries statistics of this ecologically critical area (ECA) and Marine Protected Area (MPA) of Bangladesh which would facilitate the assessment of species catch composition and hence for strategizing management plans. It is also an important input to the DNA barcode library of reef fishes of the northern Bay of Bengal.

REPRODUCTIVE ASPECTS OF MONSOON RIVER PRAWN, *Macrobrachium malcolmsonii* IN RELATION TO ECO-CLIMATIC FACTORS FOR ITS MANAGEMENT AND CONSERVATION

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Prawns are regarded as delicious food items and source of income as it is the salient exportable fisheries items of Bangladesh. Climate change may inhibit the general physiological activity of prawns. This study explores the eco-climatic effects on reproduction including size at first sexual maturity (L_m), spawning season and fecundity of prawn species. A case study was carried out on *Macrobrachium malcolmsonii* (Edwards, 1844) as a representative species in the Padma River, Northwestern Bangladesh during January to December 2014. Male individuals were identified through presence of masculinae (an appendix) on second pleopod for excluding from analysis. Body weight (BW) and total (TL) and carapace length (CL) were measured with 0.01 g and 0.01 cm accuracy. Size at first sexual maturity (L_m) was determined through the logistic model, relative growth of TL vs. CL and relationship between the percentage occurrence of ovigerous females (embryos attached with pleopods) against its TL class. The spawning season of *M. malcolmsonii* was estimated by monthly percentage occurrence of ovigerous female. Correlations among eco-climatic factors and spawning season were assessed. Fecundity was estimated from female larger than the size of L_m . A number of 757 specimens of the ranged 0.80 g to 18.27 g BW and TL ranged from 4.20 cm to 11.52 cm were analyzed. The L_m was estimated as 6.2-6.6 cm. The spawning season was estimated from April to October with peak in July. Significant correlation found between rainfall and ovigerous female *i.e.*, spawning season. Ovigerous female increased in 100 mm average rainfall and maximum ovigerous female spawned at 250-320 mm rainfall. Spawning season may be shifted with shifted of the rainy season as a result of climate change. Similar effects might be occurred for other prawn species. Total fecundity was maximum than earlier studies and ranged from 2743 to 122165 with a mean value of 6715 ± 2437 . Findings of our investigation would be very useful for sustainable management of prawn fishery including *M. malcolmsonii* in the Padma River, Bangladesh and adjoining countries considering the eco-climatic factors.

FISH DIVERSITY IN RELATION TO SALINITY GRADIENT IN THE BHADRARIVER ESTUARY, SUNDARBANS, BANGLADESH

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Variation in salinity is one of the major environmental factors influencing species diversity patterns of fish in an estuary. Therefore, evaluating the general trend of the relationship between salinity gradient and species diversity is an important task. In this present study, the diversity of fish was assessed in relation to salinity gradient in the southwest (Bhadra River Estuary, BRE) coastal region of Bangladesh. Fish diversity was assessed by fish sampling from the artisanal catch of the fishermen and visiting local fish markets from June 2019 to July 2020 in the BRE. During the dry season, mean salinity was 14.96 PSU whereas during the wet season it was 0.53 PSU in the study area. A total of 31 fish species belonging to 12 orders were identified in the BRE where 18 species were found during the dry season, and 14 species were found during the wet season. Among the fish species, *L. parsia* species was found in all the sampling months indicating that this fish is polyhaline (0.2~23 PSU). *O. pama*, *A. gagona*, *H. nehereus* and *L. savala* were abundant in brackish water condition (13~23 PSU). *M. rosenbergii*, *M. cephalus* and *P. canius* were found in brackish water where salinity ranged from 4.7~9.2 PSU. *A. latus* and *C. nama* were found in freshwater conditions (0.3~0.7 PSU). Moderate fish diversity was found during the dry season due to brackish water condition (salinity 13~23 PSU), and poor fish diversity was found during the wet season due to freshwater condition (salinity <0.5 PSU) in the study area. Based on salinization of the BRE, the suitability index indicates that commercially important fish species such as *L. calcarifer*, *M. rosenbergii*, *P. indicus*, and *P. monodon* are feasible for mariculture during the dry season (January-May); and *C. striata*, *M. gulio*, *M. vittatus*, and *P. hypophthalmus* during the wet season (July-October). The findings of this study will be useful in developing policies for the conservation and management of the aquatic resources of the coastal region to enrich our blue economy.

LARVAL REARING OF TILAPIA (*Oreochromis niloticus*) AT DIFFERENT LEVELS OF FEEDING IN BIOFLOC CULTURE SYSTEM

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A 98-day experiment was conducted to determine the growth and feeding of tilapia larvae (*Oreochromis niloticus*) in Biofloc system. The experiment was performed in fiber glass indoor tanks with four levels of treatment viz. T1 (control), T2 (normal level of feeding + floc), T3 (25% feed reduction + floc), T4 (30% feed reduction + floc) with 3 replications of each. Fifty tilapia larvae (0.5g/fish) were stocked in 100L of water in each tank and provided a diet of 3% body weight commercial tilapia feed. In this study, Biofloc has a positive impact on maintaining the water quality parameters specially the maintenance of ammonia. There are no significant differences observed in growth among the treatments. Although feeding is reduced to 25% and 30% in T3, T4 respectively, the growth was relatively higher in T3 and T4 than others. However, the FCR of T3, T4 is significantly different ($P < 0.05$) than T1 and T2 respectively. Mostly, there were no significant differences observed among hematological parameters between control and Biofloc treatments. Tangling of floc in the gills in the early life stage of tilapia, sudden reduction of DO and fluctuations of ammonia are the main barriers of larval rearing of tilapia in Biofloc system. We advise to start fish culture in Biofloc technology with larger size fish fingerlings rather than fish larvae. Further research should be initiated to find the best stocking density and feeding level in Biofloc in a better experimental setting.

Parameter	T1 (Control)	T2 (normal feeding +floc)	T3 (25% feed reduction+floc)	T4 (30% feed reduction +floc)
Initial Individual Weight (g)	0.53±.15	0.53±.21	0.53±.17	0.53±.14
Final Individual Weight (g)	10.94±.66 ^a	10.10±.59 ^a	10.02±.52 ^a	9.87±.26 ^a
No. of Fish/tank	50	50	50	50
Survival rate (%)	74%	84%	86%	86%
FCR	1.03±0.44 ^a	1.46±0.25 ^a	0.79±0.068 ^b	0.70±0.04 ^c
SGR	3.15±0.04 ^a	3.07±0.04 ^a	3.05±0.03 ^a	3.03±0.02 ^a
PER	0.69±0.02 ^a	0.94±0.19 ^a	0.59±0.04 ^a	0.54±0.02 ^a

STATUS OF AGROCHEMICALS USE IN MANU RIVER PROJECT AT MOULVIBAZAR SADAR UPAZILA OF NORTHEASTERN BANGLADESH AND FARMERS' ATTITUDE TO ITS IMPACT ON THE FISHERIES RESOURCE

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The study was conducted to investigate the mode of fertilizer and pesticide use in Manu river project area and their impact on fisheries resources surrounding Kawadighihaor area. The data were collected through a structured questionnaire from two Union of one hundred forty farmers at Moulvibazarsadarupazilla in Sylhet during April to September 2016. Paddy was the main crop in that area where fertilizers and pesticides are being intensively used to boost up the production of crops. Fertilizers like urea (0.200 ± 0.025 mt/ha), TSP (0.133 ± 0.0145 mt/ha), and MoP (0.102 ± 0.015 mt/ha) and pesticides like Basudin (14.7 ± 0.431 kg/ha), Sure (14.6 ± 0.432 kg/ha), Morfos (3.79 ± 0.257 l/ha), Diazinon (14.8 ± 0.447 kg/ha), Cup (0.97 ± 0.126 l/ha), Karate (0.725 ± 0.044 l/ha), and Brifer (9.93 ± 0.743 kg/ha), Sixer (3.78 ± 0.245 l/ha), Thrive (3.81 ± 0.265 l/ha), Ustad (1.09 ± 0.115 l/ha), were mainly used by farmers in the rice fields around the *haor*. Farmers of this area used to apply inappropriate doses of fertilizer rather than the standard. In this area, pesticide usage had become more than double (2.03 times) from 2010 to 2015. Some of 20.10% respondents used IPM (Integrated Pest Management), 57.85% only know about IPM and 22.14% do not know. Among the farmers, 57.85% were not willing to practice of IPM due to various reasons. Of the respondents 72.14% opined that pesticide use was increasing day by day to maintain the crop production level having harmful effect. A 42.85% respondents could identify diseases while 57.14% couldn't. Due to indiscriminate use of fertilizer and pesticides, the environment of the *haor* was undergoing gradual changes. All the respondents agreed that mentioned chemicals used in agriculture reaches Kawadighihaor through run off and 6% respondents opined that some fish mortality incidence occurred during the time of flash flood. Some of 58% respondents opined that use of pesticide may increase the fish diseases and 60% respondents thought decreasing breeding and nursery ground. The findings recommend to do motivation the farmers to use IPM in their crop land.

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Technical Session 3: **Climate Change and Fisheries**

AQUAPONICS, BSFL AND HF: TO ADDRESS THE FOOD AND NUTRIENT SECURITY, WATER AND LAND USE AND ADAPTION OF CLIMATE CHANGE

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Soil degradation, climate change, food shortages, waste dumping, droughts, and floods are some of the air, water, and soil pollution problems the world is coping with at present. We must pursue technological advances that are cost-effective and environmentally friendly for the existence of our next generations. A number of studies, primarily aimed at commercial and household applications of urban food production, address several scientific components, including home-based production in peri-urban areas. In some countries, modern small-scale agriculture has been developed for home decoration, roof use, education, and the production of organic food to feed the urban population. It is a new millennium aquaculture and we need to support and adopt this type of organic micro-farming. Hydroponics and aquaculture are combined in aquaponics, a closed-loop system, hydroponics fodder (HF) and black soldier fly larvae (BSFL). These can address concerns about water, fish and poultry feed, waste recycling, and nutrient security in the country. Bio-integrated soil and fertilizer-less systems and biological components are monitored and combined to improve system performance. Aquaculture wastewater is recycled by nitrifying bacteria and absorbed by plants, bio-drip filters, bio-fertilizer, free protein and increases the efficiency of water, soil amendment and nutrient utilization. The keys to sustainable development and climate change adaptation are minimizing runoff into the environment, reducing eutrophication in open water, regulating the environment of aquaculture systems for maximum growth of these species, and possibly developing aquaponics applications, BSFL, and HF for future food and nutrient security.

OXIDATIVE STRESS AND ANTIOXIDANT DEFENSES IN SEA ANEMONES, *Anemonia viridis* AFTER BLEACHING: UNDERSTANDING MECHANISMS TO BETTER STUDY THE EFFECTS OF CLIMATE CHANGE IN INTERTIDAL HABITATS

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Symbiosis between anthozoans and their associated photosynthetic symbionts in shallow marine habitats needs to endure extensive physico-chemical variations due to tidal and climatic cycles. This relationship provides advantages for hosts and symbionts. However, excessive photosynthetic activity poses risks for the host, especially under pro-oxidant stress situations, as they can challenge the host antioxidant defenses and ultimately lead to breakdown of the symbiotic relationship. Under the present climate change scenario, coral bleaching stands as one of the environmental issues of the highest concern. The present study produced aposymbiotic *Anemonia viridis* sea anemones by menthol (MTH) treatment (0.19 mmolL^{-1} for 30 days) to analyse the responses after bleaching. The effects of exposure to the pro-oxidant metal copper (10 gL^{-1} of $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$ for 7 days) in both MTH bleached and unbleached anemones were also studied. MTH elicited an extensive loss of symbionts, while Cu induced a more limited bleaching effect. ROS (Reactive O_2 species) production was significantly higher only in tentacles of MTH bleached anemones exposed to Cu. The transcriptional profile of antioxidant enzyme coding genes *ovoA*, *gr*, *gpxa*, *gpxj* and *gpxde* did not show clear alterations in any of the experimental groups. Targeted metabolomic analysis revealed low levels of all three forms of the H_2O_2 detoxifying ovothiols (OSH-A, -B and -C) in the tentacles, OSH-B being the prevailing form. Higher levels of OSH-B were quantified in the bleached group suggesting a response to the ROS generated during MTH bleaching. Glutathione appeared mainly in its oxidized form in all groups pointing to a strong pro-oxidant state during the experiment. Non-targeted metabolome analysis clustered bleached individuals apart from control ones and Cu exposed individuals apart from unexposed ones but did not show any clearly regulated metabolic pathways. In conclusion, *A. viridis* could be used as a useful model to study the mechanisms triggering bleaching in cnidarians but future studies should monitor the process preceding bleaching instead of its final outcome. Acknowledgements: Funded by Basque Govt. (IT1302-19) & MICIN (PID2020-117686RB-C31).

REPRODUCTIVE BIOLOGY OF CARANGID SPECIES *Megalaspis cordyla* IN THE BAY OF BENGAL CONSIDERING THE EFFECT OF CLIMATIC FACTORS

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The present study described the reproductive aspects of commercially important fish species, *Megalaspis cordyla* in the Bay of Bengal. The torpedo scad, *M. cordyla* is a hardtail scad, locally known as kauwamachh. Also commonly known as the hardtail scad, finny scad, finletted mackerel scad. This species is a moderately large marine fish as classified in the jack and horse mackerel family, Carangidae and belongs to the order Perciformes. Fish samples were collected monthly using traditional fishing gears including seine nets (mesh size 1.5 to 3 cm) and gill nets (mesh size 3 cm) by the commercial fishers during January-December 2021. In the laboratory, lengths (L in cm) were taken by measuring board, while body weight (BW in g) was taken by digital electric balance for each individual. The whole gonad was removed from each female individual and weighed to 0.01 g accuracy. Several models are used to estimate size at sexual maturity which is crucial to indicate minimum-allowable capture size. Fish gonad was used to calculate gonadosomatic index (GSI%) for the estimation of size at sexual maturity and spawning and peak-spawning season for this fish species. Individual's total length (TL) ranged from 18.0 to 45.0 cm for females. Based on the logistic model, the size at sexual maturity (L_m) was 27.5 cm in TL and 24.83 cm based on observed maximum TL for females. Determining the gonadosomatic index (GSI), the maturity length was assessed as 24.7 cm. Fishes smaller than this length (L_m) should be prohibited to catch, and larger than 27.5 cm fishes are recommended to capture for sustainable production. The monthly changes of GSI and modified GSI were used to determine the spawning season of *M. cordyla*. The highest GSI (>0.60% for both GSI and MGSI) were found during the month of April to January indicating the spawning season and May-June was the peak spawning season for this species. The Spearman rank correlation test showed that there was no significant correlation between temperature and gonadosomatic index ($r_s = 0.287$, $P = 0.362$) and between rainfall and gonadosomatic index ($r_s = 0.133$, $P = 0.683$). Finally, these findings would be very helpful for stock assessment and sustainable management of *M. cordyla* fish species in the Bay of Bengal.

LIVELIHOOD CHARACTERISTICS AND VULNERABILITIES OF SMALL-SCALE FISHERS TO THE IMPACTS OF CLIMATE VARIABILITY AND CHANGE

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Bangladesh, a river based country where fish and fishery sector has played a magnificent role for the development of the socio-economic status of fishing communities. Sylhet, a north eastern territory of Bangladesh has been identified as remarkable for haor basin and it's freshwater capture fisheries, but unfortunately very limited studies has focused on extensive assessment on livelihood and biodiversity sustainability. So, here the study sketched on the basis of livelihood, demography, socioeconomic status, opportunities and constraints, strength and limitations of fisheries communities developing oral history interviews, focus group discussions and household questionnaires. The findings of the study indicated physical strength and piquancy to work all around the year and obviously the extreme poverty, lack of money, gradually reducing fish availability and alternative income generating activities are the limitations of this study. On the other hand, devastating natural hazards, climate change, over catching fishing, single professional dependency and acute of proper policy implication found as the major threats of the study. Finally, findings of this study indicates sufficient awareness program, alternative income generating opportunities, training and motivational seminar can improve the livelihood sustainability which provide important guideline for wetland management, planning and development of livelihood sustainability of the fishing communities.

Socioeconomic profile			
	Variable	Category	Mean (SD)
• Human Capital	Family type	Nuclear	73.9%
		Joint	26.0%
• Physical capital	Family size (in number)	Nuclear 4 to 7	5 (5.4)
		Joint 8 to 11	10 (10.0)
• Natural Capital	Age of fishers	<30	24% (5.6)
		30 to 39	20% (2.6)
		40 to 49	33% (4.0)
• Financial capital	Education	Illiterate	47%
		Literate	53%
• Social capital	Occupation	Fishing	94.5%
		Other	5.5%
	Income	Net annual income	51,280 (710) BDT
	Access of alternative income	Yes	3%
		No	97%
	Public/private assistance	Yes	34%
		No	66%
	Access to credit	Yes	24%
		No	76%

Figure 1: Socioeconomic profile of the fishers

STUDY ON THE CONSEQUENCES OF CLIMATE CHANGE ON DRIED FISH PROCESSING COMMUNITY OF DUBLAR ISLAND: ESCAPING CONTRIVANCES & FUTURE APPROACHES

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The current study is intended to sketch out the existing risks and predicted consequences of climate change on dried fish output and the associated fishermen and dry fish laborers, based on fieldwork in four fish drying areas in Dublar Island. Individual interviews, focus group discussions, oral history and key informant interviews were used to obtain empirical findings. Time-series data from storms and sea-borne depressions in the Bay of Bengal were also investigated to support the empirical findings. The data was analyzed using a theoretical structure called Sustainable Livelihood Approaches (SLA). Secondary information assessment for climate change-related occurrences and regional findings indicated that the biophysical parameters of the Bay of Bengal are likely to deteriorate in the future, possibly resulting in more frequent catastrophic occurrences and threatening the livelihoods of the dried fish processing community in Dublar Island. The fishermen reported continuous climate-related threats because they live on the coast, are subjected to harsh weather events, and their profession involves risky sea fishing and fish drying. Fishers stated that they are frequently forced to revert back to the coast due to unsafe weather situations caused by cyclones and regular tropical depressions, which can decrease dry fish yield and cause economic losses or even fatalities. Such occurrences have a deleterious impact on the livelihoods and well-being of fishermen. To deal with the effects of climate change, fishers have implemented a variety of approaches at both the sea and household levels. Regrettably, these techniques have many constraints and only help fishers in the short term; they are insufficient for long-term perseverance. This research provides a range of measures to help mitigate and overcome the barriers, including mitigation of climate change, proper education and awareness raising, enforcement of fishing rules and regulations, favorable credit systems, reduction of fees for fishing in the Sundarbans waterbodies, and technological development. The study advocates the implementation of the Small-Scale Fisheries Guidelines (SSF Guidelines), which promote long-term development objectives such as instant relief, rehabilitative services, restoration, and reassurance to reduce climate vulnerabilities.

ENVIRONMENTAL CHANGES AND ITS IMPACT ON WETLAND ECOSYSTEM SERVICES, AQUATIC BIODIVERSITY AND HUMAN WELLBEING: INSIGHTS FROM BANGLADESH

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Status of environmental changes, ecosystem services, assemblage of aquatic biodiversity of haor basin and its subsequent impact on dependent livelihood has not been well studied, it is still unexplored and not properly managed. So this study has taken initiative to assess the trend of environmental changes, ecosystem services, aquatic biodiversity and impact of climatic parameters on human wellbeing of dependent communities of the haor basin.

A thorough survey on wetland ecosystem services was carried out to know the present status of provisioning service (fish, shellfish, mollusk and other available species, their spatial and seasonal abundance and species richness), supporting service, regulating service and cultural service. Linking with the environmental changes, ecosystem services and existing biodiversity the study also identified the livelihood strategy, strength, weakness, opportunity and threats of the dependent communities of this region.

Based on the findings, potential measures for habitat restoration and other conservation measures to improve the status of ecosystem services has been recommended. In response to environmental changes, existing coping strategies of the dependent communities and governance of natural and human resources will be also identified.



Figure 1: Ecosystem services of the haor basin

INVESTIGATE THE REASONS FOR THE HALDA RIVER'S UNEVEN SPAWNING OF INDIAN MAJOR CARPS (IMCS), A NATURAL FISH SPAWNING HERITAGE OF BANGLADESH

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Recently, the Bangladesh government declared the Halda River as the Bangabandhu Fisheries Heritage (BFH) owing to its importance and high level of conservation. A study was carried out to determine the possible causes of the uneven spawning of Indian major carp (IMCs) in the Halda River. The four significant study sites were chosen from the 94kilometerslong Halda River. The production of carp eggs and fry was 8,580 kg and 106 kg in 2021, respectively, which was a decline of 66% eggs and 73.3% fry from the previous year. The study found that the spawning environment was not conducive to IMC's spawning success due to inconsistency of turbidity, high conductivity, increased salinity, and higher temperature, which were exposed to be considerably different from the ideal spawning environment. Climate variables, rising temperature (90%), insufficient rainfall (86%), less hill water runoff(84%), and saline intrusion (76%), were reported by most responders as being related to the decline in spawning. Anthropogenic reasons, like unused sluice gates (84%), rubber dams (78%), pollution (76%), and river bend cutting (80%), result in a loss of carp eggs and fry production. All of these unfavorable conditions may lead to a substantial change in egg spawning and fry output from the previous year.

Table 1. Responder's perception (%) on natural causes for declining the spawning of IMC

Parameter	Respondents' categories					
	Egg collectors (n=50)	Fry rearer (n=30)	Hatchery worker (n=40)	Fish farmer (n=10)	Fry buyer (n=10)	Fishers' leader (n=10)
High temperature	90(43)	85(25)	85(34)	80(8)	70(7)	80(8)
Insufficient rainfall	86(43)	73.33 (22)	80(33)	80(8)	70(7)	80(8)
Less hill water runoff	84(42)	66.66 (20)	70(28)	80(8)	70(7)	60(6)
Weather fluctuation	70(35)	60(18)	50(20)	70(7)	60(6)	70(7)
Insufficient water current	60(30)	53.33 (16)	60(24)	60(6)	50(5)	50(5)

n= Number of respondents; Figure in parentheses represent the perceived respondents.

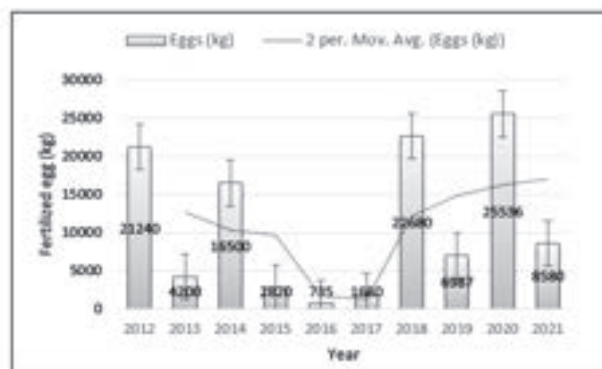


Figure 1. IMCs fertilized eggs with moving average trend line during 10 year

EVALUATION OF FISH PRODUCTION AND DIVERSITY IN THE NORTHEASTERN REGION OF BANGLADESH

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The northeastern part of Bangladesh is enriched with abundant natural fishery resources supported by the haor basin, the Surma, and the Kuhsira rivers, beels, floodplain area etc. The study was conducted to identify the status of fisheries diversity and production of fishes in the Sylhet division in Bangladesh. The Yearbook of Fisheries Statistics of Bangladesh was used to compile the catch data for four districts (Sunamganj, Moulovibazar, Habiganj, and Sylhet) for six years (2014–15 to 2019–20), and several reports and articles were used to compile the species data. A total of 117 species of fish, including prawn species belonging to 37 families and 16 orders, were recorded. Cyprinidae was the most dominant family, contributing 19 species (16.24%), followed by Bagridae (11.11%), Sisoridae (6.84%), Danionidae (5.13%), Channidae (4.27%), and Osphronemidae (4.27%). The most dominating order was Siluriformes, which contributed 31.62%, followed by Cypriniformes (28.21%), Anabantiformes (11.11%), and Synbranchiformes (5.13%). According to the IUCN species list, a total of 87 species were reported as Least Concern (LC), 10 species were Near Threatened (NT), 9 species were Not Evaluated (NE), 6 species were Vulnerable (VU), 4 species were Data Deficient (DD), and only 1 species was reported as Endangered (EN) status. The maximum annual fish catch was reported in the Sunamganj district as 549805 metric tons (MT), followed by Sylhet (405849 MT), Habiganj (320961 MT), and Moulvibazar (260180 MT). In the Sylhet division, the floodplain was the primary source of fish production. Other sources include the river, beel, pond, seasonal cultured water body, pen culture, and cage culture system. Nowadays, the cage culture system is becoming popular in the Sylhet district. The catch data displayed that annual fish production decreased in 2019-2020, a concern for fisheries scientists. This study identified the Covid-19 pandemic situation, overfilling of ponds, flashflood, irregular rainfall, climate change, siltation, the lack of fish entrepreneurs, and the reluctance of buyers of farmed fish as the significant causes of the decrease in fish production in the Sylhet region. However, if these enriched natural fisheries resources can be managed and conserved, in that case, the Sylhet region might be a hub of natural fish production to meet the national need for fish in Bangladesh.

REPRODUCTIVE BIOLOGY OF *Heteropneustus fossilis* IN WETLAND ECOSYSTEM (GAJNER BEEL, BANGLADESH) IN RELATION TO ECO-CLIMATIC FACTORS: SUGGESTING A FRUITFUL POLICY FOR AQUACULTURE, MANAGEMENT AND CONSERVATION

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The stinging catfish, *Heteropneustes fossilis* (Bloch, 1974) is a medicinal and commercially important fish species in Asia. This catfish is an important food fish as it contains high amounts of protein, iron (226 mg/100g) and calcium. This research demonstrates the population structure, size at sexual maturity, spawning- and peak-spawning season and fecundity of *H. fossilis* in Gajner Beel wetland ecosystem with an aim of its sustainable conservation through fisheries policies, induced breeding and aquaculture practices in Asian countries. Also, we observe the effect of environmental and climatic factors on the reproduction of *H. fossilis*. A total of 845 individuals were captured from the Gajner Beel wetland ecosystem through monthly protocols from January to December 2019 using cast net and only 426 female specimens were used for this study. Measurement of each individual like as total length (TL), standard length (SL) and body weight (BW) were taken by means of measuring board and digital balance. Gonads were removed cautiously through ventral dissection from female specimens and weighed. The smallest and largest specimens were 6.70–24.10 cm TL, 1.37–83.94 g BW. L_m was 14.02, 13.5, 13.0 and 15.0 cm based on maximum length (L_{max}), TL vs. GSI (%), TL vs. SL and logistic model, correspondingly. So, the range of L_m was 13.50 to 15.00 cm TL. According to monthly variation of GSI and maturation stages, April to August was considered as a spawning season and June as a peak spawning season. Fulton's condition factor (K_F) was showed significant relation with GSI values. Relation weight (W_R) showed a significant deviation from 100. Fecundity was 1,730 to 23,870 and significantly correlated with TL and BW. Environmental factors (Temperature, rainfall, dissolved oxygen and pH) showed a significant relation with GSI but TDS did not show any significant relation with GSI. We found suitable range of temperature (29-31 C), rainfall (350-380 mm), dissolved oxygen (5.0-6.0 mg/l) and pH (7.1-7.5) for spawning of *H. fossilis*. Temperature was increasing 0.029 °C /year and rainfall was decreasing 2.96 mm/year, respectively. We also described the aquaculture, conservation and management policy of *H. fossilis*. Finally, the outcomes of our study might be useful to carry out specific management program for *H. fossilis* in the Gajner Beel and elsewhere.

TOXIC EFFECTS OF CHLORPYRIFOS ON THE GROWTH, AND VITALORGAN'S HISTOPATHOLOGY OF FRESHWATER MUSSEL, *Lamellidens marginalis*

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The Chlorpyrifos 20EC is one of the extensively used agro-pesticide in Bangladesh, most of which residual into nearby natural water reservoirs. The freshwater mussel, *Lamellidens marginalis* have been exposed to Chlorpyrifos 20EC at varying concentrations of T_c (0 mgL⁻¹), T₁ (2.53 mgL⁻¹), T₂ (5.07 mgL⁻¹) and T₃ (10.15 mgL⁻¹) for 35 days to investigate its toxic effects on growth biometrics, and histopathology of liver, muscle, and ovary. The 96-hour Chlorpyrifos 20 EC LC₅₀ for *L. marginalis* have been computed as 25.37 mgL⁻¹ from PROBIT analysis. Major water regulating parameters were recorded and analyzed for each treatment group. The specific growth rate (%) was reported

Similarly, condition index (CI) and Fulton's condition factor was decent at T_c and downed at T₃ ($P < 0.05$). High mortality rate occurred in T₃ and lowest mortality in T_c. The histopathology of gill, muscle and ovary also revealed moderate to severe pathological signs in treatment groups in comparison to control. Administration of Chlorpyrifos 20EC results in detrimental growth, cytological and hematological alternation in *L. marginalis*.

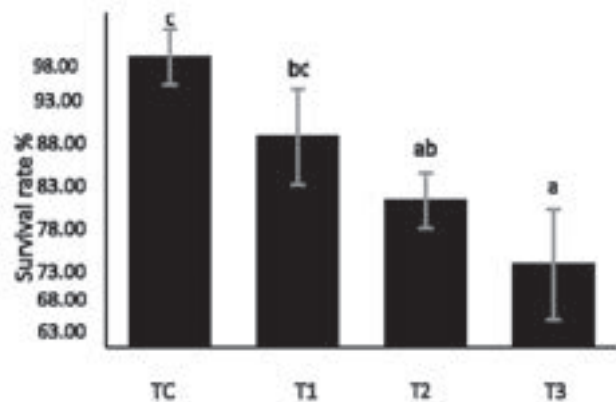


Figure. Survival rate of freshwater mussel *L. marginalis* exposed to Chlorpyrifos 20 EC for 35 days.

EFFECTS OF BIOFLOC TECHNOLOGY ON GROWTH PERFORMANCES, WATER QUALITY PARAMETERS, HEMATOLOGY AND LIVER HISTOLOGY OF MONOSEX TILAPIA (*Oreochromis niloticus*) AT DIFFERENT FEEDING LEVELS

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A 56-day experiment was conducted to investigate the effects of biofloc technology (BFT) on the growth, water quality, hematology and liver histology of monosex tilapia (*Oreochromis niloticus*) using different feeding level in Biofloc system. The experimental treatments were Control (T1) and Biofloc treatments (T2, T3, T4) with two replications of each. Thirty fish larvae/tank with an initial weight of 10g/fish previously reared in Biofloc system were stocked in their 100L of indoor glass tank. Commercial feed was provided according to 5% body weight of fish with a feed reduction of 25% and 30% in T3 and T4 respectively. Biofloc positively affect water quality parameters than control treatment. There is a significant difference observed in growth among the treatments. Although, final individual weight gain in control treatment was higher than biofloc treatments, however the reduction of feed in T3, T4 revealed the consumption of Biofloc which effects on growth of tilapia. Highest survival (86%) was found in T4 while the survival of control was significantly lower than others. Biofloc shows positive effects on FCR, SGR, PCR and PER than control treatment. No histopathological lesions in the liver were observed in both control and Biofloc treatment. Mostly, there were no significant differences among hematological parameters between control and Biofloc treatments. Fluctuations of ammonia, finding best suitable probiotic for Biofloc formations and maintenance of proper floc volume were the main barriers throughout the experimental period. Overall, this study shows that by proper water quality maintenance with a reduction of 25-30% feed can improve production performances of monosex tilapia and reduce feed cost through utilizing wasted feed and feces in a form of Biofloc.

Parameter	T1 (Control)	T2 (normal feeding +floc)	T3 (25% feed reduction+floc)	T4 (30% feed reduction +floc)
Initial Individual Weight (g)	10.67±.90 ^a	10.28±.73 ^a	10.27±.82 ^a	10.26±.69 ^a
Final Individual Weight (g)	52.1±.65 ^a	47.1±.49 ^b	46.62±.77 ^c	45.77±.43 ^d
Initial number of Fish/tank	30	30	30	30
Survival rate (%)	73%	80%	83%	86.66%
FCR	1.62±.01 ^a	1.63±.02 ^a	1.22±.03 ^b	1.13±.03 ^c
SGR	2.83±.01 ^a	2.71±.02 ^b	2.701±.02 ^c	2.67±.03 ^d
PCR	0.567±.01 ^a	0.57±.01 ^a	0.42±.02 ^b	0.39±.02 ^c
PER	1.75±.03 ^a	1.74±.07 ^a		2.34±.09 ^b

BIOFUNCTIONAL COMPOUNDS AS PUFAS MODULATE THE REPRODUCTIVE PERFORMANCE AND GONADAL MATURATION OF THE ENDANGERED CATFISH, *Ompok pabda*

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Polyunsaturated fatty acids (PUFAs) are biologically active fatty acids that are involved in fish reproduction and gonadal maturation without any lethal effects on fish health status. The present study was conducted to evaluate the effects of polyunsaturated fatty acids (PUFAs) containing diet on gonadosomatic index (GSI), sperm viability, serum calcium ion concentrations, vitellogenin, and liver histomorphology of Pabdah catfish, *Ompok pabda*. In this study, squid extracted phospholipid was used as the source of PUFAs and formulated two isonitrogenous diets with maintaining 30% protein levels. During the study period, similar physicochemical conditions of water such as temperature, pH, and dissolved oxygen (DO) were 26.5 ± 2 °C, 7.4 ± 0.2 , and 6.7 ± 0.5 ppm, respectively were maintained in each cistern. The results showed that gonadosomatic index (GSI), sperm viability, serum calcium ion concentrations, and vitellogenin were significantly ($P < 0.01$ and $P < 0.05$) higher in fish fed the PUFAs contained diet than that of fish fed the control diet and also observed the positive effects on the reproduction and gonadal maturation. From histopathology observation, lipid granules and normal morphological alteration were observed in the treated fish liver, whereas fewer lipid granules with more histological alteration of liver were observed in the control group during the spawning season. So, the present study indicated that supplementation of PUFAs in the diet improves the reproductive performances and gonadal maturation of endangered catfish, *O. pabda*.

2.56±.11^c

TWO-DECADAL TRENDS IN LANDINGS OF NON-PENAEID SHRIMPS IN INDIA

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Non-penaeid shrimps form a valuable part of peninsular India's marine fishery resources, contributing 5.03% to the total marine fish landings. The landings of non-penaeid shrimps in the country varied from 1.38 lakh tonnes in 2002 to 2.13 lakh tonnes in 2013 to 1.56 lakh tonnes in 2021 with an average of 1.61 ± 0.07 lakh tonnes (2002-2021). They are distributed all along India's west and east coast, but 90% of the catch is recorded from the northwest (NW) coast, of which Gujarat and Maharashtra contribute approximately 58% and 32% respectively. They are harvested mainly by the dol netters and trawlers operated along the NW coast. They are tiny species mainly comprised of *Acetes indicus*, *Acetes japonicus*, *Exhippolysmata ensirostris* and *Nematopalaemon tenuipis*. Among these, *Acetes indicus* is the most predominant species documented in the catch, which forms the desired food item for different commercially important finfish and shellfish. Recently, CMFRI has reported that the stock status of non-penaeid shrimp is outside of safe biological limits which implies the formulation of management strategies.

PUBLIC HEALTH CONCERNS ASSOCIATED WITH PESTICIDES AND HEAVY METALS IN COMMON DRIED FISH CONSUMPTION IN COASTAL AREA OF BANGLADESH

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The chemical contaminants in dried fish are of great food safety concern and emerging public health issue in Bangladesh. The aim of this study was to assess the public health risk associated with exposure to pesticides (organochlorine and organophosphorus) and heavy metals (lead, mercury, cadmium, chromium, arsenic) through the consumption of dried fish (Bombay duck, ribbon fish, silver jewfish, shrimp, Chinese promfret) in coastal districts (Cox's Bazar, Chittagong, Bhola, Patuakhali, Khulna) of Bangladesh. Dried fish consumption data were collected from 500 adult respondents (100 from each district) using a food frequency questionnaire (FFQ). Pesticides residues were determined using QuEChERS extraction coupled to Gas Chromatography and Gas Chromatography Mass Spectrometry, and heavy metals were estimated using atomic absorption spectrophotometric method. The results revealed that the frequency and amount of dried fish consumption was highest for Bombay duck in Cox's Bazar (11.57g/capita/day) and ribbon fish (12.10g/capita/day) in Chittagong. The estimated daily intake (EDI) and harmonized risk indicator (HRI) values expressed no health risk from pesticide residues in all the positive samples. For heavy metals, target hazard quotients (THQ) for non-carcinogenic health risk were below 1, indicating no health risk for all samples. However, carcinogenic risk R value indicated a potential health risk for chromium, and carcinogenic RT value indicated a potential health risk for all the metals. The study suggests producer's capacity buildings training, consumer's awareness, and policy makers to establish risk management strategy that control pesticides and heavy metals in dried fish consequences ensure safe food for local and global consumers.



Technical Session 4:
**Fish Biology, Genetics
and Biotechnology**

FISH GENETIC RESOURCES OF BANGLADESH: SUSTAINABLE PRODUCTION AND STOCK IMPROVEMENT

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The genetic resource refers to any biological material which contains genes and/or metabolic material that may be derived from genes. Fish genetic resource provides the aquaculture and fisheries sector with great potential to further enhance its contributions to food security and to meet the challenge of feeding a growing population. It underpins the productivity and sustainability of aquaculture and capture fisheries, and the essential services provided by aquatic ecosystems in marine, brackish and freshwaters. The need for characterization, conservation and improvement of fish genetic resources is becoming increasingly urgent given the ever-growing pressures on the aquatic ecosystems and habitats. As capture fisheries has almost reached to its plateau, aquaculture is playing an increasingly important role in meeting the demand for aquatic food from an ever-increasing human population.

The genetic quality of the hatchery stocks of the major and exotic carps species in Bangladesh have been found to be degraded significantly due to inbreeding and genetic drift. Inadvertent hybridization among all the carp species is also a common practice in the carp hatcheries. So, in order to sustain the genetic quality of the fish genetic resources it is crucial to adopt appropriate genetic management of the hatchery stocks. It is also advisable not to release hatchery produced fry and fingerlings in open waterbodies to maintain integrity of the wild stocks.

Per unit production can be increased by optimizing the aquaculture management and by improving the productivity/biological potential of the seed. The biological potential of a germplasm can be increased by conventional breeding which is a lengthy process. Thus marker assisted selection is a potential alternative that could efficiently and precisely select the better performing fish (based on growth rate and disease resistance) within a reasonably short period of time. Transgenesis is another efficient technique that can insert or modify a desirable trait in an individual directly.

Though Bangladesh has a very rich diversity of fish species for aquaculture and openwater fisheries, the fish genetic resources in terms of gene /DNA sequence in the GenBank is very poor. It is very important that the fish genetic resources be characterized and molecular markers and genes of interest be identified and made available in the GenBank for use. Molecular markers should be developed for all the important aquaculture species and marker assisted selection and gene transfer program should be initiated to develop genetically improved strains of the aquaculture species. It is recommended that the work undertaken by the government on fish genetic resources should aim to strengthen governance, improve management and technical capacities and promote sustainable use and improvement of the fish genetic resources.

ANNOTATED CHECKLIST OF THE FRESHWATER SILURIFORM FISHES OF BANGLADESH THROUGH NOMENCLATURAL REVISIONS

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Siluriformes is one of the largest orders of inland freshwater fishes in Bangladesh and they found in various water bodies including rivers, beels, khals, haors, baors, etc in Bangladesh. Now a days they are declining due to overexploitation of species, the introduction of exotic species, pollution of water bodies, habitat loss and alteration through damming and water diversion. Therefore, this study attempted to prepare an accurate checklist of fresh water siluriform fishes in Bangladesh through nomenclatural review to protect them. This checklist was prepared through revision of different books, journals and websites and listed a total of 67 species belonging 12 families of freshwater Siluriformes order. The largest family was Sisoridae containing 26 species and the second largest was Bagridae family with 14 species. On the other hand, the Erethistidae and Olyridae families were converted to the Bagridae and Sisoridae family respectively. Among all those species, 16 species are threatened, 7 species are near threatened. So, this study contributes a list of freshwater Siluriform fishes which will help to the researchers for further analysis of these fishes to protect aquatic biodiversity.

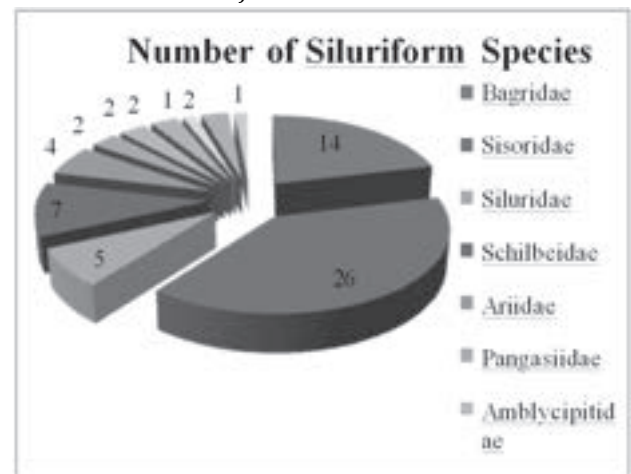


Figure 1: Number of Siluriform fishes listed under different families.

DNA BARCODING OF SOME RARE SILURIFORM FISHES FROM NORTH-WEST PART OF BANGLADESH

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Siluriformes is one of the largest orders of freshwater fishes in Bangladesh which also known as catfish because of their whisker-like barbell. Most of the catfishes are look-alike for their naked skin and barbells but genetically they are different species. Presently these species are destroying due to natural and manmade pollution. So, DNA barcoding was appropriate solution to identify the confused species and restore them. In this study, DNA barcoding was conducted to recognize some rare Siluriform species namely *Ailiichthys punctata*, *Ailia coila*, *Pachypterus atherinoides*, *Chaca chaca*, *Glyptothorax telchitta*, and *Pterygoplichthys ambrosettii*. For the phylogenetic study, DNA extraction and PCR amplification were done by using the standard barcode of mitochondrial cytochrome C oxidase subunit 1 (COI) and performed electrophoresis, purification, and sequencing for nucleotide sequences. The average percentage of GC content (43.39%) was lower than the AT content (56.61%). The estimated Transition/ Transversion bias (R) was 1.44 and the sum of transitional and transversional substitutions were 59.09 and 40.90 respectively. In the test of homogeneity, significant substitutions occur between 12 sequence pairs and the larger differences in base composition biases occur between 24 sequences pairs (>0) in the sequence taxa. The highest genetic divergence was found between *G. telchitta* and *P. atherinoides* (0.798) where the lowest genetic divergence was found between *A. punctata* and *A. coila* (0.162). The phylogenetic trees among 11 taxa Siluriform species were inferred by using four different types of methods with Kimura two-parameter (K2P) distances. In ML and MP tree, *A. punctata*, *A. coila*, and *C. chaca* comprised in clade 1 and *A. punctata* formed sister taxa with *A. coila*. *G. telchitta*, *P. ambrosettii* and *P. atherinoides* formed clade 2. Clade 3 was formed by *G. telchitta*, *P. atherinoides* and *Ailia coila*, and another sister group formed by *G. telchitta*, *P. atherinoides* in this clade. In the NJ tree, *G. telchitta* and *P. ambrosettii* formed a sister group that was different from ML and MP trees. The main difference between ML and UPGMA trees was the formation of a sister group between *P. atherinoides* and *A. coila*. This study contributes barcoding of DNA of some rare Siluriform fishes which will help the researchers for further analysis of these fishes to identify actual species and protect biodiversity.

OVARIAN HISTOLOGY AND HISTOPATHOLOGY OF OLIVE BARB *Puntius sarana* EXPOSED TO ENDOCRINE DISRUPTING CHEMICALS (17 METHYL TESTOSTERON HORMONE) IN LABORATORY CONDITION

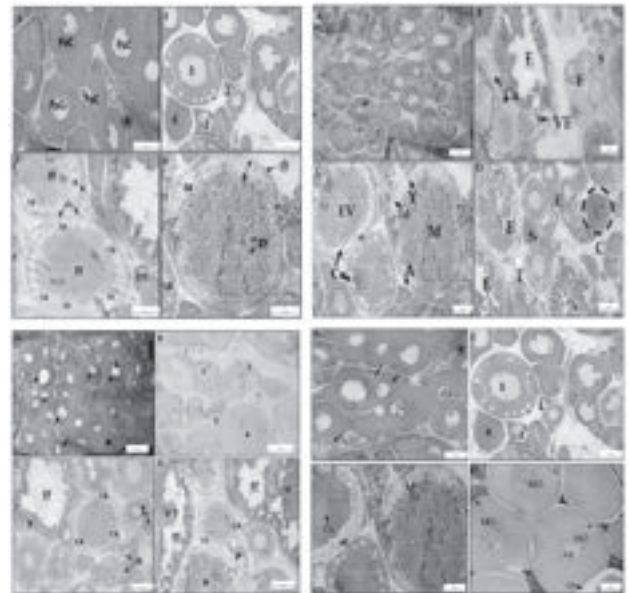
MD. Zobayer Rahman^{1*}, Sarker Mohammed Ibrahim Khalil¹, Mohammed Abdullah Al Mamun¹, M M Mahbub Alam¹, A Hossain¹, Shamima Nasren² & Shaila Bithi²

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In today's world, the incidence of Endocrine disruptors or hormonally active agents or Endocrine- Disrupting Chemicals (EDCs) in waterbodies has become a matter of concern for causing severe havoc on living biota. Among a lot of (EDCs), 17 alpha methyltestosterone reported harmful hormonal inducing agent applied on adult olive barb (*Puntius sarana*) for perceiving regular histology and alterations takes place in ovary. Sixty selected Olive barbs (*P. sarana*) were secured from different sites of Surma river from Sylhet, Bangladesh during the time range from August-September/2020). Simultaneously, some olive barbs were also collected from Brac Fish hatchery, Srimangal for In vitro experiment. Hormonal three months (90 days) with three distinct hormonal dosages (lower dosage 40 mg/kg; medium dosage 60 mg/kg and higher dosage 90 mg/kg) mixed with pelleted feed. Each 30 days intervals, histological samples made to observe alterations in the gonad due to the effect of 17 -MT hormone to assess the health status of (*Puntius sarana*). Histological sections of gonad were prepared, stained, and examined according to histology protocol. Several normal histological properties and histological alterations observed in ovary through microscopic examination such as the formation of Atretic follicle (Af), Cortical alveoli (Ca), Empty follicle (Ef), Lipid droplet (Ld), Vitelline envelop breakdown (VeB), Mature oocyte (Mo), Mature follicle (Mf), Thickened vitelline envelop (Tve), Secondary oocyte (So), Chorion (C), Zona radiata (Zr) Vacuole.



(V), Nucleus (N) etc.

Figure 1: Development stages of female *p. sarana* ovary (H/E stain). peri nuclear oocytes (Poc), nucleus (N), Primary Oocyte (3) Pre Vitellogenic-Oocyte; cortical alveoli (CA) yolk granules (Yg), (Vitellogenic-2 stage) Ovarian lumen(Ol) with Mature oocytes (MO) and a little Peri-nuclear oocytes (PeO).

ON-FARM TRIALS OF WORLD FISH GENETICALLY IMPROVED ROHU

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Rohu *Labeo rohita* (Hamilton) is an economically and culturally significant aquaculture species in Bangladesh. However, until recently, genetically improved rohu strains have not been available to Bangladeshi farmers. In 2020, a multiplier population comprised of highly-ranked families from the third selected generation of the WorldFish Rohu Genetic Improvement Program (the 'G3 multiplier') was released to commercial hatcheries as spawn. This spawn was subsequently developed into broodstock by these hatcheries and sale of this genetically improved product commenced in 2022. To assess the performance of (i.e. estimate realised genetic gain in) the G3 multiplier population, on-farm trials were undertaken in 2021-22. One pond, in each of 19 Bangladeshi semi-commercial farms, was stocked with equal numbers of tagged fish from three treatments - the 'G3 multiplier', a 'control' strain (putatively genetically equivalent to unimproved riverine stocks) and a 'commercial' strain - and managed according to each farmer's normal practices. At harvest, the G3 multiplier had the greatest mean harvest weight in each of the 19 farms and exhibited a mean realised genetic gain of 37% over the control. The growth rate of the commercial strain was similar to that of the control. The greater harvest weight exhibited by the G3-multiplier over the control and commercial strains in this study verified that the WorldFish Rohu Genetic Improvement Program has attained a rate of genetic gain comparable to that achieved in other family-based (i.e. pedigree-based) finfish programs over its first three generations.

SALINITY AND SOURCE INDUCED BODY SHAPE VARIATION IN LONG WHISKERS CATFISH (*Mystus gulio*): A MULTIVARIATE APPROACH

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Long whiskers catfish (*Mystus gulio*) is a commercially and ecologically important species. Due to the high pressure of human catch and intervention, this species is under the threat. For better sustainable management and conservation of *M. gulio* along the coastal region of Bangladesh, knowledge about this species is very crucial. Therefore, this study was carried out to find the population morphological body shape variation of due to salinity (high salinity, low salinity, and freshwater) and source (wild and cultured) factor variation.

Both truss network and advanced geometric morphometric method were used to delineate the differentiation among the population. A 47 landmark points and 17 landmark points were used to draw truss network and geometric morphometrics respectively. Multivariate ANOVA, Principal Component Analysis (PCA), Canonical Variate Analysis (CVA), Linear Discriminant Function Analysis (LDFA), and Clustering analysis were used to discriminate the morphological shape of the populations. Results of both truss network and geometric morphometric analysis indicated significant morphological body shape variation among the population of three different salinities and two different sources. For salinity variation, truss analysis showed that PC1 and PC2 contributed 15.62% and 12.61% of the variation respectively. Clustering analysis revealed two principal clusters, one for zero salinity population and another for other two closely related and overlapped populations of high salinity and low salinity. In the case of geometric analysis, PCA and CVA values were PC1 28.64%, PC2 16.30%, and CV1 72.9%, CV2 19.8% respectively. For Source variation, truss analysis showed that PC1 and PC2 were 17.78% and 13.35% respectively. For geometric source data, PC1 and PC2 values were 28.6% and 16.3%. CVA values were CV1 78.5% and CV2 21.5%. The main distinguishing body shape change is observed in the body width (dorsoventral orientation) along with less difference in the head and the tail region.



Fig. 1. Image of the specimen (*Mystus gulio*) indicating 17 morphometric landmarks and procrustes superimposition plot of *M.gulio* landmark configurations.

FECUNDITY, LENGTH AT MATURITY AND GONADAL DEVELOPMENTAL STAGES OF *Securicula gora* (Hamilton, 1822) FISH FROM NARMADA RIVER, MADHYA PRADESH, INDIA.

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Understanding the reproductive biology of any fish species provides detailed information of fish reproduction and it is also helpful to conserve a vulnerable species in the wild condition. A six month experiment, August 2021 to January 2022 was conducted to calculate GSI, fecundity and gonadal maturity of Small Indigenous Fish *Securicula gora*. *Securicula gora* (Hamilton, 1822) were collected from the different fish markets of Bhopal, Madhya Pradesh, India. In female fish, GSI was recorded between August (19.09), September (20), October (18.82), and the highest value was found in September month. In comparison, samples collected from November to January exhibited lower values. The fecundity of *S. gora* varied from 127 (fish having TL 12.3 cm and BW 10 g) to 16864 (fish having TL 13 cm and BW 19.04 g). The mean fecundity was estimated at 7162 ± 5543.26 , which revealed that *Securicula gora* is a moderately fecund fish. The size of ova ranged between 0.00-2.10 mm while the ripe eggs of *S. gora* (Hamilton, 1822) were spherical and diameter ranged between 0.90-2.10 mm during the month of September. Five gonadal developmental stages were observed, out of 116 female *S. gora* fish 19 fishes in immature phase (0.05mm-0.20mm), 21 fishes in maturing phase (0.22mm-0.45mm), 12 fishes in mature phase (0.49mm-0.95mm), 17 fishes in spawning/ripe phase (0.30mm-2.1mm) and 47 fishes in spent phase observed. Month wise mean diameter of ova observed; July (0.248 ± 0.12 mm), August (0.441 ± 0.13 mm), September (1.298 ± 0.39 mm), October (0.118 ± 0.17 mm), November (0.00 ± 0 mm), December (0.032 ± 0.06 mm) and January (0.09 ± 0.09 mm) respectively. Fish has been showing the fecundity, ova diameter, and gonadal developmental stages of the same species may be different in the population because of feeding, reproduction activities and climatic conditions.

IS 18S rDNA A GOOD MARKER FOR BARCODING FREE-LIVING MARINE NEMATODES? A CASE STUDY IN THE JIAOZHOU BAY, CHINA

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The study of free-living marine nematodes based on traditional taxonomy typically underestimated biodiversity because of its complex morphological features that needs taxonomic expertise and often limits surveys up to genus level. However, combination of traditional morphology and DNA barcoding technique can help the reliable identification of species by creating a reference library for future use of this database in ecological surveys. Unfortunately, the most widely used 18S rDNA marker provides low resolution at species level whereas the standard barcoding marker COI-5P (658bp) for animals provides poor amplification success.

This study investigated the potential of 18S rDNA and COI genes for the rapid identification and estimation of marine nematode diversity by amplifying 65 randomly selected vouchered specimens collected from four stations in the subtidal waters of Jiaozhou Bay. The results showed that partial sequences of 18S rDNA outperformed the universal COI-5P sequence in terms of amplification success. A total of 23 species belonging to 10 genera were identified among which 24 specimens belonged to Parodontophora, the most dominant genus of nematodes in the Jiaozhou Bay. The study confirmed that 18S rDNA partial sequence (900bp) successfully distinguished two morphologically identified congeneric species of Parodontophora, i.e., *P. deltensis* and *P. marina*.

Our study highlights the usefulness of 18S rDNA partial sequence as complementary barcoding markers for COI-5P. The combined molecular and morphological characters greatly enhanced the reliability of identification of nematodes and could serve as a tool for the rapid and accurate assessment of nematode species diversity.

HIGH GENETIC DIVERSITY IN *Acanthopagrus datnia* POPULATIONS ACROSS COASTAL WATER OF BANGLADESH REVEALED FROM mtDNA ANALYSIS

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Broad knowledge of genetic diversity and population structure of a particular species is essential for sustainable management and conservation strategies of marine resources. *Acanthopagrus datnia* is a commercially and ecologically important teleost fish that is widely distributed in shallow coastal waters and estuaries in the Bay of Bengal. Here, genetic diversity and population structure of *A. datnia* were examined using mtDNA control region sequences. A 572-573 base-pair fragment was sequenced from 150 individuals sampled at four localities across the coastal belt in Bangladesh. Total 116 haplotypes was identified and haplotype diversity was high ranging from 0.908 to 1.00 while nucleotide diversity was moderate ranged from 1.67% to 2.54%. Mismatch distribution analysis and significant Fu's F_s values suggested that this species experienced potential population expansion events in recent past. The pairwise F_{ST} values indicate sufficient gene flow between *A. datnia* populations. Analysis of molecular variance (AMOVA) showed weak but significant genetic differentiation ($F_{ST} = 0.0195$, $P < 0.05$) among sampled populations. This knowledge may help in preparing better fisheries management and conservation plans for this important regional species.

GENETIC DIVERSITY AND POPULATION STRUCTURE OF PARADISE THREADFIN (*Polynemus paradiseus*) IN THE BAY OF BENGAL, BANGLADESH

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Paradise threadfin (*Polynemus paradiseus*) is one the important commercial fish species in Bangladesh. In this study, we investigated the population genetic structure of *P. paradiseus* using the mtDNA d-loop region mitochondrial DNA (mtDNA) marker in the Bay of Bengal (BoB), Bangladesh. Samples were collected from four coastal regions, Karnofuli river (KF), Kirtonkhola (KK), Bishkhali river (BK), Baleshwar River (BR) of the Bay of Bengal (BoB) coast, Bangladesh from 2020-2021. All of the d-loop sequences defined 74 haplotypes where KF population comprised 18 haplotypes with 27 polymorphic sites, KK population comprised 22 haplotypes with 35 polymorphic sites, and BK and BS both comprises 17 haplotypes with 43 and 37 polymorphic sites, respectively. The nucleotide diversities (π) were low in each population ranged between 0.009 to 0.012 nucleotide differences per site. However, the haplotype diversities (h) were relatively high ranging between 0.959 and 0.994. High level of haplotype diversities in contrast with low nucleotide diversity among the BoB population indicates that this fish has experience population expansion after a period of low effective population size. Estimates of pairwise values of fixation index (F_{ST}) among the four population of the Bay Bengal ranging from 0.0001-0.023. Pairwise values of fixation index (F_{ST}) showed that Kirtonkhola river population (KK) has significant variation with Karnafuli (KF) and Baleshwar River (BS) populations. Exact test of population differentiation also showed significant differentiation i.e. non-panmixic population for KK population compared to KF and BS river populations. The neutrality tests i.e. Tajima's D tests and Fu's F_s values of all of the four populations are negative but significant ($P < 0.05$) implying a demographic expansion of this fish in the Bay of Bengal region.

EMBRYONIC DEVELOPMENT AND REPRODUCTION OF DIMUA RIVER PRAWN *Macrobrachium villosimanus* UNDER CAPTIVE CONDITION

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Prawn farming plays an important role in improving the socio-economic status of the fishers and increase export earnings of the country. Till to date, giant freshwater prawn, and brackishwater tiger shrimp is considered as the dominant crustacean species for farming. Meanwhile, some other species like Dimua river prawn (*M. villosimanus*) has been identified as potential for diversification of crustacean aquaculture due to faster growth and high market price. But the culture of the species remained unplanned due to lack of available seeds. Understanding the reproductive characteristic and embryology might be a Potential option to proceed for larvae rearing. This study aimed to unfold some reproductive biology and embryonic developmental stages of *M. villosimanus* (Tiwari, 1949) under controlled conditions.

A total of 185 specimens of adult males, females and berried females were collected from the Shibs River of Paikgacha, Khulna and stocked in cemented cisterns (3.0×2.0×0.8) m³ with a stocking density of 15 prawns/m² and with 1:2 male-female ratios. The broodstock was fed with live feeds like earthworms and supplemented with pellet feed twice a day. Maturation and egg development were obtained within 15-20 days of stocking. For the embryology monitoring, eggs were sampled in each hour for the first two days after spawning and then every 2 hours till hatching. Spawning occurred at a mean temperature, dissolved oxygen and pH of 23.85±2.48 °C, 6.63±0.71 ppm and 7.82±0.33, respectively. The egg incubation lasted for 9±1 days and passed through nine major embryonic developmental stages (Fig. 1). Hatching proceed for average 16.50±2.65 hours and led to 2.15±0.90 mm larvae. The best hatching performance was obtained at a salinity ranged between 10 to 12 ppt. The results constitute the first database for larval breeding of *M. villosimanus* species.

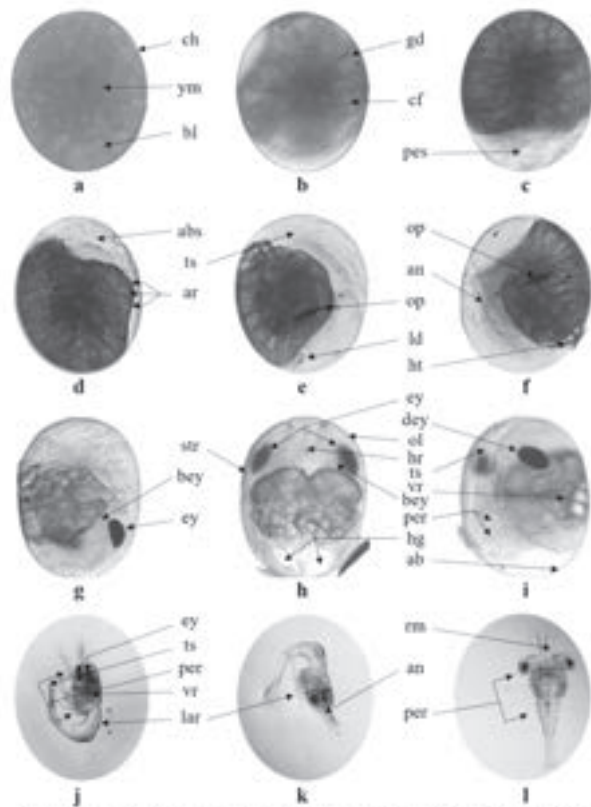


Figure 1: Embryonic stages in brackishwater prawn *M. villosimanus*. a: fertilization; b: cleavage; c: blastula; d: gastrula, blastopores making; e: nauplius with black spot; f: post-nauplius with heart-beats; g: post-nauplius with eyes pigmentation; h: post-nauplius with eyes condensation; i: pre-hatching; j: freshly hatched larva; k: two days larvae; l: five days larvae.

DEVELOPING A BREEDING PROTOCOL FOR MASS SEED PRODUCTION OF SMALL INDIGENOUS FISH SPECIES *Amblypharyngodon mola* TO PROMOTE NUTRITION-SENSITIVE AQUACULTURE IN INDIA

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Carp-Small indigenous fish species (SIS) polyculture technology is a nutrition-sensitive aquaculture approach that prioritizes the production of nutrient-dense SIS such as *mola* *Amblypharyngodon mola*, which is particularly rich in essential micronutrients, including calcium, zinc, and vitamins A and B12, and make a crucial contribution to vanquishing malnutrition around the developing world, especially for women and children. Though SIS are an underappreciated nutritional resource, their availability and accessibility are declining rapidly in many biotopes as a result of multiple numbers of stressors. Therefore, hatchery breeding methods for mass production of SIS seed are of utmost importance to increase the availability of SIS, make them more accessible to low-income consumers, and maximize the benefits of nutrition sensitive aquaculture. To address this crucial bottleneck, WorldFish is carrying out a GIZ-funded project titled "Taking nutrition-sensitive carp-SIS polyculture technology to scale" in the Indian states of Assam and Odisha. In this context, an endeavor was undertaken to develop a scalable mass seed production technology of *A. mola* under hatchery conditions based on standard guidelines of hatchery-based breeding trials for SIS. *Mola* broodstock were collected from diverse sources to maintain genetic heterogeneity and nourished into broodstock ponds under ideal farm management. Selected breeders were then transferred to cemented conditioning tanks for spawning readiness. A combination of hormone administration and environmental manipulation techniques was used to significantly raise seed production from the breeding trial. Synthetic GnRH-based inducing hormone was administered through the peritoneal cavity of *mola* broods (female: 8-10 g; male: 5-6 g; 1:2 ratio) at the rate of 0.5 ml/kg body weight. The fish were then returned to their hapa arrangements and tanks were allowed constant showering with oxygen-rich water flowing from the overhead tank prefixed with an oxygen tower. Additionally, the entire system was exposed to rainwater by taking the opportunity of the first monsoon during June-July 2022. Following hormone administration, the spawning was observed during 6-8 hours and the first hatchling was observed for 18 hours. The fertilization and hatching rates of *mola* were measured as 85% and 95% respectively. Important water quality parameters were monitored and recorded simultaneously. The *mola* hatchling was very active and ready for sale after 3-4 days. This ground-breaking breeding exercise yielded ~1.1 million *mola* hatchlings from 3.2 kg brooders. After the successful first batch of production, the partner hatchery is currently continuing up to 4th batch of production cycle and selling the hatchlings to interested small-scale farmers. This breakthrough will facilitate large-scale adoption of carp-SIS polyculture at scale which in turn will increase income and consumption of nutrient-dense fish at the household level.

GENETIC VARIATION OF *Parapenaeopsis sculptilis* (DECAPODA, PENAEIDAE) AND REASSESSMENT OF THE PHYLOGENETIC RELATIONSHIPS WITHIN THE GENUS *Parapenaeopsis* BASED ON MITOCHONDRIAL DNA VARIATION

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The genus *Parapenaeopsis* is an important group of marine shrimps for wild capture in the Indo-West Pacific region. Phylogenetics of penaeid shrimps is still a debatable issue. This study focuses on the phylogenetic relationships among seven species within the genus *Parapenaeopsis*, the population genetic variation of *Parapenaeopsis sculptilis* along Bangladesh coastline of the Bay of Bengal and the phylogeography of *P. sculptilis* in the Indian Ocean region by analysing cytochrome oxidase subunit 1 barcode (CO1) sequence. No population structure was detected in *P. sculptilis* collected from two sampling sites along the Bangladesh coastline (AMOVA and $\Phi_{ST} = -0.014$ $p > 0.05$; $F_{ST} = 0.061$ $p = 0.04$), which expanded first around 73 (CI: 36 - 119) kyr ago. The genealogical relationships in Bangladesh *P. sculptilis* population are shallow with haplotype diversity (h) of 0.58 and nucleotide diversity of 0.0014. The different *P. sculptilis* samples from Bangladesh, India and Mozambique of the Indian Ocean revealed connectivity between western Indian Ocean and the Bay of Bengal. The phylogeny within the genus *Parapenaeopsis* showed a polyphyletic relationships for *P. hardickwii* and its taxonomy needs to be reevaluated. The study will help for genetic upgradation in aquaculture and monitoring of the population genetic diversity of *P. sculptilis*.

Table 1. Genetic diversity of *Parapenaeopsis sculptilis* from Bangladesh based on mitochondrial CO1 (barcode). N = No. of individuals, N_h = No. of haplotypes, H_R = Haplotype richness, h = haplotype diversity, π = Nucleotide diversity, S = No. of segregating sites, SE = standard error

Gene	Sampling Location	N	N_h	H_R	$h \pm SE$	$\pi \pm SE$	S
CO1	SB Sundarban, Satkhira	23	6	4.7	0.40 ± 0.13	0.0009 ± 0.0009	5
	TB Teknaf Beach, Cox's Bazar	17	9	9	0.79 ± 0.10	0.0022 ± 0.0016	9
Total		40	12	11.3	0.58 ± 0.09	0.0014 ± 0.0011	11

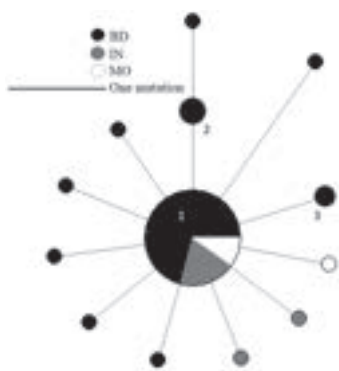


Fig. 1. Median-joining haplotype network based on 56 sequences of mitochondrial CO1 barcode of *Parapenaeopsis sculptilis* sampled from Bangladesh, India and Mozambique. Each pie is a haplotype and its size presents the frequency of samples. Distances between pies represents to mutational differences between the haplotypes. Shadings denote different sampling locations (BD- Bangladesh, IN- India and MO- Mozambique).

MITOCHONDRIAL DNA VARIATION OF *Metapenaeus monoceros* (DECAPODA, PENAEIDAE) REVEALS HIGH GENETIC VARIATION WITHIN BANGLADESH WITH DISTINCT LINEAGES IN THE INDIAN OCEAN

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The speckled shrimp *Metapenaeus monoceros* is a commercially important penaeid shrimp in the Indo-West Pacific region including Bangladesh. Phylogenetics of penaeid shrimps is still a debatable issue and molecular variation within the species is large. This study focused on the phylogeography of *M. monoceros*, including an assessment of the phylogenetic relationships among seven other *Metapenaeus* species by assessing sequence variation in three mitochondrial markers, the cytochrome oxidase subunit 1 (CO1), Control Region (CR) and 16S rRNA (16S). In addition, the mitochondrial variation along the Bangladesh coastline was analyzed. The mitochondrial variation has a clear geographical pattern with two distinct evolutionary lineages, one found in the western Indian Ocean and the Mediterranean Sea, and the second in the eastern Indian Ocean. A phylogenetic analysis of *Metapenaeus* based on the three markers revealed polyphyletic relationships within the genus, and that the taxonomy needs revision. The mtDNA variation in *Metapenaeus monoceros* in Bangladesh presents a single population (AMOVA, F_{ST} and Φ_{ST} $p > 0.05$), which started to expand around 467 (CI: 186 - 753) kyr ago, and is characterized by a large number of closely related haplotypes. The study could be used to improve the management and conservation of the shrimp fishery in the region.

Table 1. Genetic diversity of *Metapenaeus monoceros* from Bangladesh based on mitochondrial CO1 (barcode) and CR. N = No. of individuals, N_h = No. of haplotypes, H_R = Haplotype richness, h = haplotype diversity, π = Nucleotide diversity, S = No. of segregating sites, SE = standard error

Gene/Fragment	Sampling Location	N	N_h	H_R	$h \pm SE$	$\pi \pm SE$	S
CO1 (barcode)	SB Sundarban, Satkhira	16	8	8.0	0.83 ± 0.08	0.0059 ± 0.0036	11
	MG Middle ground, Bay of Bengal	18	12	10.9	0.92 ± 0.05	0.0077 ± 0.0044	22
	TB Teknaf beach, Cox's Bazar	21	10	8.3	0.83 ± 0.07	0.0056 ± 0.0034	12
	Total	55	24	9.0	0.85 ± 0.04	0.0063 ± 0.0036	29
Control Region (CR)	SB Sundarban, Satkhira	6	4	4.0	0.80 ± 0.17	0.0229 ± 0.0140	23
	MG Middle ground, Bay of Bengal	8	8	6.0	1.00 ± 0.06	0.0273 ± 0.0157	35
	TB Teknaf beach, Cox's Bazar	10	10	6.0	1.00 ± 0.04	0.0274 ± 0.0152	37
	Total	24	21	5.7	0.98 ± 0.02	0.0268 ± 0.0139	51

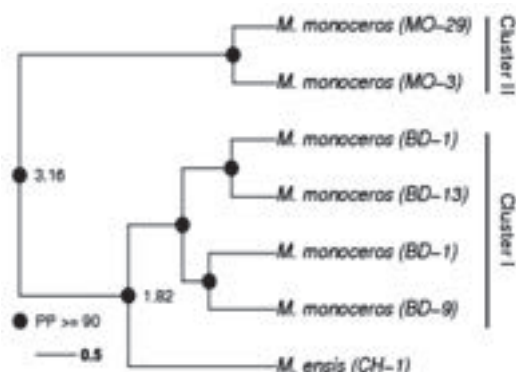


Fig. 1. Bayesian inference tree for *Metapenaeus monoceros* based on 57 sequences of CR (306 bps) and CO1 (563 bps) following a mutation rate of 1.72% and 1% per Myr respectively. Numbers at the nodes represent divergence in million years and shadings represent Bayesian posterior probabilities (PP, %). Abbreviations: BD- Bangladesh, MO- Mozambique, CH- China. Numbers following the abbreviations of countries represent the number of samples followed by haplotypes.



Technical Session 5:
**Fish Health, Pharamacology
and Pollution**

PRESENT STATUS AND CHALLENGES OF INFECTIOUS DISEASES IN FARMED FISH IN BANGLADESH; A CALL FOR SUSTAINABLE STRATEGIES

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Fisheries sector in Bangladesh represents as one of the most productive and dynamic sectors in the country. In recent decades, this sector has played a significant role in fulfilling the vast demand for animal protein requirements, consequently in food security and contributing export. With diverse aquatic resources the country has shown continuous and sustained increments in fish production since independence. The intensive cultivation of aquatic animals in order to fulfil the increased demand for human consumption makes inevitable occurrences of various infectious diseases in aquaculture. In aquaculture, diseases among farmed fishes can be caused by bacterial, viral, fungal and parasitic infections. High stocking density and improper farm practices are among the factors that contribute to the susceptibility of cultured fish to opportunistic pathogens. The climate change and evolving fish husbandry may also contribute to the balance or imbalance of pathogens, host, and environment interaction with novel pathogens being noticed or isolated annually and more familiar diseases emerging in various farmed fish species. Additionally, high levels of pollutants and suspended solids can directly bring about abnormality and mortality in farmed fishes. The biological and chemical diseases control techniques such as using different types of probiotics, prebiotics, vaccines and medicinal herbs are broadly apply in aquaculture. Antibiotics are also applying in aquaculture despite their side effects in the development of drug resistance by microorganisms. Nowadays, applying nanotechnologies in aquaculture have become a comprehensive tool for solving a lot of problems, not only disease diagnosis and treatments but also environmental management. However, several infectious bacterial, viral, fungal pathogens and parasites cause huge loss to fish industry in terms of high morbidities and mortalities, inhibiting total fish production and increased expenditure to apply of different chemicals as preventive and control measures. As a results, the occurrence of fish diseases has become a major constraint to sustainable fish production that can cause major economic and welfare challenges to aquaculture. The current challenges, successes, and prospects towards a sustainable aquaculture industry, including: limited extension services mirroring the limited knowledge by fish farmers regarding pond management practices; little expertise in fish disease diagnoses and treatments; and poor management options. Nevertheless, the proposed solutions to these problems include developing biosecurity policies at national levels, implementation of biosecurity measures, fish vaccine development against different infectious diseases, apply of different antiviral drugs and probiotics to resist viral and bacterial infection, selective breeding of disease-resistant fishes, apply of advanced diagnostic tools, disease surveillance and evolving the use of good aquaculture practices.

AQUACULTURE PHARMACEUTICALS USED FOR FISH HEALTH CARE IN NARSINGDI DISTRICT, BANGLADESH: A MATTER OF HUMAN HEALTH CONCERN

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Commercial aquaculture practices involving high inputs and higher stocking densities degrade the aquatic environment and cause disease outbreaks in cultured species on a regular basis. Inappropriate use of aquaculture pharmaceuticals, especially antibiotics for disease control in fish, can contribute to the development of antibiotic resistance. Considering the issue, the current study was carried out to assess the status of disease prevalence, aqua drugs and antibiotics used in fish health management, and potential human health concerns in the Narsingdi district of Bangladesh.



Figure 1. Disease burden and different pharmaceuticals are used for a variety of purposes in the aquaculture setup.

A set of survey tools was used to get the data. According to the respondents, 9 different fish diseases and 140 aqua drugs from various agrovet companies were recorded in the study area. About 30 different antibiotics, 18 growth promoters, and 4 enzymes were applied for disease treatment, growth promotion, improving digestion, and water quality management.

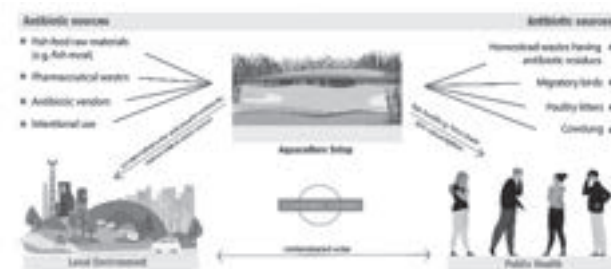


Figure 2. Exposure pathways of antibiotics through aquaculture setup where various sources input the antibiotics into the setup and, afterward, affect the public health.

This investigation discovered a number of challenges related to the application of drugs, including farmers' lack of knowledge regarding their utilization, recommended dosages, application techniques, withdrawal periods, and the risks to human health posed by their irresponsible application. However, the consequences of these products on the aquatic environment, fish health, and human health require further study for betterment of mankind.

DETERMINATION OF HEAVY METALS FROM SELECTIVE DRY FISHES AND EVALUATION OF CYTOTOXIC EFFECTS OF *Channa punctata* ON ZEBRA FISH EMBRYOS

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Sea dry fishes are a popular protein containing food in Bangladesh. During the processing of dry fishes can be contaminated by heavy metal pollution which is one of the major health concerns for human. The present study was carried out to detect heavy metals, Nickel (Ni), Chromium (Cr), Cadmium (Cd), Arsenic (As), and Lead (Pb) from sea dried fishes *Harpodon neherius*, *Pampus chinensis*, *Channa punctatus*, *Lepturacanthus savala*, *Thunnus thynnus* and *Scomberomorus guttatus* along with evaluation of cytotoxicity effects of *Channa punctata* on embryonic development stages of zebrafish. The concentrations of heavy metals were determined from selected dry fishes sample by Atomic Absorption Spectrophotometry (AAS) method. The highest levels of as concentration was 3.65 ± 0.08 ppm, found in *C. punctata* and Pb was 3.33 ± 0.07 ppm, found in *Thunnus thynnus*. In cytotoxicity assay, treatment of 50 and 100 $\mu\text{g/ml}$ *C. punctata* fish solution on zebrafish embryos showed significant abnormalities of unequal blastomeric curve, yolk sac edema, pericardial edema, spinal curvature and tail deformation at 24, 33, 48, 72 and 96-hour post fertilization (hpf). The present investigation revealed that *C. punctata* and *Thunnus thynnus* contain high levels of as and Pb which are highly toxic for zebrafish embryos.

AQUARIUM KEEPERS' AWARENESS AND PRACTICES TOWARD ORNAMENTAL FISH SPECIES' HEALTH MANAGEMENT IN BANGLADESH

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The ornamental fish industry is a broad and rapidly expanding part of fisheries, aquaculture, and global trade. Most ornamental fish enthusiasts keep them in their homes and businesses to add a new look to the space where they live. The prospect of this industry is large in Bangladesh; nevertheless, the country cannot proceed owing to a lack of sufficient knowledge on breeding and culture method, health management, legal, technological, and infrastructural concerns. Aquarium keepers are dealing with major health concerns, disease, and even mortality of their reared ornamental fish species, and they are also losing interest in ornamental fish keeping. This study depicts aquarium keepers' knowledge, perceptions, and practices about ornamental fish species health management. Questionnaire interviews were employed to acquire primary data from 300 aquarium keepers. The study found 88% of the aquarium keepers encountered various disease in their reared ornamental fish. *Poecilia reticulata* (44.83%) is identified as the most disease susceptible species according to the experience of the aquarium keepers followed by *Carassius auratus* (25.29%), and *Poecilia sphenops* (25.29%). Tail and fin rot, dropsy, pop-eye, loss of appetite, white spot, abnormal swimming, weakness, pale colour of body, swollen belly and itching are mostly experienced symptoms of disease among different species. The types of encountered diseases are mostly bacterial disease (46%), parasitic disease (23%), fungal disease (10%) viral disease (6%) and disease due to water quality issues and environmental factors (15%). The study found that 90% of the aquarium keepers reported mortality of their reared ornamental fish. Medicine was administered by 56% of the aquarium keepers to treat diseased fish. The analysis of this study will aid in the implementation of effective strategies to improve the health management of ornamental fish in Bangladesh and to develop this promising industry.

Pb(NO₃)₂ TOXICITY CAUSES RETARDED GROWTH AND HEMOCYTES COUNT, AND HISTOLOGICAL ALTERNATIONS IN GILL, KIDNEY, AND MUSCLE OF TROPICAL PEARL MUSSEL, *Lamellidens marginalis*

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The Pb is one of the extensively used heavy metals in Bangladesh and its occurrence to waters affects aquatic organisms significantly. The tropical Pear Mussel, *Lamellidens marginalis* were exposed to different concentration (T₁ 21.93 mgL⁻¹, T₂ 43.86 mgL⁻¹, and T₃ 87.72 mgL⁻¹) of Pb(NO₃)₂ and were evaluated against a control C0 mgL⁻¹ of Pb(NO₃)₂, followed by a 96-hour acute toxicity test. The LC₅₀ value was recorded as 219.32 mgL⁻¹. The physicochemical parameters were documented for each treatment unit regularly. The value of % SGR, shell weight, soft tissue wet weight and weight gain remained statistically highest for the control group in comparison with the treatment groups ($P < 0.05$). No mortality was noted for control units, while gradually decreased survival rate was recorded in different treatment groups. Fulton's condition factor and condition indices didn't vary between the control and treatment group. However, hemocyte counts were calculated as higher for control and T₁ groups. Histology of gill, kidney and muscle were well structured and healthy in

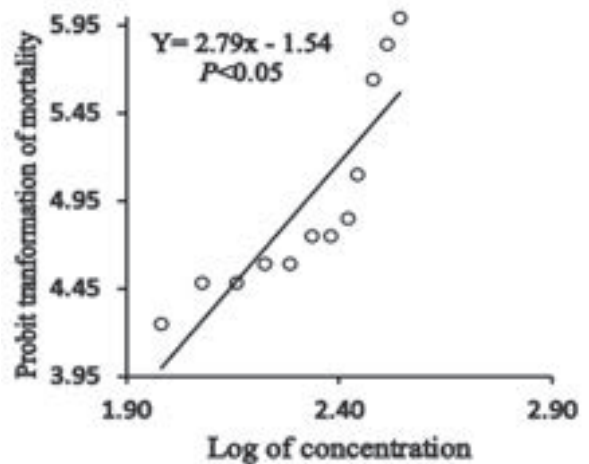


Figure 1. Probit regression line for 96-h Pb(NO₃)₂ LC₅₀ in *L. marginalis*.

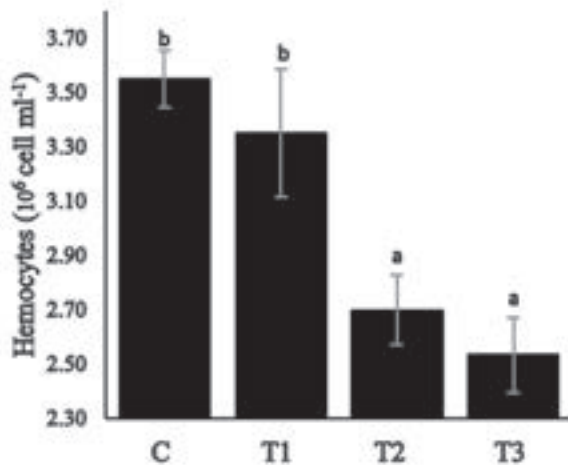


Figure 4. Hemocytes count in different treatment units.

the control group. Distinctive form pathologies were spotted in gill, kidney, and muscle tissue of different treatment groups and intensity of histological alterations were noted to be increased as the concentration of toxicity amplified. Current study therefore indicated that intrusion of Pb(NO₃)₂ in the living medium significantly altered the growth performance and hemocyte counts, and chronic toxicity induces histomorphological abnormalities in vital organs.

ANTIMICROBIAL RESISTANCE IN AQUACULTURE: CURRENT STATUS AND FUTURE SCOPE

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Aquaculture is a rapidly growing industry that currently accounts for almost half of the fish used for human consumption worldwide. Intensive and semi-intensive practices are used to produce large stocks of fish, but frequent disease outbreaks occur, and the use of antimicrobials has become a customary practice to control them. The selective pressure exerted by these drugs, which are usually present at sub-therapeutic levels for prolonged periods in the water and the sediments, provides ideal conditions for the emergence and selection of resistant bacterial strains and stimulates horizontal gene transfer. It is now widely recognized that the passage of antimicrobial resistance genes and resistant bacteria from aquatic to terrestrial animal husbandry and to the human environment and vice versa can have detrimental effects on both human and animal health and on aquatic ecosystems. A global effort must be made to cease antimicrobial overuse in aquaculture and encourage stakeholders to adopt other disease prevention measures. Shaping a new path is crucial to contain the increasing threat of antimicrobial resistance.

PHARMACOLOGY PROPERTIES OF ICTHYOCRINOTOXINS FROM SOUTH EAST OF INDIA

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Cancer treatments do not have potent medicine as the currently available drugs are causing side effects in some instances. In this context, the natural products derived from marine fish mucus have gained significance in the treatment of cancer. The toxicity effects of the crude and purified mucus extract of *Anguilla anguilla*, *Arius caelatus* and *Synaptura albomaculata* on *Artemia salina* (brine shrimp) were studied for anticancer with the human cancer cell lines; K562 (Human Leukemia Cell Line) were maintained in DMEM medium (with high glucose and glutamine) supplemented with 10% heat inactivated FBS and 1% penicillin Streptomycin, at 37°C in a humidified atmosphere containing 5% CO₂. and in vitro MTT Assay. In brine shrimp lethality assay and the mortality was observed up to 24 hrs of experiment with different concentrations such as 10 µgml⁻¹, 20 µgml⁻¹, 40 µgml⁻¹, 80 µgml⁻¹ and 100µgml⁻¹. In purified mucus extract maximum mortality was observed at 100 µgml⁻¹ concentration of *Synaptura albomaculata* (71.57 ± 6.43) extract followed by *Arius caelatus* (67.45 ± 5.98) and *Anguilla anguilla* (59.0 ± 6.02) at the same concentration. The lowest level of mortality was noticed at 10 µgml⁻¹ concentration of *Anguilla anguilla*(23.78 ± 3.29) extract followed by *Arius caelatus* (29.45 ± 4.36) and *Synaptura albomaculata* (31.85 ± 3.67) at the same concentration. In crude mucus extracts maximum mortality of (54.23 ± 3.67) was noticed in *Synaptura albomaculata* mucus extract at the concentration of 100 µgml⁻¹ followed by *Arius caelatus* (52.33 ± 3.47) and *Anguilla anguilla* (46.34 ± 4.09) at the same concentration. LC₅₀ values of the three fish mucus extracts were ranged from 124.58 µg.ml⁻¹ to 450.93 µg.ml⁻¹. The minimum concentration of LC₅₀ was found with *Anguilla anguilla* (124.58 µg.ml⁻¹) followed by *Arius caelatus* (146.09 µg.ml⁻¹) and maximum concentration (450.93 µg.ml⁻¹) was found with *Synaptura albomaculata* mucus extract. A potent cytotoxic on Human Leukemia Cell Line K562 and showed a low LC₅₀ value (>80 µg/mL) for all the three purified mucus extracts and LC₅₀ value for Adriamycin (Positive control) was found to be 39 µg/ml. The total growth inhibition (TGI) was found to be >80 µg/mL in both crude and purified mucus extracts of all the three fishes. The growth inhibition (GI) of cell line was also to be (>80 µg/mL) in both the mucus extracts and Adriamycin was found to <10 µg/mL.

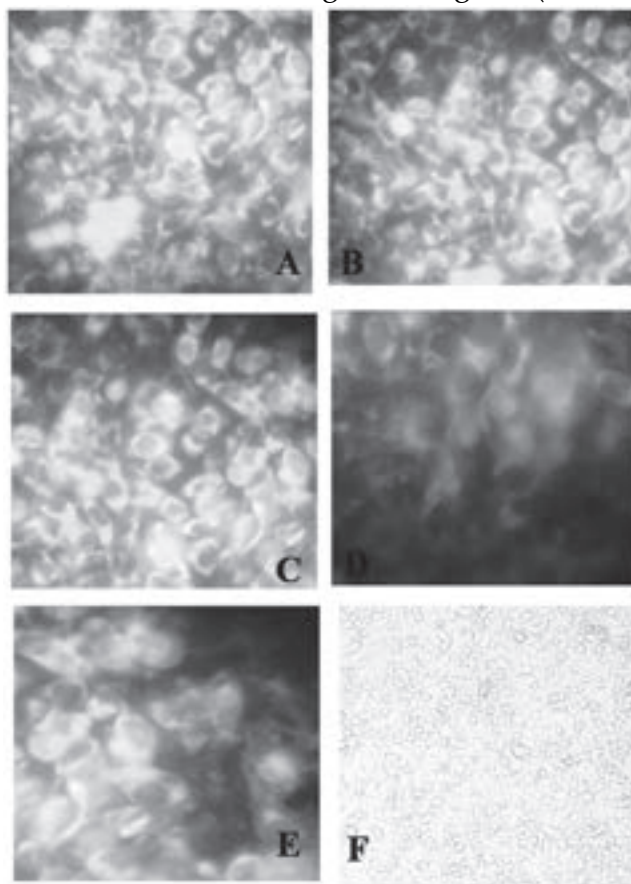


Fig. 72. Effects of *Anguilla anguilla* mucus extract against Human Leukemia Cell Line K562
A-10µg/ml; B- 20µg/ml; C-40µg/ml; D-80µg/ml; E-100µg/ml; F-control

EFFICACY OF LOCALLY ISOLATED BENEFICIAL BACTERIA (*Bacillus* spp.) ON PRODUCTION OF BLACK TIGER SHRIMP (*Penaeus monodon*)

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Bacillus spp. are gram-positive endospore-forming bacteria with beneficial effects in aquaculture industry. The dietary supplementation of *Bacillus* spp. in fish and shrimp culture improved especially growth performance, immune response and the disease resistance of fish against pathogenic bacterial infections. These naturally occurring bacteria exert their beneficial effects on the host by modifying the microbial community associated with the host, by ensuring improved use of the feed or enhancing its nutritional value, or by enhancing the host response towards disease. For this, the present study was done to know the efficacy of beneficial bacteria (*Bacillus* spp.) on growth and production of Black Tiger Shrimp (*P.monodon*). The study was done from June-August, 2020. This experiment was done in four ponds having area of twenty four decimal of SRS pond complex. Experimental ponds were partitioned into three parts for three replication of each treatment. The ponds were prepared following drying, liming, and fertilization. Then the ponds were stocked according to the experimental design (Table 1).

Table 1: Experimental design

Treatment	Dose (cfu/g feed) of <i>Bacillus</i> spp.	Mode of application	Days of culture	Stocking density	Replication
T1	2* 10 ⁸	Dietary supplementation	80	5 /m ²	3
T2	2* 10 ⁹				
T3	2* 10 ¹⁰				
T4 (Control)	-				

Throughout 80 days of culture water quality in all ponds were observed to be normal and remained within ranges which allow high growth rate and production of *P. monodon*. Temperature of water was 28-33°C and almost same in all ponds. Depth of water was maintained at a level of one meter in all ponds. Salinity of water was 2-12 ppt during culture period also almost same in all ponds. Initial level of morning dissolved oxygen (DO) was 5.0-8.8 mg/l which decreased to 3.2 at the later part of the culture period. Feed was supplied two times in a day. The growth performances, survival rate and production of *P. monodon* fed with different dose of *Bacillus* spp. according to the experimental design as dietary supplementation are given in table 2.

Table 2. Mean and standard deviations of average body weight (ABW), Survival rate, Production of *P. monodon*

Treatments	ABW(g) at 80 DOC	Survival rate (%)	Production (Kg/ha)
T ₁	16.61±0.77 ^a	64±4.0 ^a	850±10.60 ^a
T ₂	20.31±0.66 ^b	50.66±5.5 ^b	823±74.00 ^a
T ₃	20.40±0.77 ^b	41±1.0 ^c	669±22.54 ^b
T ₄	14.43±0.65 ^c	15±1.0 ^d	173±7.02 ^c

The highest production and survival rate was obtained at T₁, where shrimp was supplied with *Bacillus* spp. treated diet @2* 10⁸cfu/g feed, whereas the control diet produced the lowest production and survival rate. In case of production, T₁ has no significant difference with T₂ but has a significant difference with T₃ and T₄. The reason of the lowest survival was disease outbreak in control ponds.

THE RESPONSE OF RAINBOW TROUT (*Oncorhynchus mykiss*) TO AUTOGENOUS VACCINES AGAINST *Lactococcus garvieae*, *Lactococcus lactis* AND *Yersinia ruckeri* O1 BIOTYPE1 & BIOTYPE2

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Lactococcosis and Enteric Red Mouth (ERM) diseases, caused respectively by *Lactococcus garvieae* and *Yersinia ruckeri*, are the most important bacterial diseases in Italian rainbow trout farming. Vaccination failure has recently been observed, despite the use of commercial and autogenous vaccines. The underlying causes are thought to be related to phenotypic differences among the strains currently circulating or traditionally used for the vaccines formulation. To determine the rainbow trout serological outcome of the administration of autogenous vaccines against *L. garvieae*, *L. lactis*, *Y. ruckeri* O1 (biotypes 1 and 2), without or with adjuvant, an experimental intra-coelomatic vaccination was conducted in rainbow trout (100 ± 10 g) under controlled conditions at IZSVE. Then after 12 weeks we quantified the fish response in terms of agglutinating and specific antibodies (IgM) (ELISA) to the single bacterial species. Furthermore, the potential serological cross-reactivity between *L. garvieae* and *L. lactis*, and between *Y. ruckeri* O1 biotype 1 and 2 were studied. The sera of fish vaccinated with *L. garvieae* or with *L. lactis* bacterins showed antibody cross-reactivity (in terms of agglutinating capacity). The immunogenicity of the vaccine has always been enhanced by the use of adjuvant, and this effect was particularly marked in the case of *L. lactis*. In general, the bacterins obtained from *Y. ruckeri* (bt 1 and bt2) were found to be more immunogenic than those obtained from Lactococci, in terms of induction of agglutinating activity. Marked antibody cross-reactivity (in terms of agglutinating capacity) was observed between bt 1 and bt 2, and enhanced immunogenicity of the vaccine was observed after the use of adjuvant. Concerning ELISA, vaccination induced an increase of specific antibodies for *L. garvieae* and *L. lactis* compared to controls. This effect was more prominent in the case of *L. garvieae*, and was triggered in both cases by adjuvant. In terms of cross-reactivity, it seems that the developed sera contained antibodies reactive with antigens commonly shared by *L. garvieae* and *L. lactis*. By applying vaccination against *Y. ruckeri*, the bt 1 bacterin resulted more immunogenic than bt 2. This observation was made by studying the direct reactivity: bt 1 vs bt 1 and bt 2 vs bt 2. Analyzing the cross-reactivity it emerged that the sera obtained from the rainbow trout treated with bt 2 (with and without adjuvant) are strongly reactive against the bt 1 used to coat the plate. The study, even being a preliminary approach yet to be delivered to the field, confirmed a greater efficacy of autogenous vaccines and the results of cross-reactivity open the possibility to develop bivalent or multivalent bacterial vaccines to be exploited in rainbow trout farming.

ECOTOXICOLOGICAL EFFECTS OF *CHLORPYRIFOS* ON GULSHA *Mystus cavasius*

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Pesticides have very toxic effects on fishes through disturbance of the normal function of major organ and damaging the organs depending on the concentrations. The present study was conducted to assess the histological and hematological effects of *chlorpyrifos* on gulsha, *Mystus cavasius*. The LC50 value for 96 hours was found as 5.00 ppm and the experiment was performed with four groups. Group one was used as control (0ppm) and three concentrations such as 0.5 ppm (5% of 96 h LC50), 1.0 ppm (10% of 96 h LC50) and 1.5 ppm (20% of 96 h LC50) were used as T1, T2 and T3 respectively. During the experiment, several behavioral alterations including erratic swimming, hyperactivities, excessive mucous secretion, skin discoloration, sudden mortalities, loss of balance, gasping for air, reduction of feed intake, rapid opercular movements increasing opercula ventilation and resting at the bottom forming crowd were observed in pesticide treated fish. The histopathological abnormalities in the tissues suggest that sub lethal concentrations included moderate to severe alterations in gill, liver, kidney and spleen. Major histopathological changes like clubbing, hyperplasia, fusion of lamellae, hypertrophy, hyperplasia, breakdown of gill lamellae, epithelial lifting and missing gill lamellae of gill were observed. Collecting duct shrinkage, renal tubule disruption, melanomacrophage centres, increase space between glomerulus and Bowman's capsule, glomeruli shrinkage, necrosis, necrotising degeneration of tubules of kidney and hepatic cell disruption, disruption of central vein, increase in number of pyknotic nuclei, melanomacrophage centers, fibrosis, presence of Sinusoidal Space, increase in number of kuffer cell and pyknotic nuclei were observed in liver cells. Severe MMC, granule, degeneration of pulp, lymphocyte, vacuolation, leukocyte aggregation, necrosis, intracellular vacuolation were found in spleen. Due to the effects of chlorpyrifos, WBC was significantly increased in the experimental groups whereas RBC, hemoglobin (Hb), hematocrit (Hct), Plateletes were significantly decreased in compare to the control group ($p < 0.05$). MCV, MCH, MCHC didn't show any significant changes at the end of the total exposure period. Finally, the existence of pesticide, even at low concentrations, can cause harmful effects to *M. cavasius* and its survivability.

PREVALENCE AND ANTIBIOTIC SUSCEPTIBILITY PATTERNS OF *Escherichia coli* ISOLATED FROM WET MARKET AQUATIC FOODS IN DHAKA, BANGLADESH

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Aquaculture industry in Bangladesh is significantly contributing profound positive aspects to the socioeconomic structures of the country. Irrational and inappropriate use of antimicrobials in aquaculture and associated transfer risk of antimicrobial resistant pathogens from aquaculture settings through interlinked human-animal-environment spread pathway may affect enhanced sustainability of the sector, a One Health problem. In this study, prevalence and antimicrobial resistance in one of the key One Health significance pathogens, *Escherichia coli* from farmed aquatic foods were investigated. We sampled 104 fish/shrimps from two large wet markets in Dhaka and successfully isolated and identified *E. coli* from different organs (skin, gills, muscle and intestine) of the collected samples. A panel of 16 antibiotics were tested for sensitivity profiling of *E. coli* following disc diffusion method. Antimicrobial susceptibility testing results were interpreted using Clinical and Laboratory Standards Institute (CLSI) breakpoints. Specific primers were used to detect antibiotic resistance genes. The overall prevalence of *E. coli* in tilapia and shrimp were 55.1% and 37% respectively. The antibiogram study showed that the isolates were 65% resistant to ampicillin followed by cefoxitin and nalidixic acid (40%). On the contrary, isolates were most sensitive to both gentamicin and norfloxacin (95%) followed by meropenem and levofloxacin (85%). Phenotypically resistant *E. coli* isolates carried *bla*_{TEM}, *tetA* and *sul2* genes. Our findings confirm the presence of antimicrobial resistant *E. coli* in fish and shrimp at point of human consumption. PCR results of selected isolates further support the presence of resistance genes. The high prevalence and presence of drug resistance *E. coli* isolates in aquatic foods at point of human consumption could be a potential threat to public health. Appropriate control measures should be in place to reduce the risk and emergence of antimicrobial resistance in pathogens from aquaculture settings.

TOXIC EFFECTS OF CHLORPYRIFOS ON THE GROWTH, HEMATOLOGY, AND DIFFERENT ORGANS HISTOPATHOLOGY OF NILE TILAPIA, *Oreochromis niloticus*

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Chlorpyrifos is a widely applied insecticide that permeates on most waterways and affects aquatic organisms. The growth performances, hematological and histological impacts on Nile tilapia, *Oreochromis niloticus* following a 60 day of exposure to varying concentrations of chlorpyrifos 20 EC (T1 08 μgL^{-1} , T2 16 μgL^{-1} , and T3 32 μgL^{-1}) were compared to a control Tc 0 μgL^{-1} . The 96-hour LC50 of chlorpyrifos 20 EC was calculated as 46.80 gL^{-1} . The water quality parameters were recorded regularly. The value of dissolved O₂ and NH₃ stayed rather steady, although temperature varied considerably. It was revealed that as chlorpyrifos levels go up, the percentage of weight gain (WG%), specific growth rates (SGR), and survival rate decreases. The control group Tc had the highest percentages of SGR weight (1.16 \pm 0.58) and the T3 group had the lowest percentages of SGR weight (0.25 \pm 0.77). The hematological assessment showed significant differences of hemoglobin concentration, white blood cell counts and red blood cell numbers between chlorpyrifos treatment and control group (P<0.05). Histological alterations in the liver, gills, and muscle tissues reported to be worse for T3 as compared to others. There were no statistical differences in GSI, HSI values between control and treatment groups. The chlorpyrifos 20 EC was shown to be highly toxic to *O. niloticus* at sub-lethal dosages.

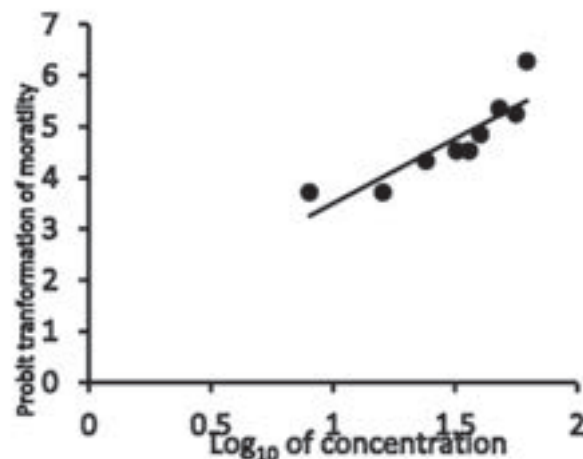


Figure 1. A 96-hour LC50 polynomial curve for *O. niloticus* exposed to chlorpyrifos 20 EC.

Fundings: Funded by UGC and SAURES, Bangladesh.

DETERMINATION OF TOXICITY LEVEL OF COPPER SULFATE PENTAHYDRATE (CuSO₄.5H₂O) ON TILAPIA (*Oreochromis niloticus*)

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Copper sulfate (CuSO₄) is an inorganic fungicide/algaeicide that is used to control algae in a variety of environments. It's also commonly used in aquaculture to keep phytoplankton and algae under control. CuSO₄ is also used therapeutically to reduce the incidence of fish endoparasites such as protozoa, trematodes, as well as external fungus and bacteria.

An was conducted to determine the acute toxicity level of copper sulfate pentahydrate on *Oreochromis niloticus* for a period of 15 days from 1st February to 15 February, 2022 on the rooftop of Faculty of Fisheries, Patuakhali Science and Technology University. The experimental design consisted of seven treatments e.g., T₁, T₂, T₃, T₄, T₅, T₆ and T₇ of 20, 30, 40, 50, 60, 70 and 80 ppm concentrations of copper sulphate respectively, three replicates per group and with fifteen fish in each replicate. The acute toxicity tests were performed according to the static non-renewable bioassay procedure and pH, temperature, dissolved oxygen, total hardness, ammonia, nitrate, alkalinity of test water was measured daily. All exposed fish were monitored on a regular basis, as well as any dead fish were removed as soon as possible. The mortality was recorded on daily basis. There is no mortality was observed in T₁(20 ppm), T₂(30 ppm), T₃(40 ppm); mortality started in T₄ (50ppm) with 20% mortality and acute mortality in T₆ and T₇ with 55% and 100% respectively. The 96h LC50 value based on Finney's probit analysis was found to be 61.66 ppm. Susceptibility of *Oreochromis niloticus* to lethal effect of copper sulphate was duration and concentration dependent as mortality increased with an increase in its concentration. The study revealed that maximum mortality occurred in between 72hr and 96hr. Results also indicated that copper sulfate is toxic to fish at high concentrations above 40 ppm. The present investigation may provide useful guidance that can be exploited by the aquaculturists to estimate the safety levels of copper sulfate in water bodies.

Table: Effect of CuSO₄ on mortality at different hours.

Treatment	24hr	48hr	72hr	96hr
T ₁ (20 ppm)	0	0	0	0
T ₂ (30 ppm)	0	0	0	0
T ₃ (40 ppm)	0	0	0	0
T ₄ (50 ppm)	0	0	9 ±3.849 ^a	11 ±3.849 ^a
T ₅ (60 ppm)	0	9 ±3.849 ^a	11 ±3.849 ^a	15 ±3.849 ^a
T ₆ (70 ppm)	9 ±3.849 ^a	11 ±3.849 ^a	17 ±3.849 ^a	18 ±3.849 ^a
T ₇ (80 ppm)	9 ±3.849 ^a	16 ±3.849 ^a	22 ±3.849 ^a	53 ±6.667 ^b

Pb(NO₃)₂ TOXICITY PROVOKES RETARDED GROWTH, ERYTHROCYTES ABNORMALITIES AND HISTOLOGICAL ALTERNATIONS IN VITAL ORGANS OF JUVENILE NILE TILAPIA, *Oreochromis niloticus*

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Lead (Pb), one of the momentous toxins, is responsible for the deterioration of ecological health in aquatic environments as well as a big threat to the aquatic living creatures. Therefore, the present study investigated the effects of lead nitrate Pb(NO₃)₂ toxicity on growth, blood cells morphology, and studied the histopathology of gills, liver, and intestine of juvenile Nile tilapia, *Oreochromis niloticus*. A 30-day *in vitro* aquarium trial was conducted where organisms were assigned in four treatment groups; control 0 mgL⁻¹, T₁ 5.20 mgL⁻¹, T₂ 10.40 mgL⁻¹ and T₃ 20.80 mgL⁻¹ following the LC₅₀ value of 51.96 mgL⁻¹ from acute toxicity test. Overall growth performance reduced significantly ($P < 0.05$) when organisms exposed to lead. Similarly, highest mortality was recorded in T₃. HSI and GSI values were significantly ($P < 0.05$) higher and lower, respectively, in exposed groups. A few erythrocytes abnormalities were identified in the exposed groups, while nucleus diameter and percentages of nuclei in erythrocytes were significantly ($P < 0.05$) lower in T₂ and T₃. Histopathological alterations were clearly visible in gills, liver, and intestine of lead exposed *O. niloticus*, while the severity of pathological signs gradually increased in higher exposure levels. A significant ($P < 0.05$) lowest length and highest width of intestinal villi were documented in T₃. In conclusion, Pb(NO₃)₂ toxicity had a negative effect on growth performance, erythrocytes morphology and affected vital organs i.e., gills, liver, and intestine of

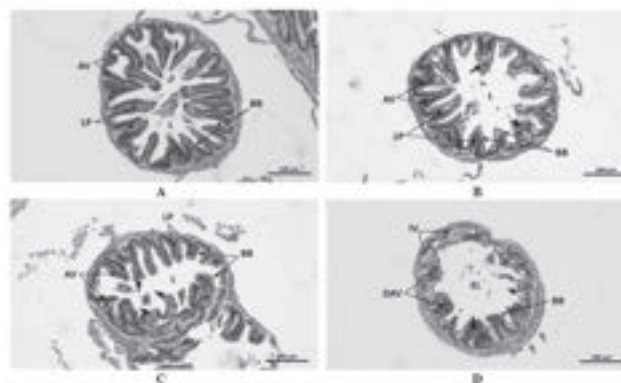


Figure 1. Transverse photomicrographs of the intestine. A. Control; B. T₁; C. T₂; D. T₃. BB: Brush border, AV: Absorptive vacuoles, LP: Lamina propria, L: Lumen, EL: Extended lumen, IV: Increased vacuoles, DAV: Disarranged absorptive vacuoles; tissue rupture (black arrows), extended serosa (blue arrows), and wider villi (white both side arrows).

IMMUNO-PHYSIOLOGICAL ACTIVITIES IN ROHU *Labeo rohita* USING BETA-GLUCAN AS A DIET

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Beta-glucans have immense potential to stimulate immune modulation in fishes by being injected intramuscularly, supplemented with feed or immersion routes of administration. Here, we evaluated the impact of dietary beta-glucan on the enhanced immunity of Rohu, *Labeo rohita*. A supplemented diet with 10% mushroom powder was administered as a source of beta-glucan for 120 days (Table 1). Tests on immunological parameters such as antioxidants, respiratory burst, reactive oxygen species (ROS), alternative complement activity, as well as serum immunoglobulin were analyzed. The results showed significant increases ($p < 0.05$ and $p < 0.01$) in K values for the beta-glucan fed immune primed *L. rohita* compared to control groups (Table 2), indicating a positive effect of beta-glucan on fish health. Hematological parameters were also determined as the

immunological indices. The total counts of erythrocytes and leukocytes were assessed using standardized methods to elucidate the immunomodulatory effects of beta-glucan on *L. rohita*. Fish were challenged with a 1.92×10^4 CFU/ml intramuscular dose of *Aeromonas veronii*. The disease-defending systems such as serum lysozyme activity and serum total protein level were shown to have significantly higher protection ($p < 0.01$), followed by the control groups (Table 2). Acetylcholinesterase (AChE) activity and serum enzyme activity were measured to support the stress effect of beta-glucan on *L. rohita*. The stress indicating results did not show any significant differences, showing that the physiological condition of fish was not harmed in any way.

Hence, the supplementation of dietary beta-glucan was found to be significant in enhancing immune responses in *L. rohita*.

Table 1. Composition of experimental diets

Ingredients	Treatment (%)	Control (%)
Fish Meal	24.34	24.34
Rice Bran	32.58	32.58
Maize Meal	32.58	32.58
Mushroom/ Wheat Flour	10.00 (Mushroom)	10.00 (Wheat Flour)
Vit. B	0.5	0.5

Table 2. Immunological parameters after fed with beta-glucan as a diet

Parameters	Control	Treatment
RBC ($\times 10^6/\mu\text{l}$)	2.34 ± 0.23	$3.39 \pm 0.35^*$
WBC ($\times 10^3/\mu\text{l}$)	7.17 ± 0.44	$8.26 \pm 0.63^{**}$
Glucose (mmol/L)	2.12 ± 0.26	2.15 ± 0.24
Serum protein (g/dl)	2.66 ± 0.25	$3.15 \pm 0.32^{**}$
Lysozyme ($\mu\text{g}/\text{ml}$)	4.60 ± 0.74	$6.11 \pm 0.74^*$
ACh50 (unit/ml)	84.10 ± 3.2	$112.1 \pm 4.8^{**}$
AChE (nmol/min/mg)	245 ± 14.5	248 ± 13.7
ROS (mmol/l)	0.17 ± 0.02	$0.07 \pm 0.01^{**}$
Respiratory burst (mg/ml)	0.30 ± 0.08	$0.68 \pm 0.11^{**}$

Asterisks are indicated significant difference (* $p < 0.05$, ** $p < 0.01$); Data have been presented as Mean \pm S.D.

STUDIES ON THE PARASITIC FAUNA OF OPEN WATER FISHES IN THE NORTHEAST BANGLADESH

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The present study was aimed to know the present status of parasitic fauna and its prevalence, intensity and abundance in the northeast part of Bangladesh and to evaluate the histopathological alterations of different parts of the fish organ due to parasitic infestation. The present status of parasitic fauna was studied on 17 different fish species collected from Singari Beel, Erail Beel situated at Golapganj Upazila, Kawadighi haor situated at Sadar Upazila and Surma River from October 2020 to March 2021 (six months). During the investigation 189 individual of different fish species were examined. Among them 91 fish were found infested with 860 parasites from 7 groups namely Digenea, Nematode, Acanthocephala, Crustacea, Protozoa, Monogenea and Cestode. A total of sixteen different parasitic genera were identified from the hosts examined as *Myxobolus sp.*, *Tetrahymana sp.*, *Dactylogyrus sp.*, *Djombangia sp.*, *Argulus bengalensis*, *Euclinostomum multiceacum*, *E. heterostomum*, *Camallanus intestinalis*, *Procamallanus viviparous*, *Gnathostoma spinigerum*, *Camallanus pearsei*, *Pallisentisophio cephalis*, *Pallisentis nandai*, *Pallisentis goboos*, *Lytocystus indicus*, *Senga ophiocephalina*. The highest prevalence (100%) was observed in *Channa striatus* and the lowest (30.76%) was observed in *Mystus cavasius*. The highest abundance and mean intensity were observed 27 and 43.2 percent respectively in *Mastacembelus armatus*. The lowest abundance (0.77%) was observed in *Nandus nandus* and lowest mean intensity (1.8%) in *Clarias batrachus*. Parasite infected fishes were euthanized and histological samples from different organ showed multiple pathological alterations in gills, kidney, liver and gastrointestinal tract. Moreover, for the first time in Bangladesh, *S. ophiocephalina* were identified by Polymerase Chain Reaction (PCR) and generated PCR product size around 700 bps. The obtained 28s RNA F and 28s RNA R sequence of *S. ophiocephalina* matched with 1121- 1463 bps (Identity- 100%) of the 28s RNA gene of *S. magnum*, *S. lucknowensis* and *S. visakhapatnamensis* strain 28S ribosomal RNA gene, partial sequence (GB Accession number KR780913.1, KR780891.1 and KR780890.1).

HISTOPATHOLOGICAL CHANGES IN DIFFERENT ORGANS OF DISEASED MRIGAL *Cirrhinus cirrhosus*

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The study was performed to study the histopathological alterations in different organs of diseased Mrigal (*Cirrhinus cirrhosus*). The study is done using a severely diseased mrigal fish and a healthy mrigal fish as a control. To observe the histological alterations, spleen, gill, kidney, liver, gut and skin and muscle organs were studied using standard histological processes. Histopathological image of gill of diseased *C. cirrhosus* showed hemorrhage in primary gill lamellae, clubbing, vacuums, disruption of secondary gill lamellae accompanied with hypertrophy and hyperplasia, and the entire loss of secondary gill lamellae. Histopathological image of liver showed haemorrhage, necrosis, hypertrophy and hyperplasia, vacuolation, numerous pyknotic nuclei, disintegration of hepatocyte cells, atrophied nucleus and necrotic hepatocytes. Histopathological changes of kidney showed aggregation of Melano-macrophage centers, vacuoles and destruction of Bowman's space, loss of hematopoietic tissues, haemorrhage and degeneration of kidney tubules. Histopathological image of skin & muscle showed photomicrographs of the muscle, brokage of myofibrils, splitting of muscle fibres, disintegration of myotomes and vacuolation within the myotomes. Histopathological image of spleen showed aggregation of inflammatory cells, mixed red and white pulp, mild splentis with accumulation of proteinous substances, lymphocides aggregated around ellipsoids, tissue damage and moderate splentis with numerous macrophages. Histopathological image of the gut showed short and stout villi, aggregated goblet cells, large lumen space with lamina propia, disruption of mucosal and sub-mucosal tissues, and vacuolation. The information of the study can be used to characterize diseases in fishes.

MOLECULAR, BIOCHEMICAL AND HISTOPATHOLOGICAL IDENTIFICATION OF BACTERIA IN DISEASED NILE TILAPIA (*Oreochromis niloticus*) FROM BIOFLOC AQUACULTURE SYSTEM WITH ANTIBIOTIC SENSITIVITY OF ISOLATED BACTERIA

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Tilapia (*Oreochromis niloticus*) is a popular aquaculture fish in Asia as well as in Bangladesh for its high nutrition quality, easy breeding, fast-growing, and good taste. Biofloc technology has shown more production compared to conventional Tilapia culture but disease outbreaks have been seen to severely impede productivity. The aim of the study was to diagnose specific pathogens isolated from diseased Nile tilapia (*O. niloticus*), using molecular, histopathological, and biochemical techniques and determine effective antibiotics through antibiotic sensitivity tests. Bacterial samples were isolated from different infected organs and cultured on nutrient agar. At the same time RS media was used as a selective media to identify the presence of *Aeromonas* spp. After the positive result on RS media, various Biochemical tests like Gram's staining, Triple Sugar Iron test, Catalase test, Motility test, Carbohydrate Fermentation test, Indole test, and Methyl Red and Voges-Proskauer (MR-VP) test. Colony morphology, clinical signs, and the results of biochemical tests indicate the suspected pathogen is *Aeromonas* spp. Finally, the obtained 16S rRNA gene sequence (1416 bp) confirmed that the isolated bacteria was *Aeromonas caviae* which shows 99.86% similarity with the complete genome (GenBank accession number AP019195.1). Distinct histopathological changes were observed in gill, kidney, spleen and skin-muscle of the diseased Nile tilapia. This evidence of pathological changes is a reliable indicator of bacterial pathogenicity. The sensitivity of the isolated bacteria were tested against fifteen commercially available antibiotics. Gentamicin is found as the most effective antibiotic against *Aeromonas caviae*. Findings of this research will be helpful in diagnosing and controlling diseases of the Nile tilapia. This research can be served as a springboard to generate interest for further research.

MOLECULAR AND BIOCHEMICAL IDENTIFICATION OF PATHOGENIC BACTERIA IN DISEASED TENGRA (*Mystus cavasius*) FROM BIOFLOC AQUACULTURE SYSTEM WITH ANTIBIOTIC SENSITIVITY OF ISOLATED BACTERIA

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Gulsha tengra (*Mystus cavasius*) is an important aquaculture resource that represents one of the most popular cultured species in the whole world. However, culture of this species face some problems, which are associated with the occurrence of pathogenic bacteria and cause high pecuniary loss. The main aim of this study was to isolate and identify the pathogenic bacteria from diseased farmed *Mystus cavasius* and to detect the antibiotic sensitivity with some commonly used antibiotics. Bacteria samples were collected from different parts of the body of both diseased and fresh tengra and cultured in both nutrient agar and broth media. The bacterial colonies were evaluated using biochemical tests i.e. Gram? staining, Motilitytest, Carbohydrate fermentation test, Indole test, MR-VP test and Catalase test. The antibiotic sensitivity of the isolated bacteria samples was also detected, using fifteen antibiotic discs i.e. Ciprofloxacin (5?g), Azithromycin (15?g), Ampicillin (10?g), Tetracycline (30?g), Streptomycin (30?g), Ceftriaxone (30?g) and Erythromycin (15?g) Levofloxacin (5mcg) Doxycycline Hydrochloride (30mcg) Oxytetracycline (30mcg) Gentamycin (10mcg), Oxacillin (1mcg) Novobiocin (30mcg), Amoxycillin (30mcg). The obtained 16S rRNA gene sequence (1410 bp) confirmed that the isolated bacteria was *Aeromonas veronii* which showed 99.93% similarity with the complete genome (GenBank Accession number CP034967. 1). Thus, colony characters, molecular studies and the biochemical analysis revealed the presence of *Aeromonas veronii*. Among the antibiotics, tetracycline and ciprofloxacin were more sensitive, azithromycin and streptomycin were moderately sensitive, and ampicillin was resistant to the isolated bacteria. Ciprofloxacin and Novobiocin could be used to control the disease of tengra infected by *A.veronii*. The results of the study will be helpful to the farmers for management of bacterial diseases.

HISTOPATHOLOGICAL CHANGES IN DIFFERENT ORGANS OF DISEASED THAI KOI (*Anabas testudineus*)

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This study was conducted to know the health and disease problems of Thai Koi (*Anabas testudineus*) through histopathological technique. The aim of this research is to observe fish histopathology including histological alteration in the gill, kidney, liver, gut, spleen and muscle organs. Gills exhibited pathological changes, which include hyperplasia, telangiectasis, hypertrophy, clubbing, haemorrhage, massive necrosis in both primary and secondary gill lamellae and missing of secondary gill lamellae. In kidney haemorrhage, vacuolation, necrosis, pyknosis, and blood cells alterations are found. The kidney was composed of numerous renal corpuscles with well-developed glomeruli and a system of tubules. Histological study shows a typical structural organization of the kidneys in the untreated fish. When kidneys were severely affected and ruptured and missing kidney tubules in some places, necrosis, parasitic cysts, large vacuoles, severe haemorrhage and presence of melanomacrophage center, and pyknotic cells were observed. Different histopathological changes were observed in liver of Thai Koi (*Anabas testudineus*) which includes necrosis, vacuoles, fungal granuloma, haemorrhagic lesions and presence of pyknotic cells. The present study also demonstrates that the liver of control fish exhibits a normal architecture and there were no pathological abnormalities. In spleen histopathological analysis showed tissue damage including necrosis and vacuolization. Secondary infection by bacteria causes damage to necrosis of the spleen organ. The spleen of fish is involved in the immune responses to pollutants and infection by bacteria.

HISTOPATHOLOGICAL CHANGES IN DIFFERENT ORGANS OF DISEASED VIETNAM KOI *Anabas testudineus*

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Vietnam koi (*Anabas testudineus*) is a popular exotic aquaculture species due to its faster growth and nutritional quality. Disease is one of the major problems in semi-intensive and intensive culture systems of Vietnam koi. The study was performed to identify the histopathological changes in diseased Vietnam koi fish to characterize the disease with the causing agents. The standard histological process was followed to obtain desired histological images representing histopathological changes in different organs (i.e. gill, liver, kidney, and spleen and skin muscle) of Vietnam koi. Diseased gill of Vietnam koi showed disarrangement of cells in gill such as vasodilation, blood congestion, loss of gill filament, cellular necrosis with epithelium rupture, lamellar fusion, swollen of gill lamellae and telangiectasia at the tip of the gill lamellae. The kidney of the diseased fish characterized with ruptured and degraded tubules, hemorrhagic, necrotic, vacuole with melano macrophage centers, pyknotic nuclei, inflammatory cells, glomerular expansion, and degeneration of renal tubule, irregular diameter of renal tubule, dilation of bowman's space, glomerular expansion, and necrosis. Histopathological abnormalities in the liver tissues were revealed by a variety of modifications, including many pyknotic nuclei, dilated sinusoids, and cellular necrosis of hepatocytes. Important clinical symptoms reported in liver including nuclear hypertrophy, cellular necrosis, numerous vacuolization of hepatocytes, Blood congestion, pyknosis, melano macrophage centres. Important histopathological changes were observed in spleen such as numerous big melano macrophage centers, inflammation in the spleen splenitis, loss of red and white pulp, and rupture of cell. In diseased fish skin, cell fading describing the necrosis was observed in the infected fish muscle. Furthermore, shortening muscle bundle, disruption of dermis layer, edema and vacuolation were seen in the diseased fish. The information of the study could be used to know the level of the intensity of the disease and to identify the pathogen.

IDENTIFICATION OF PATHOGENIC BACTERIA FROM DISEASED VIETNAM KOI *ANABAS TESTUDINEUS* AND ASSESSMENT OF THEIR SENSITIVITY TO ANTIBIOTICS

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Vietnam Koi (*Anabas testudineus*) is one of the common exotic fish species in Bangladesh and considered as a commercially important aquaculture species in Asia including Bangladesh. The study was performed to identify pathogenic bacteria from diseased Vietnam koi and to assess their sensitivity to antibiotics. The causative agents of diseased Vietnam koi was isolated by pure culture of bacteria using slant and streak plate techniques. Fifteen commercially important antibiotics such as Ciprofloxacin (5mcg), Ampicillin/Sulbactam (20mcg), Tetracycline (30mcg), Azithromycin (15mcg), Ceftriaxone (30mcg), Levofloxacin (5mcg), Doxycycline Hydrochloride (30mcg), Co-Trimoxazole (25mcg), Streptomycin (10mcg), Oxytetracycline (30mcg), Gentamycin (10mcg), Oxacillin (1mcg), Erythromycin (15mcg), Novobiocin (30mcg) and Amoxycillin (30mcg) were used to assess the sensitivity of the isolated bacteria. Four bacteria such as *Aeromonas hydrophila*, *Flavobacterium columnare*, *Edwardsiella tarda* and *Pseudomonas* spp. were identified based on their colony characteristics. *Aeromonas hydrophila*, which was confirmed based on their colony characteristics on Rimler-Shotts (RS) Medium Base, was considered as the main causative agent responsible for Bacillary Necrosis in Vietnam koi, showing clinical signs of skin lesion, fin and tail rot. Co-infections were occurred by *Flavobacterium columnare*, *E. tarda* and *Pseudomonas* spp. The antibiotic sensitivity test for *A. hydrophila* showed multi-resistances to the tested antibiotics. Ciprofloxacin (5mcg), Azithromycin (15mcg), Ceftriaxone (30mcg), Levofloxacin (5mcg), Streptomycin (10mcg), Gentamycin (10mcg) and Erythromycin (15mcg) were found more effective of which Ceftriaxone (30mcg) was the most effective one. Ampicillin/Sulbactam (20mcg), Co-trimoxazole (25mcg), Oxacillin (1mcg) and Amoxycillin (30mcg) were found resistant to *A. hydrophila*. Ceftriaxone (30mcg), Ciprofloxacin (5mcg), Azithromycin (15mcg), Levofloxacin (5mcg), Streptomycin (10mcg), Gentamycin (10mcg) and Erythromycin (15mcg) could be used to control *A. hydrophila*. The information of this study will be helpful for the management of bacterial diseases in Vietnam Koi farming.

EFFECTS OF MAJOR IMMUNOSTIMULANT ON HEALTH AND PRODUCTION OF TILAPIA (*Oreochromis niloticus*)

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The study was conducted to determine the performance of a commonly used immunostimulant, "Betamune" from ACI animal Health Limited on the growth of *Oreochromis niloticus*. The experiment was performed in the wet laboratory of the Department of fish Health Management, Sylhet Agricultural University, Sylhet, with 10 aquaria and 110 fish for 28 days. Average initial body weight of the fish was 2.75 g. The immunostimulant was used in separate nine aquaria at lower dose, recommended dose and the higher dose respectively and designated as T₁, T₂ and T₃. Each treatment had three replications. One aquarium was used as control. Tilapia fingerlings were fed "Misha feed" (commercial feed) at the rate of 10% of the body weight for 28 days. Betamune was given at 1ml, 2ml and 3ml/kg feed for T₁, T₂ and T₃ respectively. The fish in control did not receive the immunostimulant. Mean final weights of T₁, T₂, T₃ and control were found 9.63, 11.12, 8.69 and 7.40 g. Mean weight gain were 6.88, 8.37, 5.94 and 4.65. Percent weight gain were 250.07%, 304.50%, 215.84% and 168.91%. Specific growth rate (%/day) were 4.47, 4.99, 4.12 and 3.53. The FCR of T₁, T₂, T₃ and control were 1.35, 1.10, 1.56 and 1.99. Survival rate (%) were 90.91%, 100%, 81.82% and 54.55%. Among the treatments T₂ showed the best result and control showed the least growth. Thus Betamune may be used as an immunostimulant at dose 2ml/kg feed to get profitable growth of tilapia (*Oreochromis niloticus*) in Bangladesh aquaculture. However, the results may be cross-checked in pond condition before its implementation.

ECOTOXICOLOGICAL EFFECTS OF CYPERMETHRIN ON INDIGENOUS CATFISH *Clarias batrachus*

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The ecotoxicological effects of Cypermethrin (CYP), a synthetic pyrethroid were reviewed with emphasis on the potential changes in haematological parameters and histology of indigenous catfish, *Clarias batrachus*. The 96 hours LC50 was 0.75ppm. *C. batrachus* was exposed to four sub-lethal concentrations of CYP such as 0.00 ppm (C), 0.05 ppm (T1), 0.10 ppm (T2) and 0.20 ppm (T3). The experiment was conducted with these four treatments, each with three replications. The physical reactions observed in the treated fish were erratic swimming, discolorations of the skin, vertical swimming surfacing, excessive mucous secretion from mouth and gills, loss of balancing, frequent surfacing, loss of reflex, hyperactivities, rapid opercula movements increasing opercula ventilation, loss of balancing, swimming at the water surface, gulping for air, resting at bottom in crowds these effects increased with increasing concentration of the toxicants and duration of exposure. Organs like gill, liver, spleen and kidney are the best suited organs for histological observations. Histological changes in these organs were observed on 30th days of experiment. Curled shape gill lamellae (CSGL), hypertrophy of epithelial cells (HEC), Thickening and shortening of the secondary gill lamellae (TSSGL), curled shape central axis (CSCA) and almost missing the secondary gill lamellae (MSGSL) were histopathological changes in the gills of *C. batrachus* exposed to CYP. Hepatic lesions in the liver tissues of fish were characterized by sinusoidal congestion (SC), necrosis (N) and vacuolation (V), piknotic nuclei (PN), ballon shaped hepatocytes (BSH), atrophy of hepatocytes (AH). Glomerular hypertrophy (GH), hyperplasia of haematopoietic cell (HHC), nuclear pyknosis at haematopoietic tissue, ruptured kidney tubule (RKT), hypertrophy of distal tubule (HDT), Expansion of Space inside Bowman's Capsule (ESBC), vacuole formation (VF), haemorrhage (H), vacuolation (V) and occlusion of tubular lumen (OTL) were observed in kidney tissues of fish. The most common changes in spleen histoarchitecture at all doses of CYP were vacuolation, degeneration of reticulocytes (DR), haemorrhage (H), plenty of hemosiderin (PH), presence of black pigment (PBP), scattered white pulp (SWP). The haematological parameters of *C. batrachus* control group and treatment were investigated on 15th days and 30th days of experiment. In this study, significant decrease observed in RBC, Hgb, Hct and significant increase was observed in WBC and MCV in CYP treated *C. batrachus* compared to control.

ECOTOXICOLOGICAL EFFECTS OF CYPERMETHRIN ON INDIGENOUS KOI (*Anabas testudineus*)

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Pesticides have a harmful effect on aquatic community through affecting the normal function of major organs depending on distinguished concentrations of the pesticides. Cypermethrin, a commonly used pesticide of tea garden is hazardous to fish and other aquatic animals. Experiment carried out to assess the ecotoxicological effects of cypermethrin on indigenous koi (*Anabas testudineus*) to observe harmful side effect of cypermethrin (10%EC). Experimental fish were exposed to the acute toxicity test. The LC₅₀ value for 96 hours was maintained as 1.00 ppm with four groups. Control group (0 ppm) with three different concentrations of 0.05 ppm (5% of 96 h LC₅₀), 0.10 ppm (10% of 96 h LC₅₀) and 0.20 ppm (20% of 96h LC₅₀) were used as (T₁, T₂, T₃) respectively. Several behavioral amendments including restlessness, erratic movement, increased opercular activities, loss of equilibrium, irregular feeding were observed in treatment trials. Histological alterations due to sub lethal concentrations induced moderate to severe alterations in liver, kidney, gill and spleen. Major histopathologies observed in gill like epithelial cell hyperplasia, necrosis, severe fusion and epithelial lifting. Necrotic proximal tubules, glomerular shrinkage, disrupted renal corpuscle of kidney and nuclear pyknosis, hemorrhage, degenerated hepatic cell and vacuolation were observed in liver tissue. Severe Melanomacrophage centre (MMC), haemosiderosis and vacuolation were found in spleen cell. Effect of cypermethrin on the hematological parameters of experimental fishes were also studied. Values of White Blood Cell (WBC), Platelets, Mean corpuscular hemoglobin concentration (MCHC) was significantly increased in the experimental groups. On the contrary, values of hemoglobin (Hb), haematocrit (Ht), Red Blood Cell (RBC), Mean corpuscular volume (MCV) and Mean corpuscular hemoglobin (MCH) were significantly decreased with comparison to the control group (p<0.05) at the end of the total exposure period. The outcomes of the present study indicate that the existence of pesticide even at low concentrations can cause harmful effects to *A. testudineus* and its survivability.

ECOTOXICOLOGICAL EFFECTS OF CHLORPYRIFOS ON GULSHA *Mystus cavasius*

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Pesticides have very toxic effects on fishes through disturbance of the normal function of major organ and damaging the organs depending on the concentrations. The present study was conducted to assess the histological and hematological effects of chlorpyrifos on gulsha, *Mystus cavasius*. The LC50 value for 96 hours was found as 5.00 ppm and the experiment was performed with four groups. Group one was used as control (0ppm) and three concentrations such as 0.5 ppm (5% of 96 h LC50), 1.0 ppm (10% of 96 h LC50) and 1.5 ppm (20% of 96 h LC50) were used as T1, T2 and T3 respectively. During the experiment, several behavioral alterations including erratic swimming, hyperactivities, excessive mucous secretion, skin discoloration, sudden mortalities, loss of balance, gasping for air, reduction of feed intake, rapid opercular movements increasing opercula ventilation and resting at the bottom forming crowd were observed in pesticide treated fish. The histopathological abnormalities in the tissues suggest that sub lethal concentrations included moderate to severe alterations in gill, liver, kidney and spleen. Major histopathological changes like clubbing, hyperplasia, fusion of lamellae, hypertrophy, hyperplasia, breakdown of gill lamellae, epithelial lifting and missing gill lamellae of gill were observed. Collecting duct shrinkage, renal tubule disruption, melanomacrophage centres, increase space between glomerulus and Bowman's capsule, glomeruli shrinkage, necrosis, necrotising degeneration of tubules of kidney and hepatic cell disruption, disruption of central vein, increase in number of pyknotic nuclei, melanomacrophage centers, fibrosis, presence of Sinusoidal Space, increase in number of kuffer cell and pyknotic nuclei were observed in liver cells. Severe MMC, granule, degeneration of pulp, lymphocyte, vacuolation, leukocyte aggregation, necrosis, intracellular vacuolation were found in spleen. Due to the effects of chlorpyrifos, WBC was significantly increased in the experimental groups whereas RBC, hemoglobin (Hb), hematocrit (Hct), Plateletes were significantly decreased in compare to the control group ($p < 0.05$). Mean corpuscular volume (MCV), Mean corpuscular hemoglobin (MCH), and Mean corpuscular hemoglobin concentration (MCHC) didn't show any significant changes at the end of the total exposure period. Finally, the existence of pesticide, even at low concentrations, can cause harmful effects to *M. cavasius* and its survivality.

EFFECTS OF NATURAL SPIRULINA (*Arthrospira platensis*) ON GROWTH, HAEMATO-BIOCHEMICAL INDICES, GUT MORPHOLOGY AND DISEASE RESISTANCE OF STINGING CATFISH, *Heteropneustes fossilis*

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In this study, the effect of spirulina meal (*Arthrospira platensis*) as a feed additive on growth, feed utilization, haematology, gut morphology, and disease resistance of stinging catfish, *Heteropneustes fossilis* was assessed using four diets including control (T₀) without supplementation, 1% (T₁), 3% (T₂), and 5% (T₃) spirulina/kg. For 60 days, 240 fish (4.23 ± 0.11 g) were divided among 12 aquariums and fed twice a day. The findings demonstrate that the T₃ treatment (5%) had statistically better growth performance and feeding characteristics than the control. Moreover, white blood cell (WBC), red blood cell (RBC), haemoglobin (HGB), mean corpuscular haemoglobin (MCH) mean corpuscular volume (MCV), and packed cell volume (PCV) were significantly improved (p<0.05) in the T₃ treatment compared with the control. Significant elevated level (p<0.05) of total protein, albumin, and globulin, but lower levels of SGPT, SGOT, glucose, and cholesterol than the control. The LD₅₀ test of *Aeromonas hydrophila* in *H. fossilis* was conducted prior to the challenging investigation, and the result was 2.3 × 10⁷ CFU/ml. When *Aeromonas hydrophila* was challenged, *H. fossilis* exhibited disease resistance in spirulina incorporated groups. The maximum relative percentage (p<0.05) of survival (RPS) was at 5% spirulina incorporation (83.31%), and different levels of spirulina incorporation exhibited higher RPS and reduced cumulative mortality pattern than the control group. Based on the findings, spirulina powder can be utilized as a useful natural feed addition to increase the performance and

Table 1. Growth and feed utilization of *Heteropneustes fossilis* recorded in spirulina and control groups.

Parameters	Treatments			
	T ₀ (0%)	T ₁ (1%)	T ₂ (3%)	T ₃ (5%)
Initial weight (g)	4.25±0.14 ^a	4.23±0.11 ^a	4.27±0.13 ^a	4.25±0.13 ^a
Final weight (g)	10.27±0.09 ^a	11.09±0.14 ^a	15.29±1.10 ^b	17.25±0.13 ^c
Weight gain (g)	6.02±0.02 ^a	6.86±0.02 ^a	11.01±0.09 ^b	13.00±0.70 ^b
Average daily gain (g/day)	0.10±0.00 ^a	0.10±0.01 ^a	0.14±0.01 ^b	0.22±0.01 ^c
Feed conversion ratio (FCR)	2.52±0.11 ^a	2.04±0.08 ^a	1.32±0.07 ^b	1.13±0.06 ^c
Protein efficiency ratio (PER)	1.17±0.05 ^a	1.44±0.05 ^a	2.21±0.11 ^b	2.57±0.16 ^c
Specific growth rate (% day ⁻¹)	1.47±0.02 ^a	1.61±0.02 ^a	2.12±0.01 ^b	2.33±0.11 ^c
Survival (%)	100±0.00 ^a	100±0.00 ^a	100±0.00 ^a	100±0.00 ^a

Data are expressed as mean ± standard error (M ± SE). The values with different superscript letters in the same row are significantly different (P<0.05)

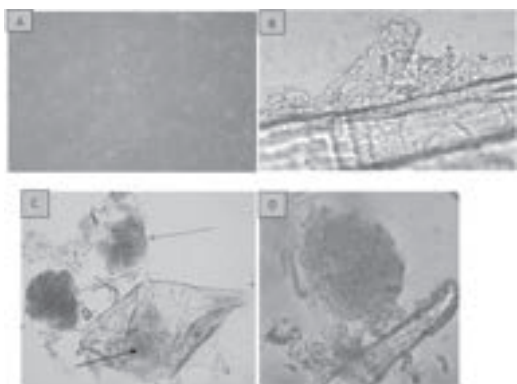
EVALUATION OF FEED UTILIZATION, IMMUNE RESPONSE AND DISEASE RESISTANCE OF BIOFILM OF *Aeromonas hydrophila* FOR ORAL VACCINATION OF CLIMBING PERCH, *Anabas testudineus*

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Bacteria often adopt a sessile biofilm lifestyle that is resistant to many unfavourable conditions. Gram negative bacteria like *Aeromonas hydrophila* has been known to have strong biofilm-forming ability. Biofilm of *A. hydrophila* found resistant compare to free cell, survived even at 100 °C for 30 min. Climbing perch, *Anabas testudineus* was immunized with Biofilm (BF) and Free cell (FC) of *Aeromonas hydrophila* vaccine at 10¹⁰ CFU g⁻¹ for 20 days and monitored for growth parameters, immune responses and disease resistance up to 60 day post vaccination (dpv). Climbing perch in the BF vaccinated group had considerably higher (P<0.05) growth and feed utilization than the FC vaccinated and control groups. The vaccinated fishes were challenged with *A. hydrophila* at 10⁷ CFU/ml. A very high relative percentage survival was recorded with BF (78.39%) when challenged by homologous bacteria compared to that with FC (36.47%). Moreover, higher haematological parameters recorded in the present study, were differentially invigorated by the oral administration of *A. hydrophila* biofilm vaccine. Furthermore, biochemical stress parameters (SGPT, SGOT etc.) in the vaccination groups showed an incremental trend in the early timeline. However, the values in the biofilm group displayed down regulated on 20 dpv onwards indicating improved health condition. Vaccinated BF fishes showed gut associated lymphoid tissues (GALT) within the lamina propria of mid gut. But in FC group fishes showed less aggregation of lymphoid cells. The unvaccinated control fish had no lymphoid cell aggregation in their intestines. The findings of the current research suggested that biofilm vaccine has the capability to be one of the potential oral vaccines in striped catfish against *A. hydrophila* infection.



Figures: Microphotograph of the 4-day old biofilm cell of *A.*

Table1: Growth and feed utilization of *A. testudineus* recorded in vaccinated and control groups

Parameters	Treatments		
	BF	FC	Control
Initial weight (g)	6.05 ± 0.37 ^a	5.95 ± 0.18 ^a	6.10 ± 0.21 ^a
Final weight (g)	15.30±0.46 ^a	11.89±0.20 ^b	11.04±0.39 ^b
Weight gain (g)	9.25 ± 0.74 ^a	5.9 ± 0.27 ^b	4.94 ± 0.34 ^b
% weight gain	372.32 ± 6.167 ^a	291.80 ± 5.944 ^b	283.21 ± 5.355 ^b
Average daily gain (g day)	0.11 ± 0.009 ^a	0.07 ± 0.003 ^b	0.06± 0.003 ^b
Feed conversion ratio (FCR)	1.26 ± 0.12 ^a	1.71± 0.03 ^b	1.91 ± 0.16 ^b
Protein efficiency ratio (PER)	2.33± 0.24 ^a	1.69 ± 0.03 ^b	1.56 ± 0.14 ^b
Specific growth rate (% day ⁻¹)	1.16 ± 0.10 ^a	0.87 ± 0.04 ^b	0.74 ± 0.03 ^b
Survival (%)	100 ± 0.00 ^a	100 ± 0.00 ^a	100 ± 0.00 ^a

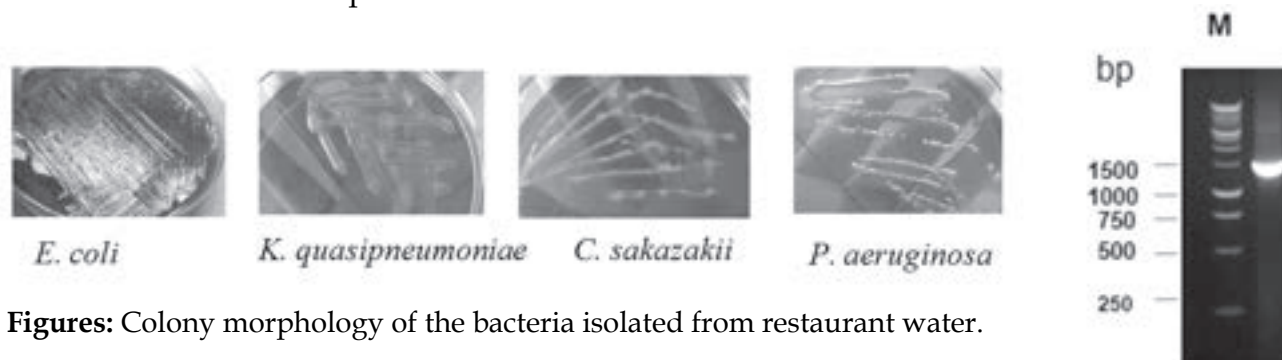
ANALYSIS OF VARIOUS DRINKING WATER SAMPLES FROM RESTAURANTS IN SYLHET TOWN TO DETECT THE COLIFORM BACTERIA BY MOST PROBABLE NUMBER (MPN) METHOD

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Recent record outbreak of diarrhoeal diseases in Bangladesh indicated the probable bacteriological contamination of drinking water system. More than 4, 50,000 people all over the country have been diagnosed with diarrhoea which was highest in 20-25 years. In this study, the bacteriological quality of restaurant water of Sylhet town was assessed by the use of Most Probable Number (MPN) method. In presumptive test 25 out of 25 water samples (100%) were positive and the total coliforms ranged between 170 to >1600 MPN/100 ml. Similarly in confirmed test faecal coliforms were also detected in the same magnitude (9 to 350 MPN/100 ml). The indicator bacterium *Escherichia coli* were detected in 10 out of 25 restaurant water samples as revealed consequently by the presumptive, confirmed and completed tests of MPN method. Moreover, bacteria were further confirmed by the polymerase chain reaction (PCR) techniques. The documentation following gel electrophoresis confirmed that the PCR for bacteria 16S rRNA gene produced about 1,450 bp length PCR product. The sequencing of *E. coli*, *Cronobacter sakazakii*, *Klebsiella quasipneumoniae*, *Pseudomonas aeruginosa* were matched with other sequenced data submitted in National Centre for Biotechnology Information (NCBI). Following submission of the sequenced data, NCBI has given the accession number of GenBank: ON863927.1 GenBank: ON798607.1 for *C. sakazakii* and *K. quasipneumoniae* respectively. By ensuring a complete regulation of microbiological quality of restaurant water should be ensured in order to make the water potable.



Figures: Colony morphology of the bacteria isolated from restaurant water.

Figure: Gel electrophoresis of 16S rRNA gene produced about 1,450 bp PCR product of bacteria.

The background of the page features a stylized, layered mountain range. The mountains are rendered in various shades of gray, with the foreground peaks being a darker gray and the background peaks being a lighter gray. The overall effect is a soft, atmospheric landscape.

Technical Session 6:
**Fishing, Processing and
Value Addition**

FISHERIES RESOURCE UTILIZATION THROUGH INNOVATION ENTERPRISE: QUALITY AND SAFETY ISSUES

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Food security, and food quality and safety are synonymous, since food science defines foods as only those consumables which are safe for human being, as these meet the dietary needs to lead active and healthy human life. Due to increased global population, along with uncontrolled global warming, that leads to threats in food security, there have been increasing needs of intensification in production systems and climate change/climate variability adaptations. Increased fisheries activities leading to increasing scopes for various new and innovative enterprises, enhance the risks and hazards in quality and safety of seafood. In this speech, the innovative enterprise development in tropical fisheries, with particular reference to risks in quality and safety, will be discussed and possible mitigation measures will be highlighted.

FISHING GEARS USED IN INLAND WATERS OF BANGLADESH: A COMPREHENSIVE REVIEW

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Fishing gears are the tool or equipment used to capture fish from any water body. Fishing gear differs greatly in terms of materials used, structure, and principles of capture and operation. This research was done to give a general overview of the fishing equipment utilized in Bangladesh's inland waters.

The catching principle of fishing gear, description, catch per unit effort, mode of operation, and impact of fishing gear was discussed. Five different groups of fishing gear, including gillnets, lift nets, seine nets, cast nets, and fish traps, were found throughout the study including a total of 22 fishing gears which are commonly used in river and floodplain areas of Bangladesh. Among nets, the highest mesh size was recorded in the gill net whereas the lowest was in the push net. The CPUE of fishing gear was also identified in the study. The highest CPUE was found in the Seine net followed by Gill net, Lift net, cast net, Traps, hook and line and Push net. The reason for the high CPUE of the seine net was that it is used abundantly in waterbodies and it covers a huge area of waterbodies that capture a large number of fish. It was found that in Bangladesh culture production is increasing tremendously day by day but capture production is not been so during the last 20 years due

to different reasons like the use of unauthorized fishing gear, destructive fishing practices, fishing in the banning period, habitat destruction, etc. Destructive fishing was practiced by many fishermen, especially with a mono-filament gill net and seine net. It is proposed that the application of harmful fishing gear should be restricted for several months to allow newly stocked fingerlings to grow to market size.

Gear type	CPUE (kg/unit/day)
Seine net	4.67-48.99
Gill net	2.83-20
Lift net	0.46-24
Cast net	0.95-5.5
Traps	1-4.69
Hook and line	0.5-3.11
Push net	0.25-2.60

Table: Variations in CPUE of different fishing gear used in inland waters of Bangladesh

CONSUMER PREFERENCE TEST OF READY TO EAT SHRIMP BALACHAO; A POTENTIAL VALUE-ADDED FISHERY PRODUCT IN BANGLADESH

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Balachao is a spicy and ready-to-eat product prepared from small fish and shrimp. It is getting popular in Bangladesh, but consumer preference is still unknown. A panel test was conducted on ready-to-eat Shrimp-Balachao with 60 respondents of different ages, genders, and areas. Twenty participants were selected from three different age classes each: less than 20, 20 to 40, and above 40 years. The male to female and dried fish preferring to non-preferring area participants' ratio was maintained at 1:1. Three different recipes of 100 gm each with 40 (A1), 50 (A2), and 60 (A3) (gm) dried shrimp and the rest with roasted onion were prepared. The recipes were provided to the panelists with a questionnaire containing a hedonic five-point scale (1-5) to measure the degree of consumer preference. The hedonic scale was categorized as extremely liked (1), moderately liked (2), liked (3), slightly disliked (4), and extremely disliked (5). Bacterial tests were found negative for *E. coli* and *Salmonella sp.* The panelists' responses were collected and analyzed with the SPSS software. The highest mean hedonic scale values were found in taste, external appearance, elasticity, odor, and crispiness in the recipes A3 (2.582±0.994), A1 (2.291±0.854), A3 (2.818±1.020), A1 (2.618±0.933), and A3 (2.491±0.998), respectively. The overall acceptability was found 2.055±0.756, 2.309±0.879, and 2.291±0.854 for A1, A2, and A3, respectively. Male panelists provided the highest mean score to A2 (2.346±0.797) while females to A3 (2.414±0.907). Panelists below 20 years provided the highest mean score for the recipe A2 (2.357±0.842), 20 to 40 years to A3 (2.391±0.839), and above 40 years for A2 (2.078±0.895). The overall acceptability of A2 (50 gm shrimp + 50 gram roasted onion) was found highest. The acceptability range was between 2 to 3 on the hedonic scale (moderately liked to liked). Hence, the study recommends recipe A2 of Balachao as a value-added fishery product in Bangladesh.

VALORIZATION OF SILVER CARP (*Hypophthalmichthys molitrix*): PREPARATION OF FISH PICKLE AND SHELF LIFE ASSESSMENT

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Due to modernization of the society, people are now more dependent on convenient foods. Valorization of fish products has been emerged as a viable option to satisfy the ever changing and diversified demands of the consumers. Henceforth, this study was conducted to develop a value-added product (e.g., fish pickle) from silver carp (*Hypophthalmichthys molitrix*) and to assess the shelf life at room (25 ± 5) and refrigeration (4 ± 1) temperatures. Fresh silver carp were purchased from local fish market of Sylhet district and transported to the laboratory. Fish pickle was prepared by adding different ingredients and kept at room and refrigeration temperatures. Results indicated that the initial moisture, lipid, protein and ash contents of fish pickle prepared from silver carp were $56.75\pm 0.16\%$, $7.28\pm 0.06\%$, $18.68\pm 0.13\%$ and $2.44\pm 0.05\%$, respectively. Moisture, lipid and protein contents of fish pickle decreased as day passed while the ash content increased in both storage temperatures. At room temperature, the rate of changes was relatively faster than at refrigeration temperature. The peroxide value was 2.30 ± 0.31 meq/kg of oil which significantly ($p < 0.05$) increased to 4.52 ± 0.19 meq/kg of oil on the 12th day at room temperature. In case of refrigeration temperature, peroxide value gradually increased to 4.18 ± 0.10 meq/kg of oil on the 30th day. The TVB-N value increased from 1.44 ± 0.15 mg/100g to 3.40 ± 0.05 and 3.73 ± 0.23 mg/100g on the 12th day at room and 30th day at refrigeration temperature, respectively. At room temperature, the values increased very swiftly compared to refrigeration temperature. Conversely, the pH value of fish pickle reduced from 5.20 ± 0.06 at 0 day to 3.38 ± 0.23 and 3.46 ± 0.11 on the 12th day at room and 30th day at refrigeration temperature, respectively. Initial sensory scores of the fish pickle were maximum. However, with the progress of storage period, all the sensory qualities of the product declined rapidly at room temperature than that of refrigeration temperature. After 12 days, room temperature stored fish pickle was found unacceptable due to spiky and sour taste as well as fungal growth at the surface of the fish pickle. But it was found in acceptable condition during 30 days of storage period at refrigeration temperature. Bacterial load of the fish pickle at room temperature increased significantly ($p < 0.05$) from 2.74 ± 0.31 log cfu/g to 6.90 ± 0.18 log cfu/g within 12 days. But, bacterial growth was slower at refrigeration temperature and reached to 6.27 ± 0.21 log cfu/g at 30th day of storage. The shelf life of the fish pickle was in good condition not more than 12 days at room temperature. On the contrary, it persisted in satisfactory condition for up to 30 days when stored at refrigeration temperature.

SEAFOOD MARKETING SYSTEM IN SOUTHWEST COASTAL FLOOD PLAIN AREAS OF BANGLADESH AND ITS IMPACT ON LOCAL FOOD SECURITY

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Shrimp farming in Bangladesh has increased drastically in last 30 years due to its high price and heavy demand in international market. But its pity that, this shift has been criticized in some literature in such a way that because of exporting nutrients in international market the country is already suffering from malnutrition and hidden hunger. To pursue the real scenario, the present study was designed based on the wholesale fish market of southwest Bangladesh. The wholesale fish market was selected as it is the most important hub to know the aspect of production and distribution. Using questionnaire and data from different wholesale markets in southwest Bangladesh the heart of shrimp production, this study has found that *gher* based shrimp sector in Bangladesh supporting fish production through polyculture. Variety of freshwater and brackish water species produced with shrimp, where 17% of southwest total fish volume in wet-weight exported and the remaining 83% destined within Bangladesh. In domestic share, about 30% consumed in southwest Bangladesh and 53% destined to other part of the country. In addition, two third of total shrimp production remaining in the country and rest is destined to international market. The benefits of shrimp production contributing to local food security and holding the potential to protect local biodiversity. Policy-makers should look for ways to preserve this polyculture system in Bangladesh, and encourage it as a potential model in other countries that have large shrimp aquaculture sectors as a way of diversifying and increasing resilient food systems.

DEVELOPMENT OF READY-TO-EAT CUTLET USING LOW-PRICED FISH: EFFECT OF STORAGE CONDITIONS ON THE QUALITY OF CUTLET

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The study was conducted to develop a high-quality value-added product, fish cutlet, using a low-priced fish, silver carp (*Hypophthalmichthys molitrix*). Prepared fish fillets were stored in refrigerator ($4\pm 1^{\circ}\text{C}$) for 16 days and in a deep freezer ($-18\pm 2^{\circ}\text{C}$) for 120 days to evaluate biochemical, microbiological, and sensory attributes. The results revealed that the proximate composition of the cutlets changed significantly at the end of both storage periods. The pH, total volatile base nitrogen, peroxide value, and bacterial counts of the products increased significantly as the storage time progressed, with the exception of total plate count for frozen cutlets. Throughout the preservation periods, however, these biochemical and microbial indices were found to be within permissible limits. In contrast, sensory scores of the products exhibited a declining pattern. Based on sensory ratings, the shelf life of refrigerated and frozen cutlets was determined to be 12 and 120 days respectively.

TABLE : Proximate composition and energy content of silver carp fillet and fish cutlets at different storage periods.

Parameters	Silver carp fillet	Fish cutlets (storage days)		
		Fresh (0)	Refrigerated (16)	Frozen (120)
Moisture	77.16 ± 0.70 ^a	61.16 ± 1.56 ^b	54.30 ± 1.58 ^c	57.10 ± 0.86 ^c
Protein	17.43 ± 0.54 ^a	18.47 ± 0.94 ^a	14.20 ± 0.56 ^b	15.48 ± 0.62 ^b
Fat	3.51 ± 0.38 ^d	6.17 ± 0.36 ^c	10.63 ± 0.80 ^a	8.26 ± 0.54 ^b
Ash	1.38 ± 0.36 ^d	3.40 ± 0.23 ^c	4.42 ± 0.46 ^b	5.70 ± 0.43 ^a
Carbohydrate	0.52 ± 0.21 ^c	10.80 ± 1.44 ^b	16.46 ± 2.17 ^a	13.46 ± 1.30 ^{ab}
Energy	103.38 ± 3.79 ^d	172.58 ± 7.80 ^c	218.27 ± 2.77 ^a	190.10 ± 3.33 ^b

The values are presented as means ± SD (n = 3). Without a common superscript letter, means in a row differ significantly (p < 0.05).

DETERMINATION OF SENSORY ATTRIBUTES, MICROBIAL, BIOCHEMICAL AND PESTICIDES CONTENTS OF DRIED SHARK AND RAY IN SOUTHERN REGION OF BANGLADESH

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Fish drying is an ancient and traditional method of producing nutrient-dense nourishment for humans. The present study was performed to investigate the sensory quality, microbial, biochemical, and pesticide contents of dried shark (*Scoliodon sorrakowah*) and ray (*Himantura walga*) from four major fish drying centers of southern Bangladesh during September 2020 to August 2021. Sensory attributes were determined by the expert panel members whereas microbial quality and biochemical compositions were determined by standard validated methods. The QuEChERS separation was used in conjunction with gas chromatography and gas chromatography mass spectrometry to assess pesticide residues. The sensory properties showed that the dried shark and ray fish products were of acceptable quality for human consumption in all drying center samples and did not differ significantly ($p < 0.05$). The APC for both dried shark and ray fish products exceeded the regulatory limit and varied significantly ($P < 0.05$) across all major fish drying centers, with the exception of the shark fish product ($9.6 \pm 0.09 \times 10^4$) of the Dublarchar fish drying center. Likewise, total fungal load was recorded and differed substantially ($p < 0.05$) in dried shark ($1.78 \pm 0.03 \times 10^3$ cfu/g) and ray ($1.5 \pm 0.02 \times 10^3$ cfu/g) fish products. All dried fish products were free of pathogenic bacteria such as *Salmonella* spp., *Vibrio cholerae*, *Vibrio parahaemolyticus*, and *Listeria monocytogens*. The biochemical compositions (protein, lipid, ash, moisture) and quality indices of dried shark and ray fish products were statistically significant ($p < 0.05$) except for ash and pH content ($p > 0.05$). The organochlorine pesticide residues (DDT and heptachlor) were not found in dried shark and ray fish products, and the pesticides posed no health risk at any of the sampling stations. Thus, the present findings demonstrated the importance of establishing an appropriate management policy that includes improved processing techniques and methods, as well as pesticides avoidance in dried fish, in order to ensure safe food for domestic and international consumers.

EFFECT OF NATURAL PRESERVATIVES ASSIMILATED ICE ON THE SHELF-LIFE OF TILAPIA, *Oreochromis niloticus*

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Icing is traditionally done as a popular method for preservation and maintaining the keeping qualities of raw fish. Numerous harmful chemical preservatives are frequently added to ice in boosting its effectiveness. The purpose of the present study was to determine whether natural preservatives assimilated ice could improve the shelf life of fish and replace artificial preservatives. For this purpose, turmeric and neem leaf powder were mixed into water at quantities of 0.5 %, 1 %, and 2%, respectively and preservatives ice was prepared. The tilapia (*Oreochromis niloticus*) fish (n= 8-10) were then stored using these natural preservatives assimilated ice in an insulated ice box and alterations in sensory quality, proximate composition and bacterial load as total plate count (TPC) were analyzed for a period of 20 days at every 5 days interval. Fish was also preserved in ice without the application of these preservatives as a control. The sensory quality test revealed that the tilapia fish treated with natural preservatives had better quality than the control fish. The rate of protein degradation in the treated sample was slower in compare to the control sample. The increases in pH were considerably slower in both treated sets of samples. At the end of the experimental period, the microbial load in the 1% and 2% turmeric and neem leaves powder treated fish were found lower than those of control and 0.5% preservative treated samples. Similar trends were seen when the bacterial load in the waters from used ice melt was examined. The results revealed that turmeric and neem had the potential to influence the fish quality during storage with these natural preservatives assimilating ice condition and extending shelf life. It can be concluded that turmeric or neem leaves might be used as suitable natural preservatives to extend the shelf-life of fish during ice storage.

SHELF LIFE ASSESSMENT OF OVEN DRIED *Channa punctatus* IN DIFFERENT PACKAGING SYSTEM

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The present study aims to find out the shelf life of oven dried *Channa punctatus* in different packaging systems (normal, vacuum and nitrogen), during September 2019 to February, 2020. Studied species was *Channa punctatus* collected in fresh condition from Shaheb Bazar fish market of Rajshahi City Corporation area. The study was carried out at quality control laboratory of the Department of Fisheries, University of Rajshahi. After that, the fishes were dried in hot air oven at 60°C and weighed. For shelf life assessment, TVB-N value and bacterial load were determined. TVB-N values for normal packaging system in 1st and 6th month were in range from 11.76 ± 0.437 mg N/100g and the mean value was 10.48 ± 1.463 mg N/100g. The TVB-N values for vacuum pack in 1st and 6th month were recorded 8.28 ± 0.075 mg N/100g and 8.62 ± 0.012 mg N/100g and the mean value was 8.39 ± 0.117 mg N/100g. The TVB-N values for packaging with N₂ gas in 1st and 6th month were recorded 8.44 ± 0.107 mg N/100g and 10.89 ± 0.503 mg N/100g and the mean value was 10.00 ± 0.860 mg N/100g. The total plate count for normal packaging in 1st and 6th months was observed 2.69×10^3 CFU/g and 3.36×10^7 CFU/g respectively. The total plate count for vacuum packaging in 1st and 6th months was recorded 2.14×10^2 CFU/g and 3.01×10^3 CFU/g respectively. And in case of packaging with N gas, the total plate count in 1st and 6th month was recorded and that ranged from 2.65×10^3 CFU/g to 3.35×10^6 CFU/g. In this study, the TVB-N values were acceptable limit for all packaging systems. But the bacterial load exceeded the acceptable limit after 3rd month for normal packaging system whereas it didn't exceed for vacuum and packaging with N gas systems through the entire storage period.

EFFECT OF LED_s GENERATED VISIBLE LIGHT WAVELENGTH IN REDUCTION OF MICROBIAL QUALITY LOSS OF DRIED FISH DURING STORAGE

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Dried fish frames a significant source of protein in most equatorial countries. However, dried fishery products frequently suffer severe quality losses due to microbial decomposition. To keep the dried fish free from microbial spoilage, several hazardous chemical preservatives are generally applied to dried fish that are detrimental to human health, thus an alternative approach is very much needed. In recent years, Light Emitting Diodes (LEDs) light is considered as a promising tool in the chemical free food preservation technology. The study aimed to evaluate the effect of LEDs mediated visible light wavelengths on the reduction of microbial quality loss during storage. Both market collected and laboratory made dried tengra (*Mystus vittatus*), and laboratory made dried Loitta (*Harpadonnehereus*) as a representative sample of fresh water and marine water fish species were exposed to different LEDs light as blue (450 nm), green (535 nm) and red (630 nm) condition for 60 days. The dried fish were also exposed to natural day light and without light (dark) condition as control. Bacterial load and fungal infestation were examined at the end of the experimental period. The findings demonstrated that dried fish treated with LED light had significantly ($p < 0.05$) lower bacterial and fungal infestations than control conditions although laboratory made dried fish showed better quality in compare to market collected dried fish. This could imply that exposing dried fish to LEDs had the potential to reduce microbial spoilage suggesting that LED light might be a useful and promising tool for preserving dried fish, replacing hazardous chemical substances, extending the storage life as well as for minimizing economic losses and ensuring consumer safety.. However, photosensitivity in dried fish products may vary depending on the type of microbial attack and the state of the dried fish. As a result, further study is needed into the different forms of dried fish spoilage, as well as the optimization of light intensity, the determination of light exposure periodicity, and the suitability of ambient conditions in getting premium grade dried fish for consumers at a low cost.

EFFECTS OF VISIBLE LIGHT WAVELENGTH ON THE SENSORY ATTRIBUTES AND INSECT INFESTATION IN DRIED FISH

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Dried fish is one of the major fishery products that are equally popular to all kinds of people. Following production, a substantial quality loss occurs during storage period in high humid conditions lead to reduction of sensory quality, nutritional value, product safety and profitability. To keep dried fish free from quality degradation, a variety of health-hazardous chemical substances are used indiscriminately at various stages of processing and preservation, posing a risk to consumer safety, hence, an alternate approach is highly desired. In recent years Light Emitting Diodes (LEDs) is considered as a novel tool in the chemical free food preservation technology. The present study aimed to assess the potential of LEDs generated visible light wavelength on the sensory attributes and insect infestation of dried fish in storage. Both market collected dried Tengra (*Mystus vittatus*) and Loitta (*Harpadonnehereus*) as a representative sample of fresh water and marine fish species were exposed to LEDs light as blue (450 nm), green (535 nm) and red (630 nm) for two months. The dried fish were also exposed to natural day light condition and without light (dark) condition as control. Physical quality attributes such as color odor, texture, broken residues and insect infestation were examined at the end of the experimental period. The sensory quality evaluation by hedonic method showed that the dried fish treated with LEDs light resulted better quality than those of product kept under control condition. Insect infestation was also lower in the dried fish maintained under LEDs light compared to natural light and dark condition. The findings of the present study revealed that LEDs light can be a potential tool in preserving the dried fish without using health hazardous chemical substance and reduction of economic losses and protection of consumer's safety. Further study is needed for the optimization of light intensity, spectral sensitivity, light exposure periodicity and to know the interaction between light and ambient condition suitability in obtaining the best quality of dried fish for the consumers within marginal cost.

MICROBIAL STATUS OF CATLA (*Catla catla*) AT DIFFERENT MARKETING CHANNEL IN SYLHET SADAR

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The research was intended to investigate the microbiological state of Catla (*Catla catla*) at different marketing channel in Sylhet sadar of Bangladesh. To attain the aim of the research selected fish samples were taken from different marketing channel of study during January'21 to May'21. The approach was created to analyze bacteriological parameters; Standard Plate Count (SPC), Total Coliform Count (TCC), and the prevalence of *Escherichia coli*, *Salmonella* spp. and *Vibrio* spp. Among all samples highest microbial load of Catla was found in retailing point (7.46 ± 0.01) followed by aratdar (7.04 ± 0.33), wholesaler (6.56 ± 0.33) and producer (6 ± 0.01) in May. On the other hand, lowest bacterial load followed the trend i.e. the sample of producer holds the lowest bacterial load (5.65 ± 0.03), while bacterial load of wholesaler (6.06 ± 0.09), aratdar (6.25 ± 0.05) and retailer (6.4 ± 0.04) in January and similarly increased slowly in the rest of the months chronologically. In the month of May, there were significant difference (P 0.05) only between producer and retailer. TCC of producer sample ranged from 26 ± 2.52 to 33.3 ± 2.19 , TCC of wholesaler sample ranged from 36.3 ± 0.882 to 43 ± 0 , TCC of aratdar sample ranged from 57 ± 7 to 81 ± 6 and the same in retailer sample ranged from 87 ± 6 to 105 ± 15 . Samples from all four sources showed highest value in the month of May, while retailer sample failed to comply with ICMSF (1986) standards. In this case, substantial difference (P 0.05) also found between producer and retailer in the studied sample. The highest value of isolated bacteria *E.coli*, *Vibrio* spp. and *Salmonella* spp. was observed in retailer sample as 86.66%, 93.33% and 80.00% respectively whereas, the lower rate was found as 26.66%, 13.33% and 20.00% in producer sample. The higher range of the bacterial load suggested that the samples might be contaminated prior to during handling, inadequate hygienic practices and contaminated water supply during transportation, processing and channel wise marketing system up to retailer. Besides, chi square (P 0.05) reveals that presence of pathogenic bacteria indicates post- harvest management disturbance i.e. poor handling, long distance travel, evisceration along with culture system problem.

ESSENTIAL OILS AND CHITOSAN AS ALTERNATIVES TO CHEMICAL PRESERVATIVES FOR FISH AND FISHERIES PRODUCTS: A REVIEW

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Meeting consumer concerns and preferences for fresh and safely processed fisheries products free of chemical and synthetic preservatives is a challenge for the aqua-food industry. As such, natural preservatives from plant and animal origin including chitosan, essential oils (EOs), plant extracts and lactic acid bacteria have attracted considerable interest recently. These preservatives have antimicrobial and antioxidant properties (Figure 1) that can retard spoilage, uphold product quality and safety as well as extend the storage shelf-life of fish and seafood. Chitosan and EOs have been successfully used in edible coatings, film wrapping and dipping solutions. The present review focuses on the effectiveness of chitosan and EOs intended for prolonging the shelf-life of fisheries products, and maintaining their freshness and quality. Moreover, the mechanisms of action of natural additives and harmful impacts of chemical preservatives are summarized, with notes on important research gaps. Overall, this study informs recent development in natural preservatives related to the aqua-food industry.

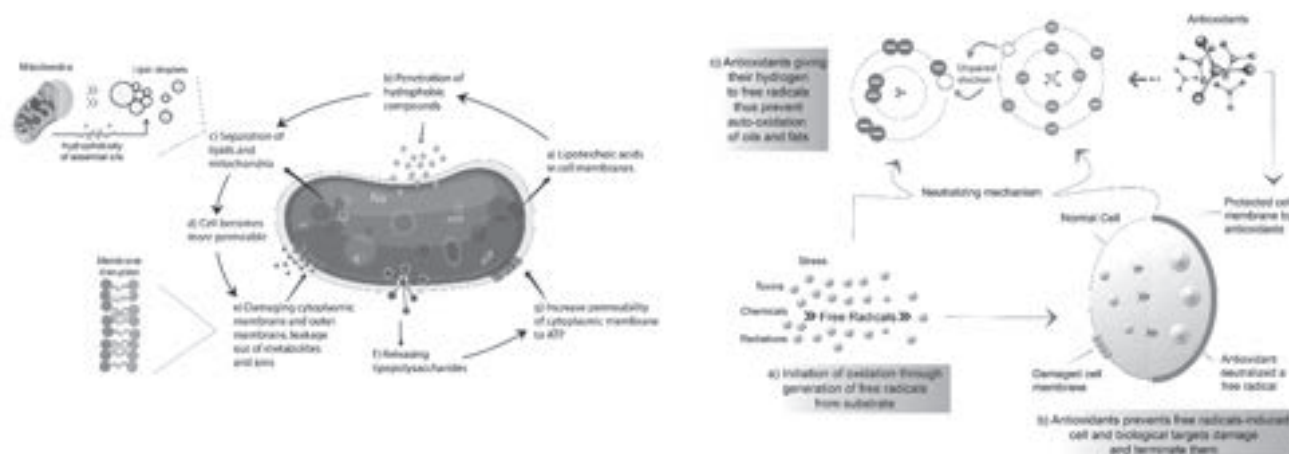


Figure 1. Antimicrobial and antioxidant mechanism of natural preservatives.

PRODUCTION AND ACCEPTABILITY OF FISH CRACKERS – AN INNOVATIVE PRODUCT FOR THE SNACKS INDUSTRY OF BANGLADESH

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Fish crackers are a popular snack item in many Southeast Asian countries. Good quality crackers must have sufficient expansion on puffing for crispness, low moisture content, and low oil absorption. Many previous studies have attempted to improve the quality and acceptability of fish crackers. We have prepared tilapia and tuna fish crackers as ready-to-eat (RTE) products by optimizing processing parameters using a required amount of fish flesh (Tilapia/Tuna) mixed properly with different ingredients, including tapioca starch, sugar, salt, ice, sodium bicarbonate etc. The colour, texture and nutritional quality were also determined by the standard method. Then the shelf-life of ready-to-eat (RTE) crackers was evaluated by biochemical and microbiological analysis (pH, TVBN, FFA, TBARS and APC) under airpack (control), modified atmosphere packaging with 100% N₂ (MAP-1) and 50% CO₂ & 50% N₂ (MAP-2) in a multilayered pouch in a month interval during storage at room temperature. Consumer's acceptability of packaged RTE fish crackers was investigated by survey method utilizing a structured questionnaire in three sales outlets such as Amana big Bazar, Rajshahi; RU souvenir shop, Rajshahi University campus; BARC canteen, Farmgate, Dhaka in June 2022. A 9-point hedonic scale method (9 like extremely and 1 dislike extremely) was used to evaluate the sensory quality during the survey.

In both crackers, around 11% protein was estimated. The lightness (L*) was high (60.67) in tilapia and low (32.85) in tuna crackers, while redness (a*) was high (13.44) in tuna and low (6.50) in tilapia. The hardness (N) was high (5.43N) in tuna crackers and low (4.90 N) in tilapia crackers. Considering the biochemical and microbial parameters, the shelf life was determined at approximately 4th month in both crackers for the air pack sample and 5th month in tilapia crackers and 6th month in tuna crackers for both MAP-1 & MAP-2 samples. In the survey, 24 consumers responded, and all opined on introducing this kind of MAP packaged fish crackers in the market. The sensory score of tilapia and tuna crackers was 7.6 (like very much) and 7 (like moderately), respectively, in terms of colour, flavour, taste, texture and overall appearance.

Considering the above findings, there is a scope to produce MAP packaged fish crackers which can be easily sold for a longer period at room temperature, ultimately making the fish crackers a convenient and nutritious snack item in Bangladesh.

Table 1: Proximate composition (%) of fish crackers

Parameters	Tilapia crackers	Tuna crackers
Moisture (%)	4.39±0.09	3.52±0.95
Ash (%)	11.93±1.89	11.77±0.61
Protein (%)	11.03±0.25	10.93±0.10
Fat (%)	22.00±2.26	22.35±3.89
Carbohydrates (%)	50.66±4.00	51.43±4.14

QUALITY EVALUATION OF READY TO EAT FISH PRODUCTS DEVELOPED FROM LOW COST *Pangasius hypophthalmus* AND *Hypophthalmichthys molitrix*

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The study was conducted to develop high-quality value-added products fish cutlet from pangus (*Pangasius hypophthalmus*) and fish stick from silver carp (*Hypophthalmichthys molitrix*) using low-cost fish. Skinless and boneless fish fillets were minced to prepare the products, which were stored in both room (28 °C) and refrigerated (5 °C) conditions to evaluate various food quality attributes through proximate composition, microbiological, and sensory analysis. Good manufacturing practices were followed while developing the fish products using different kinds of food additives. The proximate composition that is moisture, lipid, protein and ash contents of fresh pangus cutlet and silver carp fish stick were 54.38±0.36, 21.02±0.75, 18.25±0.44 and 2.74±0.12% and 69.26±0.99, 4.79±0.73, 16.45±0.34 and 2.86±0.28%, respectively. In fresh fish cutlet and stick, TPC was found respectively as 4.28±0.48 and 3.68±0.75 Log CFU/g. The changes in bacterial load (Log CFU/g) of the products in both room (28 °C) and refrigerated temperature (5°C) increased throughout the storage period (p<0.05) but the rate of increase was slower at refrigerated temperature. Sensory characteristics (appearance, flavor, taste, texture and overall acceptability) of the fish products were found to be decreased with the progress of storage period at both stored temperatures. However, product stored at room temperature showed sharp decrease of sensory attributes than refrigerated product. It may conclude from the results of the study that the shelf life of both pangus fish cutlet and silver carp stick is very short, in fact not more than 24 hours at 28°C. On the other hand, at 5°C it may remain in good condition up to 72 hours.

CONSUMER BEHAVIOR TOWARDS VALUE-ADDED FISH PRODUCTS: CASE OF FISH BURGER AND FISH PICKLE PREPARED FROM LOW COST FISH

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Global consumers' demand has been shifted towards convenience foods like ready-to-eat or value-added products. This present study was conducted to determine the present condition and future prospects of value-added fish products such as fish burger and fish pickle and to evaluate the prospects of using low-cost fish as raw materials. A total of 350 responses were collected through face-to-face interviews and an online survey. One hundred and fifty data were collected from supermarkets in Sylhet and Rangpur through face-to-face interviews and other 200 data were collected through online platform. A chi-square test of independence was used to determine the effect of independent variables on dependent variables. Frequency and percentage analysis were used to reveal the result. The results showed that most of the consumers were young and have at least an undergraduate degree, a monthly family income of above 30,000, and are mainly from the city. Lack of knowledge about these products were observed during survey. Around 22% respondents were unaware about value added fish products, 33% had little knowledge and 32% were have moderate knowledge. Among the demographics, age, marital status, and living place have significant influence on knowledge level. Despite lack of knowledge, favorable attitude and positive purchase intention were observed among the respondents. The difference in attitude was found to be significant with respondents' educational qualification, monthly household income, living place and their knowledge level about these products. Respondents with higher knowledge and previous purchase experience have a higher purchase intention. The main reason for preferring value-added fish products was found to be "bring change in daily meals", while the main reason for not preferring them was "lack of knowledge". Quality and availability were found to be the most influential factors for purchasing, whereas price was found to be the least important. Consumers are satisfied with the taste, quality, and price of both fish burgers and fish pickle. Most of the respondents were interested in buying low-cost fish products such as fish burgers and fish pickles. The most preferred price for fish burgers prepared from low-cost fish is 41-50 BDT. Nearly half of the respondents were interested in paying 31-40 BDT for 5 gm of low-cost fish pickle. Perception of the respondents represents a great possibility of value-added fish products in the Bangladeshi market.



Technical Session 7:
**Fisheries Strategies, Planning
and Policy**

CO-CREATING INCLUSIVE POLICY PROPOSITIONS ON THE REVISION OF BANGLADESH'S NATIONAL FISHERIES POLICY 1998 FOR SUSTAINABLE AND RESILIENT AQUATIC FOOD SYSTEMS

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Paradigm shifts in aquatic food systems to enhance productivity, economic gain and resilience to climate change are required for transforming the country from a lower to upper middle income country by 2031 and a high income country by 2041 together with eradicating extreme poverty by 2031 and zero poverty by 2041. To make this vision into reality, the national fisheries policy (NFP) 1998 revision process needs to be harmonized with the mid and long term mission, vision and goals recognized by Bangladesh government in perspective plan 2041 and delta plan 2100, bringing tri-focal of the aquatic food system approach: climate change, environmental sustainability and socio-economic inclusion. In this line, WorldFish jointly with FAO has been supporting Department of Fisheries in conducting divisional dialogues to co-create policy propositions, which can enable sustainable aquatic food production and ensure resilient aquatic food systems of the country. We have already conducted four divisional policy dialogues in Rangpur, Rajshahi, Sylhet and Cox's Bazar having support from different projects like BMGF- IDEA, DFID-SUCHANA, EU-Artemia4Bangladesh and USAID-BAA. Also we have been reviewing a range of documents, starting from current national fisheries policy, strategy and plans, through ongoing research and development programs, to global policy recommendations. Therefore, the results would combine local level inputs from the dialogues with sectoral experts and stakeholders, national level learnings from the ongoing research and development programs and global call for actions gained momentum for aquatic food systems during last decade. WorldFish has developed a methodological and analytical framework and shared these during the dialogues for creating evidence based and inclusive policy propositions to be considered for the policy revision. Consequently, we have identified four thematic areas and fifteen key features so far to propose for the upcoming revision process. Enabling safe and quality seed, feed and fish production, enhancing nutrition sensitive aquaculture, promoting climate smart innovations focusing adaptation and mitigation measures at scale and mainstreaming gender using disaggregated data for fisheries and aquaculture among others have received attention. Inclusion of the identified propositions in the upcoming national policy revision process can substantially be instrumental in further strengthening the growing blue economy footprint of Bangladesh on the globe.

Plenary Keynote speech

AQUATIC FOOD SYSTEMS FOR NOURISHING PEOPLE AND PLANET

Shakuntala Haraksingh Thilsted

Global Lead, Nutrition and Public Health, WorldFish One CGIAR

Global malnutrition rates have been increasing, exacerbated by the disruptions of climate change, COVID-19 and conflict. We are now further away from reaching the targets of the Sustainable Development Goal (SDG) 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture; as well as other SDGs, including SDG 1, SDG 5, SDG 8 and SDG 14. Studies have shown that aquatic food systems, including capture fisheries and aquaculture provide food and nutrition security and livelihood opportunities for over three billion people, globally, especially in low- and middle-income countries. Studies have also shown that aquatic foods have lower environmental costs compared to land-based foods; however, aquatic food systems actors are particularly vulnerable to the impacts of climate change. A necessary paradigm shift of diversification can optimize the reach of aquatic foods and aquatic food systems in nourishing people and planet, drawing on food systems enablers, including governments, research institutions, the private sector and communities.

SMARTPHONE APPS AND INTERNET OF THINGS (IoT) PERTAINING TO AQUACULTURE: A PROMISING FUTURE FOR SMART AQUACULTURE FARMING IN BANGLADESH

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In recent years, aquaculture has seen a number of technological changes. Fish farming has benefited greatly from technological advancements made possible by smartphone apps. An empirical investigation of Bangladeshi mobile apps in the aquaculture sector was carried out using virtual information where features, public ratings, downloads, size, launching date, and last update were recorded.

There were 44 mobile apps identified in Bangladesh, 36 of which were for fish farming. There were also six apps for disease and treatment, and two for fish breeding. Poultry Animals and Aqua Index, the first apps, were released in October 2015, and E-Carp Breeding, the most recent, was released in February 2022. The most downloaded (100,000+) were for Poultry Animals and Aqua Index. With more than 50,000 downloads each,

"MotsoPoramorsho-Fish Advice" and "Rupali" were developed in 2016 and 2019, respectively. "Chingri-Biggan Sommoto Casher Khutinati", "Bioflock Poddhotitemachchash", and "MotsoPoramorsho O ChashPoddhoti" received the highest ratings (5/5).

A total of 25 apps were rated, mostly between 4 and 5. Correlations indicated that downloads were unaffected by app size or ratings. According to the study's findings, the majority of farmers acknowledged the beneficial effects of the smartphone app's use of aquaculture.

The results of this study will deepen our understanding of how mobile apps are used to promote the aquaculture industry, poverty alleviation, and grow the country's economy.

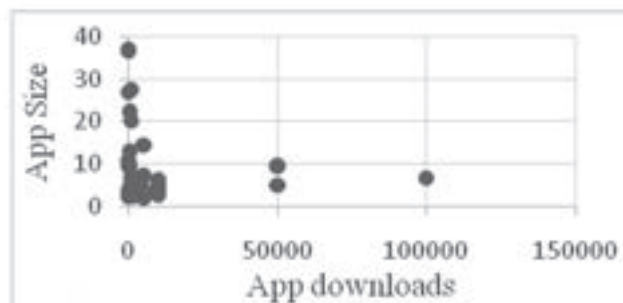


Figure 1. Correlation between App Size & Download.

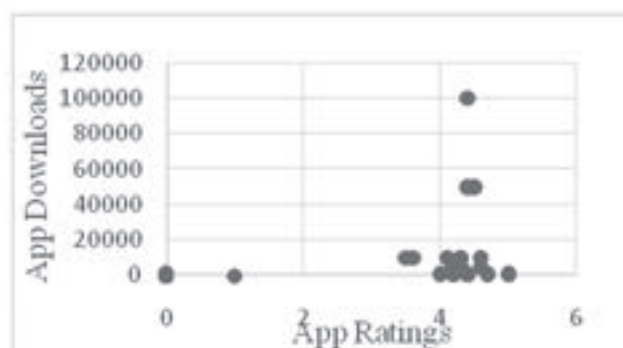


Figure 2. Correlation between App Ratings & Downloads.

ASSESSMENT OF POLICY, LEGAL AND INSTITUTIONAL FRAMEWORKS TOWARDS MARINE MEGAFUNA CONSERVATION IN BANGLADESH

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This study investigated how the national and international legislations govern marine megafauna in Bangladesh waters and the challenges in implementing these regulations. Findings show that weak policy direction, conflicting focus between international treaties by existing national legislation, lack of data, lack of effective national legislation, limited protection by national legislation, ineffective implementation, and inappropriate enforcement agencies are the major limitations in the megafauna conservations in Bangladesh waters. The study submits that marine megafauna conservation initiatives should take into account measures such as a comprehensive government approach, overhauling of the institutional frameworks for marine fisheries and wildlife conservation, incorporating the conservation of marine megafauna in fisheries laws, initiating integrated bycatch reduction legal policies, recognizing threats to megafauna from non-fishing sources such as shipping/navigation/hydrocarbon exploration, introducing sustainable shark fisheries, habitat protection, increasing coordination between government bodies and environmental education of key stakeholders, including fishing communities. Finally, significant legal reforms and a whole-of-government approach will strengthen the institutional framework for conserving marine megafauna in the Bay of Bengal.

BRIDGING THE GAP: FISHERS' KNOWLEDGE AS DATA SOURCE FOR IMPROVED FISHERIES MANAGEMENT

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Fishers' local ecological knowledge can be used to reconstruct long-term trends in species with low biomass or poorly assessed. Our study examined how small-scale fishers perceive changes in catch trends over the last 20 years in artisanal marine fisheries in the Bay of Bengal. We used a structured template related to catch and effort data to conduct focus group discussions and key informant interviews. Data were collected for major groups of species over time. The analysis revealed changes in catch rates, monthly landings per landing center, and factors that influence catch trends. All major species and groups experienced a decline in catch rates, in accordance with fishers' knowledge (Figure 1). Over the past two decades, the monthly harvest however has shown positive trends despite declining catch rates due to increased fishing effort, which has reached its historic maximum. Fishers have been traveling long distances and fishing deeper waters more frequently over time. This study suggests a geographical expansion and/or development of artisanal fisheries beyond the traditionally exploited areas. Overfishing nearby may result in such expansions of nearshore fisheries. Fishers' data and official statistics were in good agreement, however, the magnitude of change was notably different. Integration of fishers' local knowledge into policy and management will facilitate the efficient management of small-scale fisheries. Fishers' knowledge can be useful for reconstructing long-term trends in exploited species in the absence of long-term monitoring data.

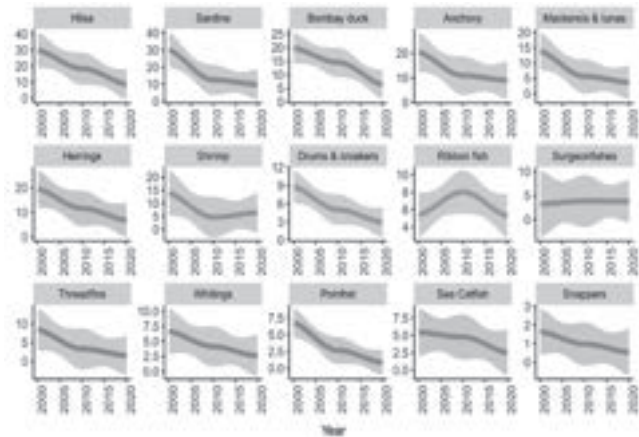


Figure 1: Relative trends in artisanal marine fisheries from 2000 to 2020. Shaded regions represent 95% credibility intervals (CIs).

INFLUENCE OF SOCIAL MEDIA ON THE RAPID DISSEMINATION OF BIOFLOC TECHNOLOGY IN BANGLADESH

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With almost 7 billion people on world, the requirements for aquatic food is increasing accordingly and hence, expansion and intensification of aquaculture production are highly required. But there lies an inverse relationship between intensification and sustainability. So, people are searching for alternative sustainable intensive farming methods. The digitalization process in Bangladesh is quite rapid. Thus, they are looking up in the digital media for information. The success stories of Biofloc Technology (BFT) which are broadcasted by media have created zeal for too many to get involved in this technology. With this view, the study was conducted to understand the influence of social media on the rapid dissemination of biofloc technology in Bangladesh.

To achieve the objective, we have collected various information and online-based data from different social platforms (Facebook and YouTube) and Google Trends. During the online-based data collection, different steps like keyword selection, web scraping, data pre-processing, and analysis were followed. Regarding social media impact, we first selected keywords as our analysis solely depends on these keywords. We retrieved data for 4 keywords (biofloc, bioflock, Fish farming in Bangladesh and Aquaculture in Bangladesh) and two comparisons by google trend analysis where found that the initial people engagement was around 20 in 2019 which climbed up 100 in 2020 and fell down to only 6 in 2021. We also analyzed the comparative scenario of the keywords 'aquaculture vs. Biofloc' from 30/9/2018 to 30/9/2021 and found that biofloc reached 3 or 4 times higher than aquaculture in 2019 and 2020 as the biofloc technology suddenly got hyped. From the analysis of facebook, it has been reported that a total of 279 unique FB pages were found based on our selected keywords. The time range of the creation was 2014-2021. There was a declining trend in terms posts, comments, sharing, creation of new pages since 2021. Despite the Covid situation in 2020, the highest number of FB pages were created and decreased dramatically. Similarly, in YouTube, we found total of 573 videos from 302 unique channels and most of the channels were created since 2015 and it is in decreasing trend. It clearly shows that, as the pandemic started, for a certain period of time people were going crazy for biofloc and that reflects in social media. The study revealed that due to media hype many involved in this venture with minimum and no fish farming experiences and mostly failed to receive economic return.

PRIORITIZING FISHERIES STOCK FOR MONITORING AND MANAGEMENT: INSIGHTS FROM HILSA (*Tenualosa ilisha*) GILLNET FISHERY OF BANGLADESH

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The artisanal gillnet fishers of Bangladesh have been targeting the country's iconic flagship species, Hilsa (*Tenualosa ilisha*), to sustain their livelihood. Although it is evident that higher fishing pressure resulted in stock depletion of both targeted and non-targeted bycatch species; however, inadequate biological and catch information on fisheries stocks in Bangladesh limits the quantitative risk assessment for captured species. In this study, the Productivity Susceptibility Analysis (PSA) approach—a semi-quantitative risk evaluation approach that used both the intrinsic biological characteristic of stock and their susceptibility due to fishing to generate risk score—was used to categorize the 75 species of Hilsa gillnet fishery of Bangladesh for prioritizing their monitoring and management. Results revealed that seventeen non-targeted bycatch species of Hilsa gillnet fishing from inland (7 species; e.g., *Pangasius pangasius*, *Plotosuscanius*, *Sperataaoret.*) and marine habitat (10 species; e.g., *Leptomelanosomaindicum*, *Netumathalassina*, *Scomberoidescommersonnianus* etc.) were determined to be at high risk due to fishing. Since there is a strong association exists between the exploitation rate (>0.5 = overfishing status) and the risk score (>1.8 = overfishing status) derived from PSA; therefore, this study suggested that species with a risk score over 1.8 needed urgent conservation action for their long-term sustainability.

KNOWLEDGE, PRACTICE, AND ECONOMIC IMPACTS OF COVID-19 ON SMALL-SCALE COASTAL FISHING COMMUNITIES IN BANGLADESH: POLICY RECOMMENDATIONS FOR IMPROVED LIVELIHOODS

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COVID-19 has profoundly impacted global livelihoods and disrupted the food supply chain, including the aquaculture and fisheries industries. Little is known about the response to COVID-19 and the impact it has on incomes, livelihoods and knowledge and practice in the coastal artisanal fishers communities of Bangladesh. Therefore, the aim of this study was to determine the socio-demographics of selected coastal fishers, their knowledge about COVID-19 and the preventive practice taken to reduce it. The impact on their fishing habits and income was also examined to determine potential policy areas. Data were collected via a structured questionnaire from 250 respondents from three coastal districts, Cox's Bazar, Patuakhali and Barguna, Bangladesh during April–June 2020. The research shows that the fishers' knowledge about COVID-19 and measures taken to reduce it were significantly higher in Patuakhali and Barguna than in Cox's Bazar. The pandemic caused lower consumer demand, reduced fish prices and created fish transportation issues due to movement restrictions enforced during the lockdown. Irrespective of geographical location, fishing trips were reduced by frequency and duration compared with the pre-COVID-19 period, consequently lowering the income of fishers. Fishers have received little or no support from private, non-governmental or governmental sources. Considering the evidence in this paper of economic hardship, this paper recommends artisanal fishers in Bangladesh should be provided with support to improve their health education, access to professional health facilities and financial services. This will contribute to improved food security and sustainable livelihoods that can better withstand local and/or global crises.

REACH THE DOORSTEP WITH NUTRITION MESSAGES TO REDUCE MICRONUTRIENT DEFICIENCIES IN COST-EFFECTIVELY

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Aquaculture: increasing income, dietary diversity and empowering women project of WorldFish is working in Rajshahi and Rangpur divisions of Bangladesh. The project intends to increase aquaculture production by improving smallholder farmers' farm management skills; promoting innovative technologies to expand commercial aquaculture; strengthening backwards and forward market linkages; supporting policy reform; and building the capacity of the training partners, including NGOs, feed companies, and local service providers(LSPs).

To improve the nutritional status of the women of reproductive and young children through increased dietary diversity and fish consumption, the project makes the partnership with BRAC and TMSS which has a strong network of community health workers(CHWs). The CHWs ensure primary health care services with antenatal and postnatal care to pregnant and lactating mothers of both fish farming and non-fish farming households. WorldFish organized nutrition orientation of around 440 CHWs to disseminate nutrition messages on the importance of dietary diversity and fish especially small fish consumption during their service delivery to reduce micronutrient deficiencies.

A study was conducted in the BRAC intervention area to observe the effect of nutrition message integration in the BRAC mainstream platform through their CHWs counselling on community knowledge and practice. The study used a quantitative method and cross-sectional data for analysis to identify the impact of the project intervention. Data were collected following lot quality assurance technique in both intervention and control areas. In total, the study team collected 280 samples among which 140 were from intervention and 140 were from control areas. The respondents' demographic characteristics were h o m o g e n e o u s .

The analysis found that regarding fish consumption there is no significant difference between intervention and control areas. However, the impact of the project is conspicuous in the case of feeding the 7-24 months children with small fish. The study found a significant difference in intervention and control areas in this regard. These patterns are similar in the case of knowledge as well as the practice of the community people. The study team recommended that there are scopes for the CHWs to emphasize the nutrition integrated messages each time of visits to the household. Moreover, the intervention on feeding under two children with small fish to reduce micronutrient deficiencies can be taken widely.

INCLUSION OF DRIED FISH AND SMALL FISH POWDER IN TRIBAL DIET PLAN: A POTENTIAL STRATEGY FOR ALLEVIATING ODISHA'S DUAL BURDEN OF MALNUTRITION

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Indigenous peoples are among the poorest and thus the most threatened segment of the world's population in terms of social, economic and environmental vulnerability. Along with other stressors, food insecurity is still a concern in Odisha and currently, the state is dealing with dual burden of undernutrition which is especially common in tribal regions. To address this issue, the Government of Odisha has launched several nutrition-specific and nutrition-sensitive schemes and interventions in recent years. One such major service is the Supplementary Nutrition Programme (SNP) under the Integrated Child Development Services (ICDS) which aims to improve the health and nutrition of children aged 6 months to 6 years, as well as pregnant and lactating women and adolescent girls. The government is promoting nutrition by providing hot cooked meals and take-home rations, which are supplied through different Anganwadi Centers in the state. With a common goal of enhancing the nutritional outcomes from aquatic foods and assisting in accelerating progress on reducing malnutrition in hard-to-reach tribal communities, USAID and WorldFish along with other partner government organizations piloted the inclusion of dried fish based products in the SNP. This entailed including small fish powder in hot cooked meals for children aged 3 to 6 years and dried fish in take-home rations for pregnant and lactating women and adolescent girls aged 11 to 18. Based on an approved Standard Operating Procedure (SOP), the pilot has been implemented in 50 Anganwadi Centers (kindergartens) of Kaptipada block, Mayurbhanj district. This is a groundbreaking and unique case of incorporating fish-based products in the government school feeding program to address dual challenges: improving nutritional outcomes of aquatic foods and reducing malnutrition in the state. Based on the community feedback and acceptance of dried fish-based products in SNP, as well as an enhanced understanding congregated from the pilot, this nutrition-sensitive approach can be adopted at the policy level and scaled to ameliorate the undernutrition scenarios across Odisha and Indian other states.

COMPARATIVE ANALYSIS OF MANAGEMENT PRACTICES AND PROFITABILITY OF CARP-PRAWN POLY CULTURE, PABDA AND MONOSEX TILAPIA FARMING IN BANGLADESH

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Aquaculture is in the process of being intensification to meet the growing demand for protein as the capture fishery is declining. The Jashore region of Bangladesh is now gaining popularity for aquaculture and fish farming. This survey was conducted on carp-prawn polyculture, pabda and monosex tilapia farming in different areas of Jashore district of Bangladesh during October 2019 to May 2020 to assess the current management practices, prevention and control of diseases, and the profitability of the cultured systems. Fifteen fish farms involved in the carp-shrimp polyculture, pabda and monosex tilapia culture were selected and their owners were interviewed using a structured checklist and open-ended questionnaires. Results revealed that Galda (*Macrobrachium rosenbergii*), pabda (*Ompok pabda*) and monosex tilapia (*Oreochromis niloticus*) fish were commonly cultured in the selected areas together with other carp species including *Lebeo rohita*, *Catla catla*, *Cirrhinus mrigala*, *Cyprinus carpio*, etc. For successful management, fish farmers reported to take necessary steps during the pre-stocking, stocking and post-stocking stage such as collecting fry, preparing ponds, feeding, monitoring and managing the risk of disease. Among the three culture systems, better management was found in the Pabda farming system, while the highest stocking density was found @ 800 - 1200 fry/decimal in pabda farming system followed by Tilapia culture system @ 130 -180 fry/decimal and Carp-Prawn culture system @ 80-120 PL/decimal. The net profit of the pabda farming system (580598 BDT ha⁻¹) was significantly higher than the carp-prawn polyculture (515242 BDT ha⁻¹) and Monosex tilapia (191178 BDT ha⁻¹) (p<0.05). The most common diseases reported by farmers are dropsy, gill rot, saprolegniasis, motile aeromonas septicemia, anchor worm disease in Pabda farming followed by WSSV and vibriosis in Carp-prawn farming system and argulosis in tilapia farming. Liming and salt bath treatment were the most effective preventive measures whereas the different chemicals (Benzalconium Chloride, Povidone vet aqua, Vit-C, KMnO₄ and Ivermectin, Erythromycin) were used for the treatment of the infected fish. The disease outbreak during the culture period, lack of capital, high price of feed ingredients, low fish price, inability to find quality fish at the appropriate time have been identified as the major issues to succeed in the fish farming. The information of the survey can be utilized by the farmers during selection of the farming systems, management of the studied farming systems, prevention and control of the diseases using approved drugs and chemicals.

COMPARATIVE ANALYSIS OF MANAGEMENT PRACTICES AND PROFITABILITY AMONG CRAP POLY CULTURE, STRINGING CATFISH AND VIETNAM KOI FARMING IN BANGLADESH

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Aquaculture practices in Bangladesh are growing very fast. Different culture systems are being practiced for different fishes. These culture systems have different management practices and profit levels. Chandpur and Lakshmipur districts in Bangladesh became famous for carp polyculture and other fish farming in the recent years. The present study was conducted to compare the management practices, prevention and control of diseases, and profitability among Carp polyculture, Stringing Catfish (shing) and Vietnam koi farming in Bangladesh during August 2019 to July 2020. Data about management, production cost, the prevalence of diseases, and benefit of the three culture systems were collected from nine farms i.e three from each culture system. Among these three farming better management was found in carp polyculture, while stocking density in carp polyculture was 19,513 individuals ha⁻¹ composed of Tilapia (9,880 individuals ha⁻¹), Catla (494 ind. ha⁻¹), Rui (1,974 ind. ha⁻¹), Mrigel (988 ind. ha⁻¹), and Common Carp (2,470 ind. ha⁻¹). Stocking density of Vietnam Koi and Stringing catfish (Shing) were 2,03,035 and 3,29,251 ind. ha⁻¹ respectively. The cost-benefit analysis was performed based on management cost and selling price. The highest net profit was found in Shing monoculture (6,96,893 BDT ha⁻¹) followed by Carp polyculture (1,81,450 BDT ha⁻¹) and Koi farming (1,28,440 BDT ha⁻¹). The production of all farming systems was significantly different from each other, but the net profit of shing farming was significantly higher than carp polyculture and koi culture ($p < 0.05$). The most common diseases found were Fin and Tail rot, Argulosis, Epizootic Ulcerative Syndrome (EUS), nutritional diseases and environmental problems. As preventive measure farmers used salt, lime, and KMnO₄. For the treatment of diseases, Benzalchronium Chloride 80% solution, Vimermectin BP 1% solution, Ascorbic acid, etc. were used. The outbreak of fish disease, unexpected flood, and excess leasing cost, high feed price, low fish price, etc. were major concerns in fish farming. The information of the study will be useful for proper management of fish farms, prevention and control of diseases, and the selection of profitable culture systems.

EFFECT OF NUTRIENT MANAGEMENT ON PLANKTON COMMUNITY IN POND

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Knowledge about plankton community is important for aquaculture due to their influence on environmental variables. The goal of this study was to evaluate the ecological effect of three nutrient managements on the plankton community in pond. The assay was done at Sylhet Agricultural University campus, Sylhet, Bangladesh from September to October 2018. Twelve ponds were selected for four treatments with three replications; T₀ was control treatment without any feed and fertilizer, T₁ was treated with only fertilizer (cowdung-370.5 kg, urea 9.88 kg, TSP 9.88 kg per hectare), T₂ was treated with fertilizer and feed (cowdung-370.5 kg, urea 9.88 kg, TSP 9.88 kg per hectare and half feed compared with T₃-twice daily) and T₃ was treated with only feed (twice daily). Tilapia (*Oreochromis niloticus*) fry was stocked in all treatments and fed initially at 50% of their body weight on T₃. Then it was gradually reduced up to 5% of body weight at the end of the study. Feed application rate in treatment T₂ was half the amount of feed given in the treatment T₃; fertilization was done weekly in treatment T₁ and T₂. Four groups of phytoplankton viz. Chlorophyceae, Cyanophyceae, Bacillariophyceae and Euglenophyceae and four groups of zooplankton viz. Rotifera, Copepoda, Cladocera and Crustacea were recorded in the present study. Chlorophyceae and Rotifera were found to be the most dominant groups of phytoplankton and zooplankton respectively. The mean abundance of both phytoplankton and zooplankton were found to show significant difference ($P < 0.05$) among the treatments especially between T₂ and T₀. The recorded mean abundance ($\times 10^3$ cells/l) of plankton was highest in treatment T₂ (77) followed by T₁ (55.71), T₃ (41.76) and T₀ (16.88). Fortnightly monitoring of selected physico-chemical parameters viz. temperature, pH, dissolved oxygen and transparency were carried out in all ponds and the recorded values were within the productive range. The study revealed that the control treatment (without feed and fertilizer) was not good for plankton on the contrary the application of both fertilizers and feed was better for the growth of plankton population in pond environment, which is ultimately beneficial for aquaculture. It may be recommended that application of fertilizer and supplemental feed is the best management technique of semi intensive fish culture for fish farmer in general.

ASSESSING FISHERIES POLICIES OF BANGLADESH: NEED FOR CONSTANCY OR TRANSFORMATION?

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The Bangladesh government has two adopted two fisheries policies after its independence. The national fisheries policy (1998) has been formulated with the aim to enhance production, alleviate poverty, and meet up animal protein demand, to earn foreign currency and to maintain ecological balance in Bangladesh. Over the last two decades, the country's umbrella policy for safeguarding fisheries is still in practice but gets little attention by researcher and policy makers to assess its effectiveness. This study analyzes the fisheries policy frameworks and evaluate how policy changes are affecting fisheries production with certain ecological balance. The paper takes its outline in describing elements in the historical process of the development of the national fisheries policy, namely the issue of equal or restricted access to the fish resource. The findings suggest that changes in policy could not offer solutions to prevent over exploitation and overcapitalization that presently exists in conventional open access fishery. In addition, key constraints underlying in between policy and in implementation includes, ignorance of conservation laws, overwhelmingly top down decision making, lacking appropriate policy goals, inadequate enforcement, outdated policy and pretended action strategy, lacks enforcement regulations against pollution as well as poor coordination and technical know-how of the personal concerned. For achieving inclusive growth in fisheries sector, The UN Sustainable Development Goals and the government stated the Vision 2021, policy reform is recommended with special emphasis on marine fisheries sub section formulation, socio-economic development of relevant communities, updating existing governance, strengthening institutional capacity to appropriately manage this potential sector.



Technical Session 8:
**Oceanography and
Blue Economy**

PROSPECT, POTENTIALS, RISKS AND CHALLENGES TO MEET BLUE ECONOMY DREAMS: BANGLADESH PERSPECTIVE

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The development of ocean-based nations like Bangladesh is possible by the successful blue economy. According to Gunter Pauli, the ocean will provide 10 million employments through 100 technologies over the course of ten years. There are 88 trillion US dollars in the global economy, while the oceans alone account for 24 trillion. Goal 14 of the Sustainable Development Agenda stresses submerged life. The blue economy has been an effective tool for boosting employment and accelerating economic growth. Oceans are a crucial source of food, energy, and minerals, therefore human civilization depends on them every decade. It serves as the main platform for international trade. Bangladesh has a tremendous potential to develop into a developed nation by the year 2041 because it is an ocean-based nation. To become a developed country, blue economic development must be used sustainably. A major risk factor for the successful implementation of the blue economy is the absence of a robust marine policy, inadequate ocean governance, illegal, unreported, and uncontrolled fishing operations, marine pollution, haphazard tourism, and unplanned coastal development. To give an all-encompassing approach to ocean-based sustainable development that integrates the economy, environment, and society in close alignment with the UN 2030 Sustainable Development Goals (SDGs), a blue economy roadmap is required. With the use of the ecosystem-based Marine Spatial Planning technique, the transition to a Blue Economy will necessitate significant and fundamental changes in the regulatory-management-governance policy process. Strong ocean governance and policy are required for sustainable blue development.

LENGTH-BASED BAYESIAN BIOMASS (LBB) AND LENGTH BASED SPAWNING POTENTIAL RATIO (LBSPR) OF MARINE FISHES IN THE BAY OF BENGAL, BANGLADESH

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Length-based Bayesian Biomass (LBB) and Length based spawning potential ratio (LB-SPR) models were used to assessed the current status of commercially important marine fishes i.e., Little tuna (*Euthynnus affinis*), Frigate Tuna (*Auxis thazard*), Talang Queen Fish (*Scomberoides commersonianus*) in Bay of Bengal, Bangladesh. Data were collected fortnightly from BFDC Ghat, Cox's Bazar, BFDC Chittagong, and Mohipur, Khepupara from July 2021 to June 2022. Data were analyzed to determine Length at first sexual maturity (L_m), selectivity, Fishing Mortality, Length at first capture, GSI and SPR by different computer-based programs including R. The result of this study shows that two fish species among three were caught before mature stage. Maximum recorded length of Frigate Tuna, Little Tuna and Talang Queen Fish were 45cm, 71cm and 120cm respectively. Length at first maturity of Little Tuna, Frigate Tuna and Talang Queen Fish were 37.79 cm, 24.83 cm and 60.95 cm. Maximum lengths (L) of Little Tuna, Frigate Tuna and Talang Queen Fish were 71.5, 58.5 and 156 respectively. K value and M value of Little Tuna, Frigate Tuna, Talang Queen Fish were 0.56 and 0.86, 0.92 and 0.95, 0.16 and 0.32 respectively. M/K value of Little Tuna, Frigate Tuna and Talang Queen Fish were 1.53, 1.5 and 2.0 respectively. Z/K value of Little Tuna, Frigate Tuna and Talang Queen Fish were 3.2, 1.9 and 4.4 respectively. Among these three fish species GSI value of two fish species i.e., Little Tuna and Talang Queen Fish were determined. Peak spawning season of Little Tuna was range from September to November and partial spawning season was in April month. Whereas peak spawning season of Talang Queen Fish was in August month partial spawning season was during February to April months. SPR of Little Tuna, Frigate Tuna and Talang Queen Fish were 20%, 25% and 10% which mean the stocks of these fish are vulnerable. The current relative biomass (B/B₀) ratios were smaller than the B_{MSY}/B₀ in Little Tuna, Frigate Tuna, Talang Queen Fish. The present status confirmed that Bangladesh's coastal water fishery resources are declining. More specific targeted management measures should be taken to recover the country's marine fishery resources.

HORSESHOE CRAB: AN UNAPPRECIATED NON-CONVENTIONAL MARINE LIVING RESOURCE HAVING HUGE POTENTIAL FOR BLUE ECONOMY DEVELOPMENT AND ATTAINING UN SUSTAINABLE DEVELOPMENT GOALS (SDGS) IN BANGLADESH

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Horseshoe crabs (Crustacean shellfish) are horseshoe-shaped living fossils, usually found in the soft, sandy, or muddy intertidal habitats of marine, coastal and mangrove habitats of most tropical and subtropical areas of the world including the northern Bay of Bengal. Yet little or negligible knowledge about this non-conventional fishery resource is available in the context of Bangladesh. By merging the literature review and primary empirical data, this research aimed at compiling existing utilization patterns, summarizing user perception of the status/availability of horseshoe crab and point out the prospects and research gaps of this non-conventional resource for blue economy development in Bangladesh. The blue blood of horseshoe crabs has important biomedical applications that can detect deadly end toxin contaminants and has a crucial contribution to the world pharmaceutical industry. For instance, during the COVID-19 pandemic horseshoe crab blood was used as raw materials in corona virus vaccine preparation. Apart from important bioactive products, the Horseshoe crab is considered a multiple-use resource, as it plays an important role as bait in a commercial fishery; as an important food source for multiple species of migratory shorebirds; as well as in several other minors, but important, uses. This detritus based omnivorous crustaceans are processes several potential roles in ecosystem functioning, nutrient recycling, maintaining ecological balance etc. Due to rising demand and huge economic value in the global market, pressure on harvesting wild horseshoe crabs from the Asian region has increased in recent years. Though horseshoe crabs exhibit a declining global population trend, reducing the stock size and are considered overexploited, nevertheless, recently received increasing research, policy and conservation attention for their critical ecological roles, and conservational prominence. Although marine, coastal and mangrove habitats of Bangladesh support horseshoe crabs distribution (three species among the four extant horseshoe crabs in the world) and may have a huge export potential for the global market of the biomedical industry. These non-conventional fishery living resources may be capable to contribute to blue economy development and attaining several directly or indirectly interlinked SDGs e.g. 14- develop life below water, 1-poverty elevation, 2- erase hunger etc. in the context of Bangladesh. However, this living fossil is highly undervalued in Bangladesh and no systematic harvesting practice, blue blood extraction, preservation and export, medicinal and ornamental utilization and human consumption is reported so far. Lastly, but not least, knowledge scarcity on general biology, ecology, resource sustainability and conservation status - either increasing, decreasing or static), the volume of existing natural stocks (abundance), and population dynamics with a frontier of Maximum Sustainable Yield (MSY), and maximum economic yield (MEY) and allowable harvest limit of the horseshoe crab in Bangladesh-call for urgent research.

BIOLOGICAL FEATURES OF SKIPJACK TUNA (*Euthynnus Affinis* CANTOR, 1849) FROM THE BAY OF BENGAL, BANGLADESH

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Skipjack tuna (*Euthynnus affinis*, Cantor, 1849) belongs to the family Scombridae is one of the important commercial fish in the Bay of Bengal. The present study was conducted to determine the population structure (Length Frequency Distribution, LFD), relationship between length and weight (LWR), Fulton's condition factor (K_F) and relative weight (W_R) of *E. affinis* in the Bay of Bengal, Bangladesh. A total of 731 *E. affinis* individuals were collected from four landing stations (Chittagong; Cox's Bazar; Kuakata, Potuakhali; Patharghata, Borguna) during January to December, 2021. Total length (TL) was measured by using the measuring scale and total body weight (BW) was measured using an electronic balance with 0.01g accuracy. The minimum and maximum TL of the Skipjack tuna were found as 23.0 and 68.0 cm. The body weight (BW) ranged from 17.0 to 3736.0 g. The population structure showed that 45 cm TL size group was numerically dominant and followed by 55 cm group for *E. affinis*. Relationship between total length and body weight showed isometric growth pattern ($b = 3.04$) that indicates that the size and weight of *E. affinis* increases proportionally. Also this growth pattern indicates that the surrounding habitat provides favourable environment for the growth. The LWRs (TL vs BW) were highly significant with r^2 value 0.941. In the present study, the mean value of Fulton's condition factor (K) was found as 1.20 which indicates that the fish was in good condition in their natural habitat. The mean value of W_R was 100.42 that indicate that the relationship between prey and predator is in balanced condition. The size at sexual maturity was 36.24 cm where about 50% fishes were matured. Asymptotic length was 70.37 cm and weight was estimated as 4254.5g. The natural mortality was assessed as 0.31 year⁻¹ in the Bay of Bengal. The optimum catchable length was 38.49 cm and below this size fishing should be recommended to prohibit for sustainable exploitation of *E. affinis* in the Bay of Bengal. Therefore, the findings from our study could provide important information to design effective conservation and management planning for sustainable production.

BANGLADESHI INDIGENOUS MARINE MICROALGAE: A POTENTIAL SOURCE OF NUTRITIONAL SUPPLEMENTS

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Microalgae are under-exploited resources but contain miracle biochemical properties (protein, lipid and carbohydrates), which have great potential as supplementary nutrition sources in enhancing the nutritional value of dietary feeds. These organisms can also synthesize various essential amino acids (EAA) in addition with various long-chain fatty acids in the form of triacylglycerols. This study investigated the suitability of biochemical properties of five (5) Bangladeshi indigenous microalgae species, *Chaetoceros* sp., *Isochrysis* sp., *Skeletonema* sp., *Nannochloropsis* sp., and *Tetraselmis* sp., as nutritional supplements for different feed products. The experimental species were collected from a previously isolated and preserved sample of live feed laboratory, Marine Fisheries and Technology Station, Bangladesh Fisheries Research Institute, Cox's Bazar, Bangladesh. The algal cultures were maintained using f/2 Guillard's medium and harvested during their exponential phase, dried and analyzed for proximate, amino acids and fatty acids profiles. The resulting nutritional value based on biochemical properties was compared among the species and other non-native similar species. The Bangladeshi indigenous microalgae exhibited similar and superior nutritional properties in several cases. Protein was the prominent component (31.3-53.7%), followed by carbohydrates (16.1-24.5%) and lipids (11.7-34.1%). *Chaetoceros* sp. was found rich in EAA (58.07%), followed by *Nannochloropsis* sp. (46.84%), *Skeletonema* sp. (43.87%), *Isochrysis* sp. (43.57%), and *Tetraselmis* sp. (43.31%) respectively. In the case of fatty acids, *Isochrysis* sp. was found rich in saturated fatty acids (72.57%). In contrast, the cells of *Skeletonema* sp. and *Nannochloropsis* sp. were found rich in monounsaturated fatty acids (74.38%) and polyunsaturated fatty acids (29.33%), respectively. All the organisms were also found as a good source of essential long-chain polyunsaturated fatty acids. The study's findings suggest that all these species possess attractive nutritional supplements, which have great feasibility as nutritional supplements for the production of different dietary feeds.

PROSPECTS TO ACHIEVE THE GOALS OF BLUE REVOLUTION IN INDIA THROUGH PRADHAN MANTRI MATSYA SAMPADA YOGNA

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Aquatic food including finfish and shellfish are highly nutritious, and yet relatively affordable to fulfil demand of feeding population, but despite their significance, are often overlooked in food systems research and policy. Fisheries in India, is an important sector of food and nutritional security with over 14 million people directly depend on fisheries for their livelihood. India's fisheries resources consist of 7,516 kilometres of marine coastline, brackish water resource of 1.44 million hectares, and under freshwater 195,210 kilometres of rivers and canals, 2.9 million hectares of reservoirs, 2.4 million hectares of ponds and lakes, and about 0.8 million hectares of wetlands. The fish production in the country has shown continuous growth since independence and is now the second largest producer in the world. The total fish production in the country rose from 0.75 million metric tons in 1950-51 to 14.1 million metric tons during FY 2018-19, and contributes to 1.1 per cent of the Indian GDP. If unutilized and underutilized vast and varied fishery resources are used in a sustainable manner, it may offer great opportunities for livelihood development and ushering economic prosperity. The Blue Revolution has the vision to achieve economic prosperity of the country and the fishers and fish farmers, as well as contribute towards food and nutritional security through utilization of resources for fisheries development, keeping in view the Sustainable Development Goals (SDGs). Recognizing the importance and potential of the fisheries sector, the Government of India approved the flagship scheme, Pradhan Mantri Matsya Sampada Yojana (PMMSY), in May 2020 and was launched by the Hon'ble Prime Minister on 10th September 2020 under the Aatmanirbhar Bharat COVID-19 relief package of Rs. 20,050.00 Crore with a vision to bring Blue Revolution through sustainable and responsible development of fisheries sector. PMMSY sets out ambitious goals of fish production by 70 lakh MT by increasing aquaculture productivity from the current national average of 3 tons to 5 tons per Ha, doubling exports from Rs. 46,589 crores to Rs. 1,00,000 crores, generating 55 lakh additional employment opportunities and doubling fishers and fish farmers' income through holistic development of fisheries and aquaculture resources. To achieve the goal set under PMMSY in an efficient and effective manner, many supporting areas are being strengthened under PMMSY. Additionally, many community outreach activities such as training and workshops on aquaculture and disease management, etc have been organised by National Fisheries Development Board (NFDB) in collaboration with the States/Union Territories, Indian Council of Agricultural Research (ICAR) fisheries Institutes. To summarize, by proper implementation of the planning to accomplish the targets set under PMMSY, it is likely to achieve the mission of Blue Revolution in near future.

SPATIAL PREDICTION OF SEAWEED HABITAT MAPPING FOR MARICULTURE IN THE COASTAL AREA OF BANGLADESH USING A GENERALIZED ADDITIVE MODEL

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Seaweed is a promising marine macroalgae of the millennium, providing various ecological, social, and economic benefits. Bangladesh is blessed with a vast maritime area of 710 km long coastline and 37,000 sq. km extended shelf, coastal and maritime area of about 119,000 sq. km. Around 200 seaweed species (47 green, 59 brown and 94 red) of 77 genera were recorded from the coastal area of Bangladesh. A precise prediction of habitat suitability map for mariculture of these seaweed species can help to expand their farming along the entire coastal areas of Bangladesh. Therefore, the present study aimed to understand the drivers of commercially seaweed species and predict their suitable habitat for cultivation in three culture methods (floating long line, off-bottom long line, off-bottom net) in the coastal area of Bangladesh.

The Generalized Additive Model (GAM) was applied to predict the potential habitats of seaweeds farming utilizing large scale dataset of farming of these 4 species under three culture systems, environmental conditions and bathymetry. Required data were compiled from *in-situ* measurements, satellite observations and model simulations. The results showed that TSS, turbidity, salinity, nutrient concentrations, depth and sea surface temperature are the main predictors of seaweed farming. Our findings clearly showed that floating long line system has a great potentiality to expand along the coastal areas of Bangladesh. The finding of this study will serve as a tool to start commercial mariculture of seaweed by providing information on site suitability for farm establishment.

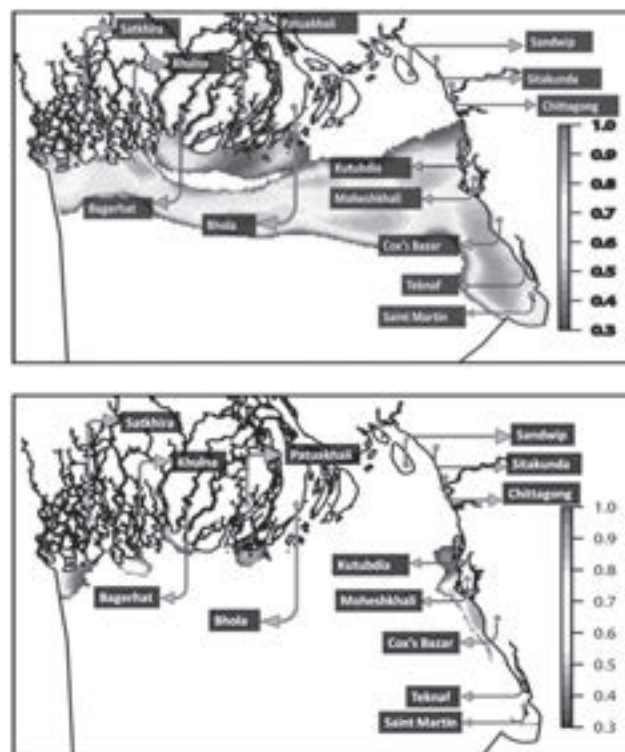


Fig. 1. Spatial distribution of seaweed culture probability in the coastal area of Bangladesh. Probability 1 indicates the 100% culture probability of seaweed. Probability <0.20 are removed from the map. The probability of off-bottom net/long line (top) and floating long-line (bottom) are shown.

EFFECTS OF CULTURE DEPTH ON THE GROWTH PERFORMANCES OF GREEN MUSSEL *Perna viridis* IN RAFT CULTURE SYSTEM

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The green mussel *Perna viridis* is an edible mollusc with enormous culture potential. The present study revealed the effects of culture depth on the growth and production performance of green mussel in raft culture system in Southeast coast of Bangladesh. The culture of *P. viridis* in three different depth such as 1.5 feet, 3 feet and 4.5 feet in three different locations (Khurushkul, Moheshkhali and Caufaldandi) in the Cox's Bazar coast was evaluated during September 2021 to April 2022. Mussel seeds are transplanted from our culture system at Moheshkhali Channel and are allowed to grow on mussel socks suspended from floating rafts.

The specific growth rate (SGR) was significantly higher in 1.5 feet ($1.17 \pm 0.32\%$ day⁻¹) and 3 feet ($1.15 \pm 0.31\%$ day⁻¹) and lower in 4.5 feet depth ($1.05 \pm 0.30\%$ day⁻¹). The growth of green mussel in different depth were ranked in the following sequence: 1.5 feet (24.92 ± 13.89 g) > 3 feet (23.63 ± 12.91 g) > 4.5 feet (19.38 ± 12 g). Subsequently, the overall growth of green mussel in different location were ranked in the following sequence: Khurushkul > Moheshkhali > Caufaldandi. The specific growth rate (SGR) was higher ($1.45 \pm 0.15\%$ day⁻¹) in Khurushkul than Moheshkhali ($1.06 \pm 0.21\%$ day⁻¹) and Caufaldandi ($0.87 \pm 0.25\%$ day⁻¹) respectively. The correlation analysis, multivariate approaches showed that the growth of green mussel was greatly influenced by the water parameters, plankton abundance and ingested gut compositions. The principal component analysis (PCA) revealed that the growth of green mussel increased with the increase of salinity, dissolved oxygen, food availability, while they decreased with the increase of temperature and turbidity. Thus, our results clearly demonstrated that the growth of green mussel was influenced by depth where below 3 feet depth the growth is low.

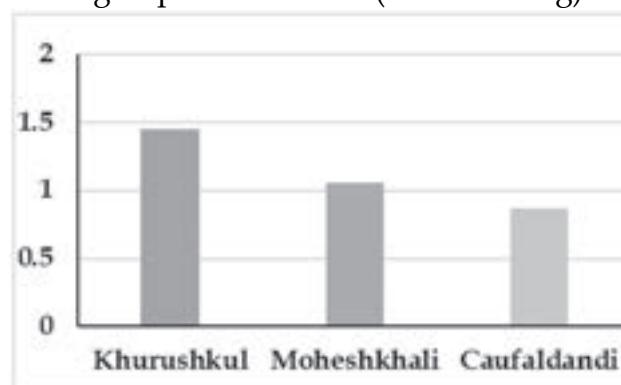


Figure 1. Specific growth rate (SGR) of green mussel in different depth.

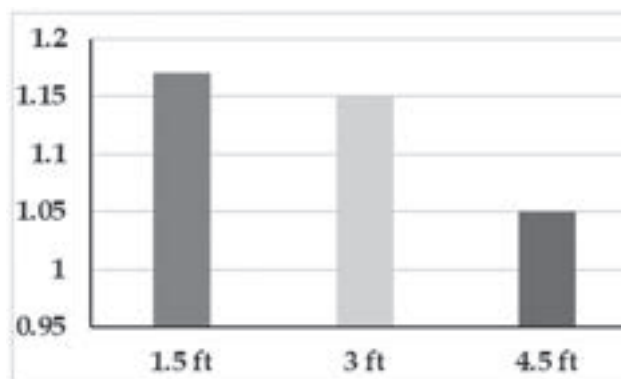


Figure 2. Specific growth rate (SGR) of green mussel in different location.

COMPARATIVE ENACTMENT OF DIFFERENT FARMING SYSTEMS OF *Gracilaria tenuistipitata* SEAWEED CULTURED AT THE SOUTH-EAST COAST OF BAY OF BENGAL, BANGLADESH

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Seaweeds, otherwise known as marine algae, are an excellent source of nutritious food. The comparative performances of different culture systems (off-bottom long line, off-bottom net, and floating long line) of a red seaweed *Gracilaria tenuistipitata* cultured in the Nuniarchora coast of Cox's Bazar was evaluated. Seaweed was partially harvested at every 15 days interval during October 2021 to April 2022. The daily growth rate (DGR) and Biomass production of cultured *Gracilaria tenuistipitata* was significantly higher in floating long-line culture system compared to the off-bottom long line or off-bottom net culture system. Moreover, production performances were greatly affected by the culture season due to difference in physico-chemical water quality parameters. Interestingly, the agar content was also significantly higher in *G. tenuistipitata* cultured under floating long line system. Many of the parameters of nutritive value (proximate composition, mineral contents, fatty acid and amino acid profile) was also significantly higher in floating long-line culture system compared to the off-bottom long line or off-bottom net culture system. In contrast, the heavy metal contents (Pb, Cd, As, Cr) was significantly lower in *G. tenuistipitata* cultured under floating long line system compared to other two systems. The findings of our study clearly showed that floating long line culture system is a promising culture technology for seaweed farming in Bangladesh.

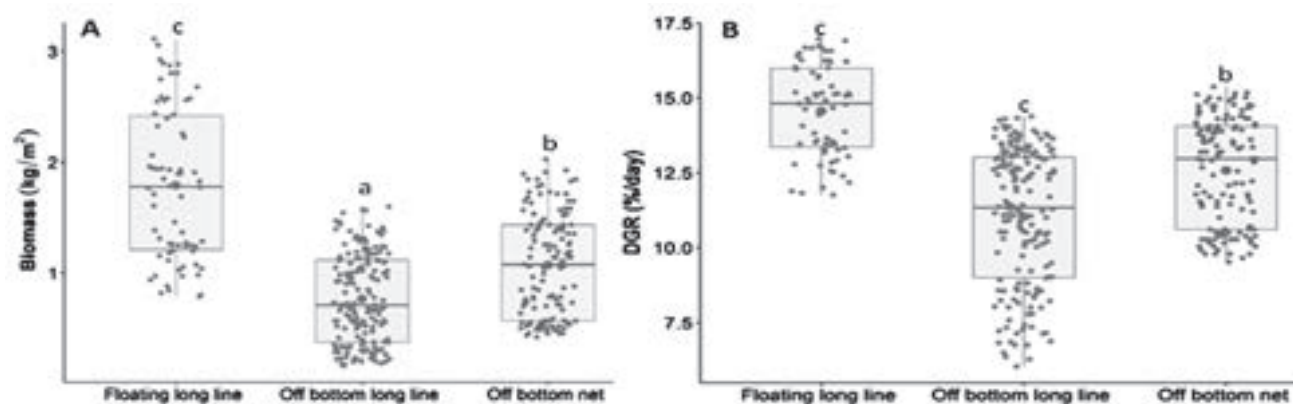


Figure 1. Comparison of Biomass (kg/m²/month) and DGR (%/day) in different culture systems of *G. tenuistipitata*.

LINKAGE AMONG THE ENVIRONMENTAL PARAMETERS AND GROWTH PERFORMANCES OF *Hypnea* sp. SEAWEED UNDER THE OFF-BOTTOM LONG LINE AND NET CULTURE SYSTEMS

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Seaweed farming has a great prospect in Bangladesh especially in the southeast coast at Cox's Bazar. The present study aims to establish the linkage between the environmental parameters and growth performance of *Hypnea* sp. cultured under the off-bottom long line and off-bottom net culture systems. For this purpose, five off-bottom long line (14m×5m) and five off-bottom net (3.5m×1.8m) culture plots were established in the intertidal zone of Nuniachora, Cox's Bazar. Seaweed was partially harvested every 15 days interval. The daily growth rate (DGR) and Biomass production (kg/m²) of cultured *Hypnea* sp. were significantly higher in the off-bottom net culture system compared to the off-bottom long line. Moreover, production performances were greatly affected by the culture season due to differences in physico-chemical water quality parameters.

The correlation analysis showed that the biomass production of *Hypnea* sp. was positively correlated with salinity and nutrient concentrations (NO₃-N, PO₄-P, NH₃-N), whereas it was negatively correlated with the temperature, TSS, and turbidity. A multivariate PCA analysis was performed to attain a deeper understanding of the interrelationship of the multiplex scenario of DGR and biomass with seasonality and ecological factors. The PC1 accounted for 64.93 % and PC2 for 12.86 % of the variability. PCA analysis further revealed that DGR and biomass production of *Hypnea* sp. increased with the increase of salinity and nutrient concentrations, while they decreased with the increase of temperature, TSS and turbidity.

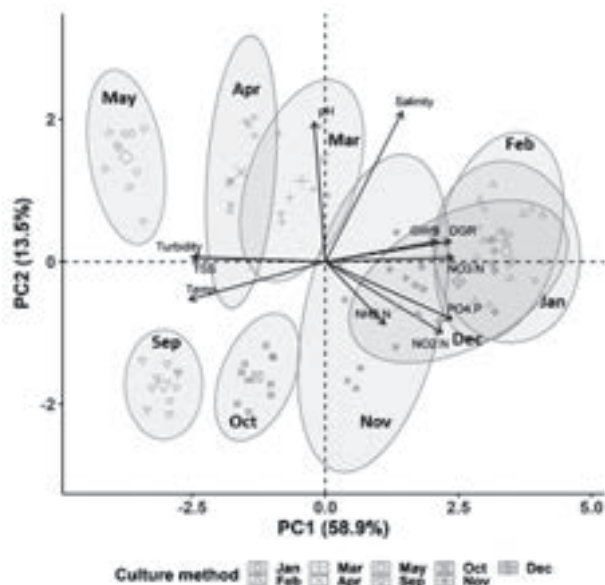


Fig. 1. Biplots of the principal component analysis (PCA) of the monthly variation of growth parameters of *Hypnea* seaweed with the water quality parameters datasets.

A QUANTUM JUMP IN THE SEAFOOD EXPORTS OF INDIA

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Seafood is considered as one of the highly salutary food item for all age groups including children, active adults, pregnant women and the elderly. It is an eminent root of high quality easily digestible protein. The Indian seafood export showed a quantum jump in 2021-22 by staggering an all-time high earning of Rs. 57.586 thousand crores (equivalent to 7759.6 million USD) with export of 1.37 million tonnes of seafood. The average demi-decadal (2017-18 to 2021-22) export value of seafood was Rs. 47,932.57 crores with total export of 13,15,612 tonnes. Shrimps remained the major export earning seafood with value increased from Rs. 30,868.17 crores in 2017-18 to Rs. 42,706.04 crores in 2021-22 showing a growth rate of 38.35%. Similarly, USA remained the top importer of seafood from India with total earnings increased from Rs. 14,769.83 crores in 2017-18 to Rs. 24,603.67 crores in 2021-22 showing a growth rate of 66.58%.

LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR OF BLOOD COCKLE *Tegillarca granosa* FROM THE SUNDARBANS ESTUARY OF BANGLADESH

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Blood cockle, *Tegillarca granosa* is a bivalve belonging to the Arcidae family. It dwells in estuaries or bays and found along the coasts of the Middle East and East Asia. The length-weight relationship (LWR) aids to perform stock management with predicting individuals' weight from their length i.e., biomass and conservation of the species. However, LWRs of the Sundarbans' blood cockles haven't been investigated yet. Thus, the study aimed to estimate LWRs and condition factor (Kn) of *T. granosa* from the Sundarbans for the first time.

A total of 187 *T. granosa* individuals were collected from the lower stream of the Kholpetua estuary at Gabura in Shyamnagar, Satkhira. The data were collected in three consecutive months (i.e., from Dec-21 to Feb-22). By using the slide calipers, shell length (L) was measured with an accuracy of 0.01mm, body weight (W) was taken with a digital balance to the nearest 0.01g. The relationship of $W = aL^b$, where W is the weight (g) and L is the shell length (mm) of *T. granosa*, "a" is the intercept and "b" is the slope was used to establish the length-weight relationship. The values of "a" and "b" were calculated using regression

formula: $Kn = W_0/W_c$ where $W_0 =$ observed weight and $W_c =$ calculated weight.

The length and weight of *T. granosa* ranged 24–53 mm and 7.81–52.45 g, respectively (Figure: 1). The computed growth coefficient (b) was 2.33 and $R^2=0.93$. The b values were calculated as 2.23, 2.36 and 2.54 in Dec-21, Jan-22, and Feb-22, respectively. Overall, the mean Kn value was recorded as 1.010 during entire sampling period. The mean Kn value was maximum in Dec-21 (1.010) and minimum during both Jan-22 (1.007) and Feb-22 (1.007). Negative allometric growth indicates light weight of *T. granosa*.

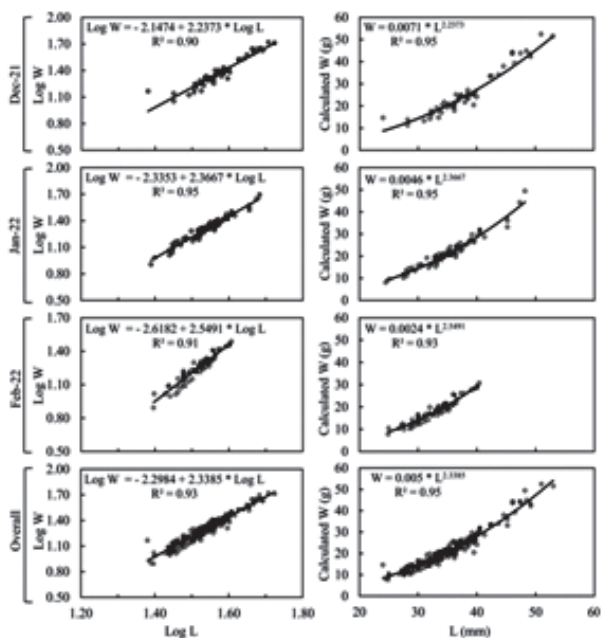


Figure 1: LWRs of *T. granosa* in the Sundarbans mangrove estuary

NUTRITIONAL, BIOMEDICAL, COSMECEUTICAL VALUES OF SEA CUCUMBER: APTITUDES FOR PROMOTING BLUE GROWTH AND ATTAINING SUSTAINABLE DEVELOPMENT GOALS (SDGS) IN THE CONTEXT OF BANGLADESH

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Sea cucumbers (Echinoderms, Order: Aspidochirotida, Family: Holothuriidae), are sessile marine invertebrates, occurring in the benthic habitat of most tropical and subtropical marine waters across the world (ca. 40 species) including the northern Bay of Bengal. Yet little or negligible knowledge about this un-conventional fishery resource is available in the context of Bangladesh. By combining literature review and primary empirical data, this research attempt to compile existing utilization patterns, summarize user perceptions on the availability of sea cucumber, identify research gaps, and point out the opportunities associated with this resource for promoting blue growth development in Bangladesh. Sea cucumbers are used in traditional meals and folk medicines in many parts of the world. Due to its nutritional richness, prospective health advantages, and usage in the treatment of chronic inflammatory disorders, sea cucumbers, and their extracts have become extremely popular and of great interest among researchers and nutritionists. For Asia-Pacific countries (e.g. China, Japan, Korea, Singapore, and Malaysia), sea cucumber is important as a high-nutrient food item (marketed as fresh but mostly dried condition) and for creating pharmaceutical items for foreign exchange gains. The majority of sea cucumber extracts are being researched for their anti-inflammatory and immunostimulatory capabilities, and the prevention and treatment of cancer, even if the precise components and their specific roles have not yet been determined. Sea cucumber fisheries had rapidly grown and expanded due to the growing international market, supported by continuing demand for these organisms for biomedical research programs and aquaculture. However, the attractive price for processed sea cucumbers and the declining wild fishery has led to considerable interest among private and government agencies in developing alternative methods of producing it, especially through aquaculture. Though having enormous economic value, and may have a huge opportunity to promote blue growth and contribute to attaining several directly or indirectly interlinked SDGs e.g. 1-poverty elevation, 2-erase hunger, 14- develop life below water, 15-life above water etc. in the context of Bangladesh. Yet, sea cucumbers are highly undervalued in Bangladesh and no systematic capture from nature, aquaculture practice, human consumption, medicinal use or export is reported so far. Last but not least, scarcity of knowledge of general biology, ecology, resource sustainability, conservation status, as well as population dynamics with a frontier of maximum sustainable yield and economic yield, and the permitted harvest limit of sea cucumber from natural stock, aquaculture feasibilities, and value chain development in Bangladesh- call for urgent researches and government initiatives.

BAY OF BENGAL FISHERIES: PRESENT STOCK STATUS AND FUTURE MANAGEMENT POLICY IN BANGLADESH

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This study was conducted with the status of commercially important fishes in the Bay of Bengal using monthly fish samples through traditional fishing gears by the hired fishing boats and fishers from different fishing and a long data series from commercial fish landing centers (2007 – 20210). Sexual maturity was estimated based on gonadosomatic index and maximum length of 15 commercially important fishes using samples from October 2019 to December 2021. Condition factors and form factor were estimated of 15 commercially important fishes. Data on fishers, declining of catches/ production are going on through survey, Focus Group Discussion (FGD) and survey local fish market to identify the major causes for declining the fishes in the Bay of Bengal. A total of 740 fish species was recorded from the Bay of Bengal, Bangladesh. The minimum and maximum length for different fishes obtained from the Bay of Bengal were 51.0-105.0 cm for *Lates calcarifer*, 10.5-34.5 cm for *Panna heterolepis*, 16.5-38.0 cm for *Pampus chinensis*, 16.0-68.0 cm for *Euthynnus affinis*, 8.10-31.8 cm for *Setipinna taty*, 11.5-39.4 cm for *Sillaginopsis panijus*, 10.0-23.1 cm for *Polynemus paradiseus*, 16.0-41.0 cm for *Megalaspis cordyla*, 6.5-36.0 cm for *Harpadon nehereus*, 10.0-23.6 cm for *Coiliadus sumieri*, 9.00-22.0 cm for *Thryssa setirostris*, 12.50-27.0 cm for *Anodontostoma chacunda*, 11.0-37.00 cm for *Ilisha megaloptera*, 14.30-49.0 cm for *Priacanthus macracanthus*, and 12.60-30.50 cm for *Amblygaster leiogaster*. Growth pattern of marine fishes was determined from the calculation of length weight relationship. Based on the value of 'b', isometric growth found for 4 species, 5 species and negative allometric for 6 species. Size at first sexual maturity for different fishes obtained from the Bay of Bengal were 90.0 cm for *L. calcarifer*, 14.4 for *P. heterolepis*, 22.0 cm for *P. chinensis*, 33.0 cm for *E. affinis*, 15.0 cm for *S. taty*, 17.0 cm for *S. panijus*, 14.5 cm for *P. paradiseus*, 20.0 cm for *M. cordyla*, 17.5 cm for *H. nehereus*, 13.5 cm for *C. dussumieri*, 12.8 cm for *T. setirostris*, 17.8 cm for *A. chacunda*, 16.7 cm for *I. megaloptera*, and 19.0 cm for *P. macracanthus*. Most of the commercially important marine fishes spawn from April to September. Current ban period in the Bay of Bengal, Bangladesh is from 20th May to 23th July. The period should be adjusted from mid-April to June based the findings of this sub-project and other relevant data on spawning- and peak spawning season of marine fishes from the Bay of Bengal, Bangladesh. Additionally, growth parameters for 15 commercially important marine fishes were estimated as well as the recruitment pattern mortality (total, natural and fishing) and exploitation rate were also estimated. The balance stock exists for *P. heterolepis*, *S. panijus*, *H. nehereus* and *T. setirrostris*, and rest were under exploited. Fishing with mosquito net in estuaries & mangrove and fishing through Behundi net was found as the major man-made causes or threats for declining of commercially important marine fishes in the Bay of Bengal followed by catches of fry, fingerlings, & *jatka*, poison fishing in mangroves, illegal fishing from Indian and Myanmar fishers, catches of brood fish and use of destructive fishing gears. It was also observed that indiscriminate fishing has been increasing much more with an introducing fishing gear namely 'China net'. Finally, this study will contribute towards a scientific basis for stock assessment and sustainable management policy of marine fish species in the Bay of Bengal.

A HABITAT SUITABILITY INDEX MODEL FOR IDENTIFYING POTENTIAL MUSSEL FARMING SITE IN THE MAHESHKHALI CHANNEL COX'S BAZAR

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Green mussel aquaculture is a low investment income-generating activity (almost zero inputs) and a source of animal protein for the poor coastal community. When initiating any aquafarming, the major factor affecting sustainable productivity is the suitable site selection. Using GIS-based habitat suitability indices (HSI), this study describes potential mussel (*Perna viridis*) farming sites in the Cox's Bazar coast. For this, two field surveys were carried out to collect environmental parameters from 55 locations of the Maheshkhali channel. Thus, water temperature, salinity, dissolved oxygen, particulate inorganic matter, pH, chlorophyll-a and water flow velocity, which were reported as suitable habitat parameters for mussel populations in nature, were used as input variables to develop HSI model and determine HSI score. The model results revealed that the southern part of the Maheshkhali channel is more suitable (HSI >0.60) for spat (baby mussel) settlement and growth because of relatively higher levels of salinity (16-19 ppt), chlorophyll-a ($0.8-12.5 \mu\text{L}^{-1}$), dissolved oxygen ($2.7-7.5 \text{ mg L}^{-1}$) and pH (7.1-7.9). In contrast, freshwater dominated the northern part of the channel characterized by a high suspended sediment load that is less viable (HSI <0.30) for mussel populations. Moreover, HSI model results were validated with the mussel abundance data, and there was a positive correlation between HSI calculated score and observed mussel density ($r = 0.956$). Based on the HSI model it can be proposed that the southern part of the Maheshkhali channel is suitable for mussel aquaculture.

PHYTOPLANKTON ECOLOGY IN COASTAL HABITATS ALONG THE NORTHERN BAY OF BENGAL

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Phytoplanktons are microscopic and polyphyletic group of aquatic organisms, and vary in terms of size, shape and traits of life history. They are functionally diverse and the dominant primary producers (i.e., contribute 50% of global primary production) in the sea and therefore, form the foundation of marine food web. Thus, knowledge on phytoplankton dynamics is important to understand the trophodynamics of aquatic ecosystems. But, the topic remains poorly studied in the context of tropical coastal habitats. The present study describes the community structure and drivers of phytoplankton in different coastal habitats along the northern Bay of Bengal. Thus, data were collected on phytoplankton, zooplankton and a range of environmental variables from the estuarine, mangroves and coral habitats of Bangladesh during dry season from October 2020 to March 2021. Our study found that eco-hydrological characteristics of the estuarine, mangroves and coral habitats differs from each other (Figure 1), although phytoplankton assemblages in these habitats commonly dominated by diatoms. In estuarine system, the main diatom taxa included *Coscinodiscus*, whereas *Ceratium* and *Chaetoceros* were dominant in coral system, and *Coscinodiscus* and *Chaetoceros* in mangroves system. The concentration of micronutrients (silicate, nitrate and phosphate) was the most important driver of phytoplankton in all habitats. In addition, zooplankton had a vital role in regulating phytoplankton community composition in the coral system. These results suggest that the phytoplankton dynamics in tropical coastal habitats is largely driven by nutrients, which, when compared, have less influence on phytoplankton growth in the temperate region.

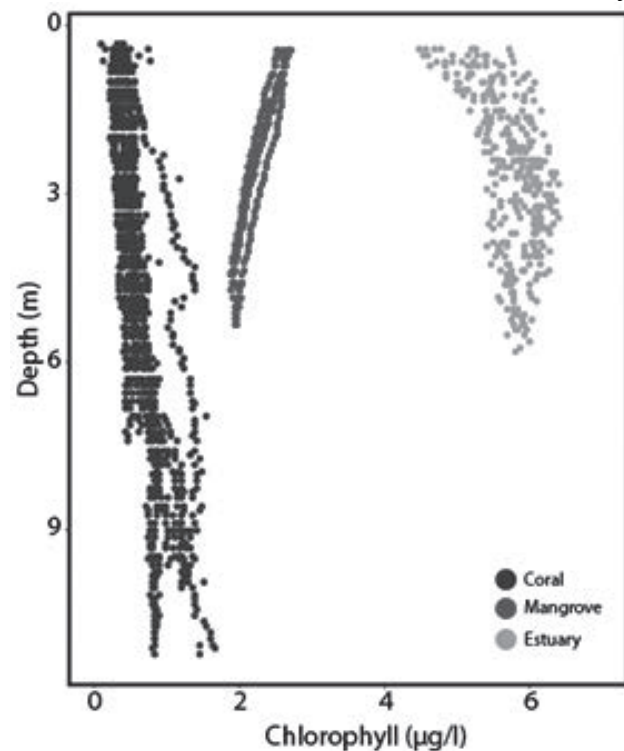


Figure 1: Vertical variability in chlorophyll in the coastal ecosystems of Bangladesh.

LENGTH-BASED BAYESIAN BIOMASS (LBB) AND LENGTH BASED SPAWNING POTENTIAL RATIO (LBSPR) OF MARINE FISHES IN THE BAY OF BENGAL, BANGLADESH

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Length-based Bayesian Biomass (LBB) and Length based spawning potential ratio (LB-SPR) models were used to assess the current status of commercially important marine fishes i.e., Little tuna (*Euthynnus affinis*), Frigate Tuna (*Auxis thazard*), Talang Queen Fish (*Scomberoides commersonianus*) in Bay of Bengal, Bangladesh. Data were collected fortnightly from BFDC Ghat, Cox's Bazar, BFDC Chittagong, and Mohipur, Khepupara from July 2021 to June 2022. Data were analyzed to determine Length at first sexual maturity (L_m), selectivity, Fishing Mortality, Length at first capture, GSI and SPR by different computer-based programs including R. The result of this study shows that two fish species among three were caught before mature stage. Maximum recorded length of Frigate Tuna, Little Tuna and Talang Queen Fish were 45cm, 71cm and 120cm respectively. Length at first maturity of Little Tuna, Frigate Tuna and Talang Queen Fish were 37.79 cm, 24.83 cm and 60.95 cm. Maximum lengths (L) of Little Tuna, Frigate Tuna and Talang Queen Fish were 71.5, 58.5 and 156 respectively. K value and M value of Little Tuna, Frigate Tuna, Talang Queen Fish were 0.56 and 0.86, 0.92 and 0.95, 0.16 and 0.32 respectively. M/K value of Little Tuna, Frigate Tuna and Talang Queen Fish were 1.53, 1.5 and 2.0 respectively. Z/K value of Little Tuna, Frigate Tuna and Talang Queen Fish were 3.2, 1.9 and 4.4 respectively. Among these three fish species GSI value of two fish species i.e., Little Tuna and Talang Queen Fish were determined. Peak spawning season of Little Tuna was range from September to November and partial spawning season was in April month. Whereas peak spawning season of Talang Queen Fish was in August month partial spawning season was during February to April months. SPR of Little Tuna, Frigate Tuna and Talang Queen Fish were 20%, 25% and 10% which mean the stocks of these fish are vulnerable. The current relative biomass (B/B₀) ratios were smaller than the B_{MSY}/B₀ in Little Tuna, Frigate Tuna, Talang Queen Fish. The present status confirmed that Bangladesh's coastal water fishery resources are declining. More specific targeted management measures should be taken to recover the country's marine fishery resources.

IDENTIFICATION OF POTENTIAL PRODUCTIVE ZONE AND DOMINANT PHYSICAL-BIOGEOCHEMICAL DRIVERS OF SEASONAL CHLOROPHYLL-A CONCENTRATION IN THE BAY OF BENGAL

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The seasonal variations and driving mechanisms of the surface and subsurface chlorophyll-a concentrations in the Bay of Bengal are far from resolved, as only a few local, short-term studies have been performed. Hence, this study investigates a comprehensive basin-wide framework of the seasonal variations in the chlorophyll-a concentration, its dominant external forcing, and the internal dynamics of the Bay of Bengal. Multivariate empirical orthogonal function decomposition and heterogeneous correlation analyses are applied to numerous observational, reanalysis, and satellite datasets, including chlorophyll-a, nutrients, temperature, salinity, turbidity, and wind stress curl datasets collected from various sources, including the Copernicus Marine Environment Monitoring Service, World Ocean Atlas, and ERA-Interim. This study suggests that the chlorophyll-a concentrations at both the surface and the subsurface chlorophyll-a maximum (SCM) are higher during summer and early autumn than during the other seasons, especially along the coastal regions and western part of the Bay of Bengal. During summer and early autumn, riverine nutrient inputs, the intrusion of nutritious water from the Arabian Sea, and coastal upwelling are the three dominant drivers controlling the chlorophyll-a concentrations at both the surface and the SCM. The positive wind stress curl-induced uplift of the thermocline increases the nutrient supply and thus significantly enhances the chlorophyll-a concentration at the SCM along the entire western side of the bay during the second half of the year. During spring, the deep euphotic depth plays a vital role in controlling the concentration and depth of the SCM. The depth of the 26°C isotherm can be used as a proxy of the depth of the SCM. This study provides an improved understanding of the high chlorophyll-a concentrations and their drivers in five potential zones within the Bay of Bengal, which will help to identify the rich marine ecosystems therein.

EXPERIMENTAL CULTIVATION OF SEAWEED ON THE COX'S BAZAR COAST, BANGLADESH

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The current research was carried out in Rezu Khal to determine the best location for seaweed cultivation. This research also discovers commercially valuable seaweed species that are appropriate for production. Temperature, salinity, pH, DO, conductivity, and FNU of surface water ranged from 20.9-26.2°C, 24-26.2‰, 6.45-8.5, 92-105%, 33256-64267 $\mu\text{S}/\text{cm}$, 11.1-42.8, respectively. Phosphate-phosphorus ($\text{PO}_4\text{-P}$) concentrations in surface water were 2.6-7.6 mg/l, 0.04-0.12 mg/l for Nitrate-nitrogen ($\text{NO}_3\text{-N}$), 0.002-0.04 mg/l for Nitrite-nitrogen ($\text{NO}_2\text{-N}$), 0.15-0.83 mg/l for Silica (SiO_3), and 0.13-0.28 mg/l for Ammonia (NH_4). In the chosen areas, three seaweed species (*Gracillaria lemaneiformis*, *Hypneamusciformes*, and *Sargassum oligocystum*) were cultured. Seaweed samples were collected from St. Martin's Island (a natural bed of seaweed) for experimental cultivation. For the culture, two methods (net and long line) were used. Every 15 days, 15-20 kg *G. lemaneiformis* was identified in the net method in the current investigation. Every 15 days, *H. musciformes* grew between 4 and 12 kg. *S. oligocystum* grew well, however it was difficult to keep it alive. Biochemical composition was also determined for seaweed species. The average value of ash, moisture, protein, lipid, carbohydrate, and fiber were ranged between 13.55-13.58%, 23.89-24.04%, 12.94-13.11%, 0.96-0.97%, 43.19-43.32%, and 5.04-5.32% *G. lemaneiformis* and *H. musciformes*. The concentration of Ca, Mg, Cu, Fe, Mn, Zn, Ni, Pb and Cr varied between 767.14-798.14, 8249-8663, 10.15-10.59, 6038.57-7566.29, 9.71-9.93, 29.3-29.54, 11.68-11.77, 3.56-3.91 and 0.40-0.59 mg/kg in both seaweed (*G. lemaneiformis* and *H. musciformes*). Seaweed cultivation along those areas has provided a new dimension to the promise and possibilities of seaweed mariculture on the Bangladesh coast. The findings of this study imply that seaweed growing is viable, and coastal residents can engage in seasonal income-generating activities in coastal waters.

MICROPLASTICS POLLUTION IN THE SURMA RIVER SYSTEM, NORTHEAST BANGLADESH: AN EMERGING THREAT TO UPSTREAM WATER QUALITY AND AQUATIC LIFE

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The Surma River, one of the major rivers in Bangladesh, is a habitat of several indigenous fish and other living creatures which makes it a significant resource to the fisheries and surrounding communities. However, the ecological health of this environment has deteriorated due to careless human activities, for instance, emission of mismanaged plastic garbage into the river. Therefore, current research was the very first-time approach to investigate the abundance of microplastics (MPs), categorized in different types, and their size and color distribution in water, sediment, and representative organisms (fish, crustacean, and bivalve) of the Surma River. Sampling was performed in late winter from three different river sites covering a stretch of about 10 km. Water, sediment and organism samples were processed following standard procedures to separate selected MPs types under a stereomicroscope. In addition, types of polymers were subjected to further analysis with Attenuated Total Reflection (ATR). Current study identified the consistent existence of three common types of MPs i.e., fiber, fragment and microbead. Besides, current research also recorded a phenomenal high abundance of MPs as 194.5 – 686.5 items/L in surface water, 1.87– 15.13 items/g in sediment, and 1.47–48.93 items/g in organisms. Quantified MPs contained a diverse color range, while MPs <200µm were prevalent in all three sampling sites. Finally, the present investigation revealed that all the study areas were polluted by MPs where the sampling site named Kazir Bazar was significantly ($P<0.05$) polluted which requires further attention. This is unfortunate but true that the pollution rate would be increased in the Surma River unless prompt actions are taken by the authority.

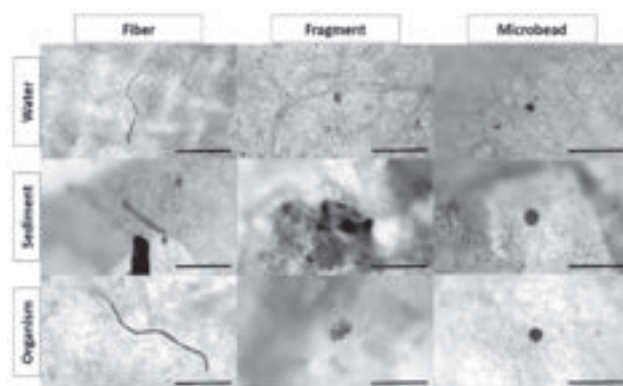


Figure 1. Microscopic images of different types of microplastics (fibers, fragments, and microbeads) in water, sediment, and organism level. (Scale bar = 200 µm).

LENGTH-BASED BAYESIAN BIOMASS (LBB) AND LENGTH BASED SPAWNING POTENTIAL RATIO (LBSPR) OF HILSA, *Tenualosa ilisha* (HAMILTON, 1822) IN THE BAY OF BENGAL, BANGLADESH

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Length-based Bayesian Biomass (LBB) and Length-Based Spawning Potential Ratio (LB-SPR) models were deployed to assess the current status of Hilsa, *Tenualosa ilisha* from the Bay of Bengal, Bangladesh. About 20,610 specimen's data were collected from January 2018 to December 2021 from commercial fish landing sites on monthly basis, and their total length (TL) and weight were measured. The results revealed that both seine net and gill net were used to capture most of the *T. ilisha* before first spawning time. The maximum-recorded total length (TL) for this species in the study area was 58.9 cm with a mean length of 38.0 ± 10.73 cm. The M/K value corresponds to the maturation of *T. ilisha* was 1.1. The ratio of current relative to unexploited biomass (B/B_0) was greater than the relative biomass that can produce MSY (B_{MSY}/B_0) in hilsa indicate healthy stock. On the basis of LB-SPR assessment model, it could be concluded that these species become vulnerable to fishing at its maturation' size 31.75 cm. The range of annual SPR of *T. ilisha* was estimated between 0.27 to 0.29 in the Bay of Bengal, Bangladesh, meet the threshold value of 0.2. These indicate that the exploitation level of *T. ilisha* is maintained to reach the maximum sustainable yield with the concurrent recruitment and juvenile survival. The Spawning Potential Ratio of *T. ilisha* based on time series data analysis, as a biological reference point was estimated near about 0.2, which comply the SPR for sustainable fisheries. However; the rate of fishing mortality should be reduced constantly.

EFFECTS OF TEMPERATURE ON INGESTION OF MICROPLASTICS IN NILE TILAPIA

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Microplastics (MPs) are fragments of any type of plastic less than 5 mm in length. MPs pollution and global warming are global concerns, creating various physiological problems for aquatic organisms. Polyamide (PA) is one of the most commonly produced plastics. This study was carried out to know the effects of virgin PA (10 mg/L water) in relation to different temperatures (30, 33 and 36°C) in Nile tilapia (*Oreochromis niloticus*) for 15 days exposure and 15 days recovery period. Significant differences were found in PA ingestion of the treated different temperature groups. Fishes from 33°C groups ingested higher amounts of PA (175 ± 20.81) during the exposure period while fishes of 36°C contained lower amounts of PA (2.5 ± 0.55) during the recovery period in their GIT. Significant alterations of erythrocytic cellular abnormalities like echinocytic cells, elongated shape, fusion, spindle, twin, and tear drop, and nuclear abnormalities like binuclear, kidney shape, karyopyknosis, nuclear bridge and nuclear degeneration abnormalities expressed the physiological state of the fish throughout the exposure and recovery period. This study confirms the toxicity of polyamide MPs in Nile tilapia in relation to different temperatures and should be considered as bio-monitoring tools in the ecosystem.

MICROPLASTIC CONTAMINATION IN AQUACULTURE: SOME PRELIMINARY INVESTIGATIONS TO UNCOVER THE UPCOMING THREAT IN BANGLADESH

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Microplastics (MPs, <5 mm) are ubiquitous in fisheries and aquaculture environments. Due to persistency and potential toxicity, MPs are threatening to public as well as aquatic environment. But research on MPs in Bangladesh is scarce. To determine the MPs contamination in aquaculture, the present investigation was conducted initially to detect MPs from catfish flesh, commercial fish feed, and rearing pond water samples of Mymensingh aquaculture zone, Bangladesh. Further, some protein ingredients of fish feed *viz.*, fish meal, soya meal and some fish feed sample *viz.*, starter, grower collected from three different feed companies namely Nourish, Mega and Quality fish feed, were analyzed to find out abundance of MPs. Density separation method of 40% NaBr solution was used to extract, 30% H₂O₂ solution at 1:1 ratio was used to digest fish flesh and feed/ feed ingredient samples, vacuum filtering was used for filtration and light microscopy was employed to analyze the MPs. A total of 191 MPs particles were recorded, 134 found in rearing water ranging from 8-53 μ m, 45 found in fish feed ranging from 10-88 μ m, and 12 found in fish flesh ranging from 7-15 μ m. From feed/ feed ingredient samples, 1161 MPs were detected. The starter feed with higher percentage protein contained highest number of MPs than grower feed with lower percentage protein. Film (80.45%) was the most abundant type followed by fragments (10.77%), granules (7.14%), and fiber (1.64%). About 50-150 μ m sized of MPs were the mostly common. Fish meal ingredient showed 54 MPs but no MP was found in soya meal ingredient. This preliminary study demonstrated the situation of MPs contamination in fish, fish feed and rearing water, and the results presented here may serve as a reference for future research on the risks of MPs in the aquaculture and public health of Bangladesh.

SHELF LIFE EXTENSION OF REFRIGERATED NILE TILAPIA *Oreochromis niloticus* FILLETS USING SEAWEED EXTRACTS

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Seaweeds are emerging as a viable and plentiful source of natural antioxidants and antimicrobials, and diverse claims for health-promoting properties. Thus, use of seaweed extract is an effective way to inhibit lipid oxidation and retard microbial growth in fish, which maintain the nutritional quality and prolong their shelf life. The aim of this study was to evaluate the effects of ethanolic extracts of *Padinatrastomatica*, *Sargassumnatans* and *Sargassumfluitans* on extending the shelf life of Nile tilapia (*Oreochromis niloticus*) fillets during refrigerated storage.

Seaweeds were extracted using absolute ethanol. The control and treated fillets (2% extracts of each seaweed) were stored at $4\pm 1^{\circ}\text{C}$ in air tight polyethylene bags, and chemical (pH, peroxide value, thiobarbituric acid reactive substances (TBARS) and total volatile basic nitrogen (TVB-N)), microbiological (aerobic plate count (APC)) and sensory evaluation was performed at every 4 days intervals until appearing undesirable for human consumption.

During the storage period, *P. tetrastomatica* extracts treated fillets showed significantly ($P < 0.05$) the lowest pH, peroxide value, TVB-N, TBARS and APC values than those of other seaweed extracts treated and untreated fillets. *P. tetrastomatica* extracts treated fillets had acceptable sensory characteristics up to 16 days of storage followed by *S. fluitans* (12 days), *S. natans* (8 days) and control (4 days) fillets. Results of this study suggest that ethanolic extracts of *P. tetrastomatica* retains the quality and extends the shelf life for 12 days longer than control fillets in refrigerated condition. Thus, it can be concluded that *P. tetrastomatica* extracts (2%, w/v) can be used as natural preservatives for the preservation of Nile tilapia fillets.

SPATIO-TEMPORAL DISTRIBUTION OF CHLOROPHYLL-A, TOTAL SUSPENDED MATTER, AND COLORED DISSOLVED ORGANIC MATTER IN THE COASTAL AREAS OF SUNDARBAN MANGROVE FOREST USING REMOTE SENSING SATELLITE IMAGERY

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The Sundarban mangrove forest is one of the most productive ecosystems and serves as an important nursery ground for many commercially valuable fishes which is influenced by the vast amounts of nutrients carried by the rivers Rupsha, Passur, Shibsra, Baleswar, Bhola, Kholpetua, Arpangashia, and Malancha. This study evaluates the effectiveness of Sentinel-2 MSI and Landsat-8 OLI multispectral remote sensors to determine the spatial and seasonal fluctuation of Chlorophyll-a (Chl-a), Total Suspended Matter (TSM) and Colored Dissolved Organic Matter (CDOM) in the complex tidal river systems of the Sundarban mangroves. Several algorithms and processors have been applied to retrieve these water quality parameters. For validation in-situ samples were collected in winter (December) and pre-monsoon (April) then measured in a lab using standard a protocol in order to validate remote sensing data. Ocean color-2 (OC-2) and Ocean Color-3 (OC-3) bio-optical algorithms were applied and OC-2 gives better estimates for this region than OC-3, with $R^2 = 0.73$, RMSE = 0.27 for winter and $R^2 = 0.55$, RMSE = 0.32 for pre-monsoon (spring) for MSI sensor. This study showed that Chl-a concentrations (mg/m³) are higher in the winter than in the pre-monsoon (spring), especially in the onshore areas as compared to the offshore areas. This could be because the Sundarban mangroves serve as a gateway for increased levels of monsoonal and post-monsoonal riverine nutrients. The Green/NIR band ratio algorithms were used for TSM concentration (mg/L) estimations and showed that the highest concentration of TSM was located in the nearshore and narrow waterway regions and a low concentration was located in the offshore region. TSM concentration was found to be higher during the pre-monsoon season, when secchi disk transparency was found to be lower. Pre-monsoon higher TSM concentrations are accelerated by the resuspension of sediments, which is regulated by the wind speed in this study area. The C2RCC processor in-built into the SNAP software was utilized to get the CDOM for OLI seasons. For the OLI season in the study area, there observed a strong association with absorption coefficient a^{CDOM} (m⁻¹). R^2 for a^{CDOM} is 0.65 during the pre-monsoon season and 0.74 throughout the winter. a^{CDOM} was observed higher during pre-monsoon seasons. Therefore, in order to estimate the biological status and productivity of the underwater ecosystem of the coastal water using remote sensing, these water quality parameters should be determined first.

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Technical Session 9:
**Socioeconomics, Livelihoods
and Gender**

IMPACTS OF BANGLADESH FISHERIES SECTOR ON THE SOCIOECONOMIC DEVELOPMENTS, LIVELIHOODS, AND GENDER

Syed M Istiak

Fisheries Specialist

Director, Deep Sea Fishers Ltd and ASAP Healthy Food ltd, Bangladesh

Socioeconomic development is the progressive reinforcement of a fisheries system's quantitative and qualitative dimensions towards higher levels of efficiency, ensuring fundamental rights, nutritional security, mobility, justice, and democracy at all levels. Socioeconomic developments are measured by evaluating the changes in GDP, literacy, production, income, education level, unemployment level, and level of participation in civil society. Bangladesh's fisheries industry is versatile, dynamic, and people-centered, where its contribution to the GDP is 3.57 %. About 19.5 million people are actively involved in Bangladeshi Fisheries, of which 1.4 million are female. In 2020-21, the fisheries production was 4.6 million MT, and fish intake was 62.58 gm/day/person, which is 2.58 gm more than the required quantity. Fisheries sectors provide 100 % more fish to 169 million (BBS 2022) in Bangladesh. The fisheries sector is the backbone of this nation and contributes to the socioeconomic development of Bangladesh variously. Fisheries production increased 5.5 times more than in 1991 and the per capita income of Bangladeshi people increased by 8.5 times. As per World Bank report, present per capita is USD 2,503. Fisheries play a significant role in food security, livelihood upliftment, and social security of the people. The secondary data of 11 fisheries-prone districts were evaluated and found that the literacy rate increased by 14% from 2011 to 2021, the Crime rate was reduced by 12%, and Fish production increased 44 % from 2011 to 2021. The suicide rate reduced by 8%, per capita income was increased by 66% from 2011 to 2021, and health service expenses were increased 50% from 2011. Fisheries can provide a significant contribution to household cash income. The adoption of new technologies, bargain power, and social participation of fisheries entrepreneurs has increased. Infrastructures have developed that help to access inputs, markets, and information. Fishery-related livelihoods are complex, dynamic, and adaptive. Higher educated people came forward to participate in the fishing business. Fishing often shows this high degree of integration with other economic activities at the local level, such as agriculture, dyke cropping, homestead gardening, livestock, bird rearing, trading, and the provision of labor. Gender aspects in fisheries, men, and women often have distinct roles. Children also often engage in fisheries at this subsistence level. As the financing institute comes forward and the government has taken a lot of activities to provide financial support to the fishing industry, the bondage loan system has almost been eliminated, except in marine artisanal sectors. However, the fishing industry faces some challenges also, like natural, social, and price of fish-related issues. Comprehensive research is needed to know more about this issue.

COVID-19 AND FISHERIES: A STUDY ON IMPACTS OF LOCKDOWN ON ARTISANAL FISHING COMMUNITIES OF BANGLADESH

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Globally the COVID-19 pandemic has caused disruption of existing systems related to food, transportation and livelihood. The pandemic has adversely impacted the small scale fishers (SSF). However, little is known about the impacts of COVID-19 on the artisanal fishing communities. Therefore, this study aimed to understand the impacts of COVID-19 on artisanal fisheries of Bangladesh. A questionnaire survey was conducted in 7 landing sites of south west coastal zone of Bangladesh. The survey was focused to collect information on fishing, catch, price and fisher's livelihood status. We focused on 60 days' time period covering 23 days of pre-lockdown and 37 days of during-lockdown time. This study found that there was limited fishing pressure during the lockdown period which benefitted fishers with higher catch per unit effort (CPUE) when compared with pre-lockdown time. However, due to higher (average 30%) transportation cost than normal and reduction in fish price (4 to 83%), fishing turned as less profitable operation. Therefore, fishermen spent less time (5h a day and 6 days in a week) in fishing during the lockdown period. Together, these factors reduced small scale fisher's income significantly which forced over 70% of them to take some forms of loan to meet their livings. Around 22% fishers took loan with high interest from local lenders which may affect them for generations. Among the various aspects of fisher's life, food security (25%) was affected the most followed by economy (23%), health (20%), education (19%) and socialization (13%). One of the big positive impact for small scale fishers was that they were relieved from competition with industrial fishers in this period. Therefore, allowing fish transport, establishing enough cold storage facility and proper implementation of social safety measures to protect people who lost their income amid the pandemic could benefit the lives of small scale fisher's community. In this study, we proposed a framework, implementation of which can protect this fisher community against any future crisis.

THE PREMIUM OF HILSA SANCTUARY: A SOCIO-ECONOMIC AND ECOLOGICAL EVALUATION FROM THE MEGHNA ESTUARY, BANGLADESH

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Sanctuaries are widely regarded as a protected area where fishing has been placed under some restrictions by local, state, regional and national authorities for the conservation and management of fisheries resources. These sanctuaries have a broad array of positive and negative social, economic, cultural and political impacts on fishers. This study aims to analyze analyzed the socioeconomic and ecological benefits and costs of hilsa sanctuaries to protect single most important hilsa species using Sustainable Livelihood Approach (SLA). Under the Protection and Conservation of Fish Act of 1950, six sites along the Padma, Meghna, Tetulia, and Andharmanik rivers have been designated as hilsa sanctuaries. Findings of the current study revealed that most fishers perceived production of hilsa and other species were increased as a direct consequences of sanctuaries establishment (Figure 1). However, a considerable proportion of hilsa fishermen was found to have low socioeconomic capital, as measured by monthly income, housing circumstances and asset ownership. During the restricted fishing season in the sanctuaries, these households are particularly vulnerable to food insecurity. The government's compensation scheme is a good example of payment of ecosystem services in an open water fishery; however, this scheme does not include all the affected fishers. It is found that hilsa sanctuaries lead to income loss of the poor fishers which is insufficiently compensated by government support program. To compensate income loss, fishers resort illegal fishing which undermine the success of sanctuary. If the sanctuaries are to function effectively, affecting fishers must be addressed by offering enough compensation schemes so that fishers are able to support their families. Moreover, some fishers believed that a co-management approach involving fishers and government is the possible best management option for operating sanctuaries in a sustainable way.

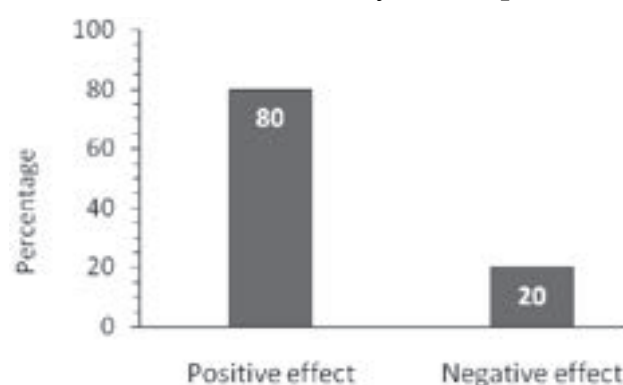


Figure 1. Community perception on the effect of hilsa sanctuaries of Bangladesh.

SOCIAL AND TECHNOLOGICAL CHANGES IN A COASTAL FISHING VILLAGE IN BANGLADESH

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The objective of this study is to investigate the social and technological changes in a traditional coastal fishing village of Moheshkhali Island in Cox's Bazar district. Using a semi-structure interview protocol and oral history, the study tracks these changes for the timeline of 1972-2021. This study mainly interviewed the veteran and senior fishers of traditional low-caste *Jaladas* (literally meaning slave of water) fishing communities who are involved in estuarine and coastal fishing. We have conducted a historical analysis that covers at least fifty years to examine the processes and factors that influence the transformation in a traditional fishing livelihood that changed in the village over time. The introduction of modern technology & innovation in livelihoods like electricity, high powerful boat engines, using modern equipment (Mobile phones, GPS), increased access to educational institutions, social behavior, diversified occupation, unity, division of labor, and medical facilities changed daily activities and wellbeing of the fishing communities. The development of new equipment, specifically mechanized boats and modern fishing nets and gear has been one of the most critical factors affecting traditional fishers, particularly since the mid-1980s. Many of these changes, such as significant reduction in the urban-rural gap, improvements in health facilities, better literacy rate, improved transportation system, and increased fishing income, have positive impacts. Key problems and constraints of the coastal fisheries identified in this study were piracy while fishing in the sea; lack of social safety; competition between users; inadequate boat and net facilities; adult illiteracy; habitat destruction; unclear and poor credit policy; overpopulation, fishing overcapacity limited market access; a high percentage of dependency on fishing; ineffective regulatory mechanisms; top-down management structures; and absence of strong fishers' organizations, etc. While the fishers reap the benefits of social and technological advancements, the flip sides of these changes often make vulnerable that need to be addressed. Though the lack of specifics or in-depth studies carried out in this fishing community, we believe that this study will be highly beneficial for future research, determining policy, and improving livelihood.

WHAT MAKES SMALL-SCALE FISHERIES VULNERABLE? TOWARDS VIABLE RESPONSES IN THE CONTEXT OF BANGLADESH

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By firmly anchoring in local communities where fisheries represent a way of life, Small-Scale Fisheries (SSF) make important contributions to erasing hunger, livelihoods, national economies, poverty reduction, etc., especially in developing countries, including Bangladesh. At the same time, SSF are among the most vulnerable communities in the world that are subjected to a wide array of threats and stresses. Nevertheless, knowledge of the factors that make the Bangladesh SSF vulnerable is scarce. By combing data from the literature review and Key Informant Interviews, this research aimed to critically examine this knowledge gap of the factors that make the Bangladesh SSF vulnerable. Similar to global experiences, SSF of Bangladesh exists in diverse aquatic ecosystems (e.g. inland flood plains, rivers, mangrove wetlands, coastal, and marine waters) but faces major challenges from natural and anthropogenic sources. The findings revealed that these threats and stressors entailed biophysical, economic, social, technological, and governance issues and their dynamic interactions make the SSF vulnerable in Bangladesh. For example, the small-scale fishers constantly face different manifestations of climate change such as extreme cyclonic events and salinity intrusion (biophysical factors). The small-scale fishers are among the most socially sections of society for widespread illiteracy and poor awareness (societal factors). They also face many economic challenges including urbanization and industrialization, expansion and intensification of aquaculture and agriculture, instability of market prices and high fishing costs (economic factors). Some other threats come from technological aspects such as unhygienic and poor landing infrastructure, inadequate preservation, cold storage and processing facilities. Though SSF is often ignored in policy and fisheries governance domain that still suffer from mismatching among fisheries regulations, top-down decision-making process, conflict, and discrimination in government support, to mention a few governance factors. By exposure to different vulnerability factors, the Bangladesh SSF faces negative repercussions to food and nutrient security, livelihoods, economy, employment, values and culture, identity and social and environmental sustainability; that ultimately jeopardize and hinder the viability of SSF communities in Bangladesh. The findings will offer a better understating of the SSF vulnerabilities and they would be helpful to the decision-makers and other stakeholders in dealing with issues towards effective responses for viable SSF communities in Bangladesh.

SOCIO-ECONOMIC CONTEXT AND COMMUNITY RESILIENCE AMONG THE PEOPLE INVOLVED IN FISH DRYING PRACTICES IN THE SOUTH-EAST COAST OF BANGLADESH

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The south-east coast, specifically Cox's Bazar region of Bangladesh, has achieved a tremendous impetus for producing a large volume of dried fish by involving thousands of marginalized coastal people. The study aimed to assess the socio-economic profile, livelihood strategies, and resilience of the communities involved in fish drying on the south-east coast using a mixed-methods approach and an Analytic Hierarchy Process (AHP). The study's findings revealed that communities engaged in drying were socio-economically undeveloped due to their lower literacy, unstable incomes, and labor-intensive occupations. Apart from notable child labor employed in fish drying in Nazirertek, female workers had relatively higher participation than males. Nevertheless, the female workers had less control over their daily wages and reported working at USD 3.54-5.89 per day, which was relatively lower than male workers who received USD 4.15-8.31 per day. Through fish drying activities, very few workers, producers and traders were found to be self-reliant, while the livelihoods of the workers were not as secure as the processors and traders. In addition to suffering from various shocks and constraints, dried fish processors and workers, dried fish traders, off-season income, an abundance of fish species, fish drying facilities, trader's association, and social interrelationship played a significant role in maintaining community resilience. The study recommends appropriate interventions to alternative income diversification options, strong collaboration between communities, local authority, and government for sustainable livelihoods and better community resilience.

TOWARDS LIVELIHOOD VIABILITY OF MUNDA INDIGENOUS COMMUNITIES OF THE BANGLADESH SUNDARBANS

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The Sundarbans is the world's largest coastal wetland and delivers countless ecosystem services, having great importance for local livelihoods, the national economy, and the global environment. Mangrove-dependent ethnic Munda community of the Sundarbans, Bangladesh, has undergone severe livelihood challenges due to the long-term effects of climatic disasters (e.g., tropical cyclones, floods, salinity intrusion), non-climatic changes (e.g., land use changes and land degradation, urbanization, and pollution), implementation of the new policy, rules and regulation (e.g., ban season, restricted area), etc. Particularly, the COVID-19 pandemic brought tremendous challenges to the income and livelihood strategies of the Munda people due to different restrictions, including access to forest resources. This study addresses a research gap in the context of the COVID-19 situation's effects on the ethnic Munda communities towards a transition of livelihood viability of the mangrove-dependent fishing community. As the effects of the COVID-19 pandemic receded, the communities adopted different strategies to overcome the challenges. The most common coping mechanisms used by the Munda people in the Sundarbans are borrowing from family and friends or taking out a loan from a moneylender or microcredit organizations, reduction the number of meals per day, taking just staple foods, selling household assets, and in some extreme cases marrying off young girl children to reduce the financial burden. Many adopted multiple occupational portfolios to adjust to emerging situations. For example, nipa leaf collectors or honey collectors involved in fishing. Incapable of dealing with an unstable environment, some left their primary occupation and migrated to urban centers. Transferring a household member to another place for work is now more common as a translocal livelihood strategy. Finally, this study submits that policies should make an effort to reduce the impact of sudden adverse events on the already vulnerable livelihoods and to increase the advantages of ecosystem services for the long-term socioeconomic and environmental development of the mangrove ecosystem.

ECONOMIC VIABILITY AND SEASONAL IMPACTS OF INTEGRATED RICE-PRAWN-VEGETABLE FARMING ON AGRICULTURAL HOUSEHOLDS IN SOUTHWEST BANGLADESH

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Integrated aquaculture is being intensified to address the scarcity of food and land resources that has arisen due to the ever-growing population of Bangladesh. Integrated aquaculture is an efficient method, however, there is limited evidence in the context of Bangladesh. This study analyses the seasonal impacts of cropping patterns, production, cash-flow, and profitability on integrated rice-prawn-vegetable farms (RPVF) compared with conventional rice farms (CRF). This study was conducted in two communities: Bilpabla and Gutudia in the Dumuria Upazila (sub district) of Khulna district in southwest Bangladesh. Primary data were collected through face-to-face recall interviews from farmers of both CRF and integrated RPVF. A survey of 20 randomly selected farmers (10 from each of CRF and RPVF) was undertaken, along with direct observations and transect walks to obtain in-depth information for descriptive analyses. A simple profitability analysis was performed to get a clear image of the economic comparison between CRF and RPVF. In RPVF, farmers cultivated diverse produce in the wet season, such as prawn, shrimp, and carps in reservoirs and vegetables on dikes, and boro rice with vegetables in the dry season, whereas only rice (boro and aman) was cultivated in both seasons in CRF. The annual per hectare net revenue from integrated RPVF was US\$ 2742.7, 3.6 times higher than from CRF (US\$ 756.6). RPVF had a higher benefit-cost ratio of 1.58 as compared with 1.34 for CRF. Year-round vegetable cultivation and the higher price of prawn/shrimp in the monsoon make a significant difference to profitability between the two systems. In addition, year-round vegetable production and selling has resulted in a smooth cash-flow in integrated RPVF, thus reducing the financial burden on the farmers in terms of the cost of feed, seed, drugs, and chemicals for prawn/fish, as well as total labor investment. The integrated RPVF system had positive year-round socioeconomic impacts on farming households through intensifying land uses, diversifying food production, enhancing income, and ensuring consistent cash-flow. This can be promoted in other parts of Bangladesh and elsewhere in the world.

READY TO USER FISH POWDERS (RUFPS) ARE CRITICAL IN COMBATING ADOLESCENT FEMALE MALNUTRITION

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Despite the rapid expansion of aquaculture as well as progression in many social and health indicators, at least 40% of Bangladeshi are sufferings from various malnutrition burdens. Fish is one of the main staple food items in Bangladesh and contributes the highest amount of animal protein along with many essential micronutrients. Ready-to-use fish products (RUFPS) like fish powder could potentially provide an option to mitigate malnutrition challenges for vulnerable populations, including adolescent female (10-19 years old). The fish powder was developed from five available, low-priced, and nutritious fish species (punti, kachki, chapila, sardine, and anchovy), and each was chosen using a food security index that has three main pillars: availability, affordability, and nutritional utilization. The present study developed three different sub-types of powder, including powder from whole fish, powder from gutted fish, and powder from fish muscle. From five fish species, 13 different forms of powder were developed, where kachki was only used for whole fish powder. The nutrient content, including macronutrients (protein, lipid, ash, moisture, and energy), fatty acids profile, amino acids, and micronutrients was analyzed at different laboratories. The analyzed data revealed that small-sized fish species, specifically whole fish powder provides 2-3 times higher nutrients compared to other forms of powder from the same species. A randomized controlled trial (RCT) was then carried out utilizing whole fish powder of chapilain six different communities, with half serving as the control group and the other half as the intervention group. Additionally, both anthropometric and biomarkers were taken on two occasions from the adolescent female along with 24 hours recall method, food frequency, consumer preferences, and a female autonomy questionnaire were investigated. Among the biomarkers (Fe, Ca, vitamin A, vitamin B₁₂, ferritin, and CRP (C-reactive protein), B₁₂ demonstrated greater impact than others. Furthermore, the 16-week long intervention showed a significant impact on the adolescent girls' energy and nutrient intake as well as fruitful nutritional outcomes. Finally, our findings stated safe and nutritionally sound ready-to-use fish products/powder can tackle the burden of malnutrition for vulnerable populations in Bangladesh.

Poster Session

IDENTIFICATION OF MARINE FISH PEPTIDE AS A TREATMENT OPTION AGAINST THE MULTIDRUG-RESISTANT *Acinetobacter baumannii*

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Fish peptides are essential to the survival of the fish as well as having critical functions in human physiology and pathophysiology. The identification of viable peptides from marine fish is a significant objective in drug research. The SDR enzyme can play a role in the type II fatty acid synthesis (FASII) pathway, which is vital for a Gram-negative bacterium and inhibition of the protein can block the replication activity of the bacteria. Initially, 34 peptides have been retrieved from marine fishes and docked against the short-chain dehydrogenase/reductase (SDR) protein. Three peptides, namely Histone H2A (DRAMP18698), Piscidin-1 (DRAMP02330), and HKPLP (AP02038), have been selected based on their docking scores of 258.4, 250.4, and 250.1 kcal/mol, respectively. The allergenicity and toxicity analyses revealed the efficacy and non-toxic properties of the peptides. Computational analysis revealed the selected 3 peptides against the targeted protein that can be effective and promising antimicrobial resistance (AMR) drug candidates. To begin, the study retrieved the experimental protein structure of 6PZN from the protein databank and refined its 3D structure from the GalaxyRefine server. The Ramachandran plot score function was utilized to validate the refined model. The Antimicrobial Peptide Database (APD3) was used to extract the 34 fish peptides, which were then predicted and eliminated as potential candidates using the PEP-FOLD 3.5 website. The protein's binding site residues have been found (Fig. 1A) and visualized from the active pocket using the BIOVA Discovery Studio Visualizer Tool (Fig. 1B;C;D). PyRx tools have also been used to find the binding sites from the server during molecular docking simulations (Table 1).

Table 1. The binding energy of peptide molecules; Histone H2A, Piscidin-1, and HKPLP and docking score.

Peptide ID	Docking Score	Ligand RMSD	Molecular Weight
DRAMP18698	-258.4	42.04	1384.72
DRAMP02330	-250.4	79.42	2488.21
AP02038	-250.1	72.34	2572.42

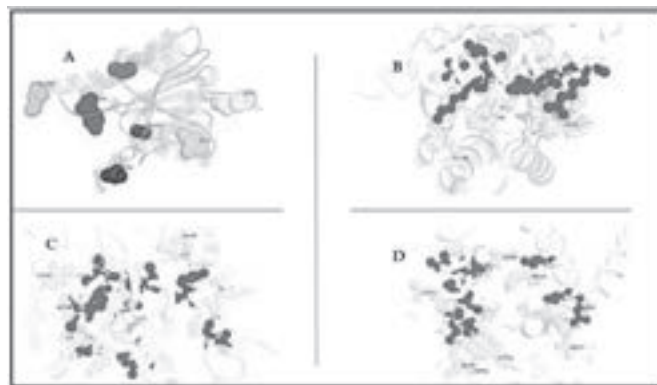


Fig. 1. (A) SDR active side, (B) Histone H2A, (C) Piscidin-1, (D) HKPLP peptides

INCREASING FISH DISEASE BURDEN AND USE OF ANTIBIOTICS IN POND-BASED AQUACULTURE IN SOUTH CHATTOGRAM, BANGLADESH

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Aquaculture production is rising day by day due to aquaculture intensification and diversification of the culture system. In Bangladesh, the fish disease has become a major impediment to achieving adequate production and a determinant of aquaculture's financial success. As a result, fish producers use a wide range of drugs and antibiotics to combat such diseases. Considering the issue, the current study was carried out to assess the status of disease burden and use of antibiotics in pond-based aquaculture in South Chattogram, Bangladesh.

Data were collected using participatory rural appraisal tools with 80 fish farmers, 10 technical persons, and 10 chemical sellers from the 5 Upazilas of South

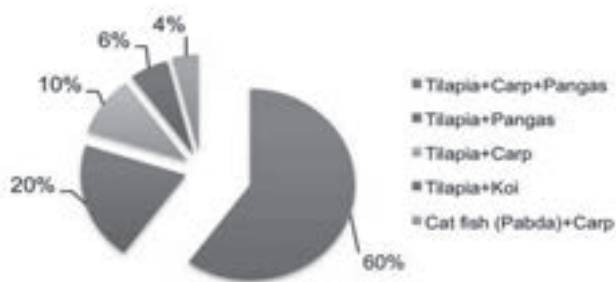


Figure 1. Pattern of different fish species cultured.

Chattogram. According to the study, Tilapia infection (91.25%) and Edwardsiellosis (80%) were the most problematic diseases that had a significant impact on tilapia and Pangas production. In the study area, 37 brands belonging to 10 distinct antibiotic groups were reported. The most commonly used antibiotics were erythromycin, sulfadiazine, and trimethoprim (97.5%), oxytetracycline (95%), ciprofloxacin (90%), and a few other antibiotics with lower

applications. The current study highlights several issues with antibiotic usage by farmers, such as a lack of knowledge about antibiotics, application methods, and indiscriminate antibiotic use in study area. The subsequent concern over antibiotics' impact on the environment, animal, and human health demands extensive investigation to detect possible hazards.

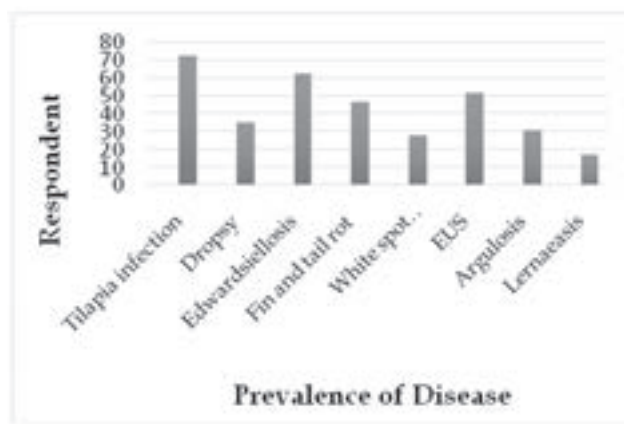


Figure 2. Disease prevalence in the study area.

GROWTH PERFORMANCE AND COST-BENEFIT ANALYSIS OF BRACKISHWATER FIN FISHES (*Mugil cephalus* AND *Rhinomugil corsula*) WITH PRAWN (*Macrobrachium rosenbergii*) IN POLYCULTURE AT COASTAL PONDS

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The study was carried out to observe growth, production and profit of prawn, stripped mullet (*Mugil cephalus*) and corsula mullet (*Rhinomugil corsula*) at different stocking ratio under polyculture in the Bagerhat district for four months. The experiment was designed as a randomized block design and had three treatments based on stocking ratio with three replicates in each treatment. Juveniles of prawn (*Macrobrachium rosenbergii*) and fingerlings of fin fishes (stripped mullet and corsula mullet) were stocked at a stocking ratio of 3:1:1, 4:1:1 and 5:1:1/m² in T₁, T₂ and T₃, respectively. Prawn and fin fishes were fed with a commercial diet and farm made formulated feed on a daily basis. Recorded water quality parameters were within suitable ranges of prawn and fish culture. Higher growth (43.0 g) of the prawn was achieved in T₁ followed by T₂ (41.0 g) and T₃ (38.0 g), but prawn growth was not significantly different between T₁ and T₂. The growth and survival rate of prawn, stripped mullet and corsula mullet were lower in T₃, where the stocking ratio was higher. Higher production of the prawn was obtained in T₂ (1148.0 kg/ha) than those of T₁ (954.6 kg/ha) and T₃ (1083.0 kg/ha). But significantly (p<0.05), higher production of stripped mullet was found in T₁ (650.0 kg/ha) and T₂ (579.5 kg/ha) than T₃ (500.5 kg/ha). Similarly, higher production of corsula mullet was found in T₁ (850.0 kg/ha) and T₂ (834.9 kg/ha) than T₃ (719.8 kg/ha). However, combined production and net profit of prawn and fin fish farming were significantly (p<0.05) higher in T₂ (2562.4 kg/ha, BDT 277,384.51/ha) followed by T₃ (2303.3 kg/ha, BDT 229,693.95/ha) and T₁ (2454.6 kg/ha, BDT 179,393.31/ha). So, from a production and economic point of view, polyculture of prawn and fin fish at a stocking ratio of 4:1:1/m² is more profitable compared to other stocking ratios and this system may be suggested to disseminate at coastal farmers' level.

CHALLENGES AND OPPORTUNITIES IN THE TRADITIONAL PRODUCTION AND DISTRIBUTION OF DRIED FISH IN SYLHET DISTRICT

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The purpose of the research was to evaluate the current retail market for dried fisheries products with their production and marketing systems in the Sylhet district. A total of 21 freshwater fish species that were used for sun drying were found, categorized into 12 families, together with 1 type of prawn. In a different market system, the lowest price is 250 to 300 tk, while the highest price per kilogram was found between 1100 and 1400 tk (BDT). Due to the scarcity of raw materials and their expensive price, larger fish were frequently dried. Additionally, it was discovered that fish from the Cyprinidae (18%), Bagridae (18%), and Channidae (14%) families were more prevalent in the study regions because they were more accessible, more affordable, easier to dry, and in high demand by consumers. According to the results, it shows that fish supply has decreased over time, which may have an impact on how well their business performs. In response to the findings, a number of recommendations have been made, including training for those involved in the value chain of fish drying as well as suitable institutional and governmental support to conduct extensive long-term monitoring of several key species in significant ecosystems and locations.

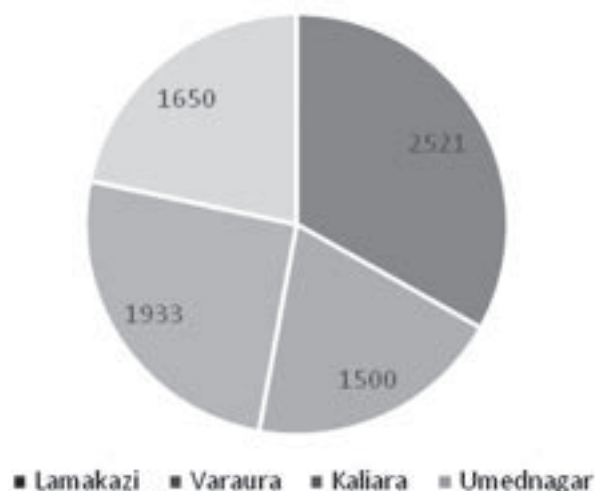


Figure: The average monthly production of dried fish (per kilogram) at the four drying stations of Sylhet.

GEAR AND CRAFT USED FOR FISHING AT BAMUNJI AND CHATAL BEEL OF JAMALPUR, BANGLADESH

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The aim of the current study was to explore the fishing gears and crafts utilized in two *beels*, Chatal and Bamunji, in Bangladesh's Jamalpur region. Through the use of several data collecting techniques, including in-person interviews with fisherman from the study areas, focus group discussions, key informant interviews, and direct observation, data for this study were gathered during a six-month period, from June 2020 to November 2020. The study's findings show that fishermen in the Chatal and Bamunji *beel* use a total of 18 varieties of gear, including 10 types of nets, 4 types of traps, 3 types of hook and lines, and 1 type of wounding gear. Seine nets were found to be the most dominant gear followed by gill nets and traps. The most commonly used materials for construction of gears are synthetic twine, float, rope, bamboo pole, sticks, monofilament fiber, metallic weight, sinker, barbed iron hook, and coconut thread or nylon. Two traditional boats are available in this area which are used in fishing operation. The catch per unit of effort (CPUE) of fishing gear was also measured in this study, and it was discovered that while CPUE varied monthly, there were no differences between Bamunji *beel* and Chatal *beel*. The highest CPUE of fishing gear was observed to be in October followed by August and September.

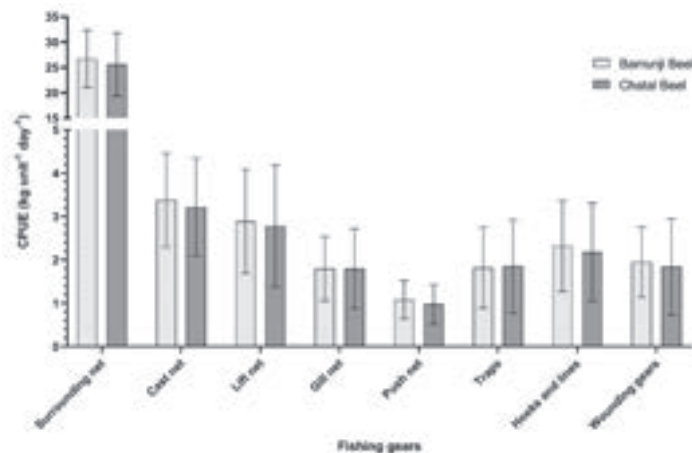


Figure 1. CPUE of various fishing gears used in Bamunji and Chatal *beel*.

Illegal fishing practices is a measure concern in the study area, especially with mono-filament gillnet and, which are mainly used by fishers who have limited alternative employment options. Finally, for the sustainable and efficient use of the fishery resources of the studied areas, this study recommends for cooperative and comprehensive management strategies from government and non-government organizations as well as local resource users.

A NOVEL *IN SILICO* STRATEGY TO PREDICT THE POSSIBILITY OF A FARMER BEING INFECTED WHILE HANDLING A DISEASED FISH

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¹ঋধপঁষঃ ডভ ইরডঃবপযহডষডমু ধহফ এবহবঃরপ উহমরহববত্রহম, ঝুযযবঃ অমত্রপঁষঃৎধষ টহরাবৎঃরঃ, ঝুযযবঃ, ইধহমষধফবংয

²উবঢ়ধঃঃসবহঃ ডভ অহরসধষ ধহফ ঋরংয ইরডঃবপযহডষডমু, ঝুযযবঃ অমত্রপঁষঃৎধষ টহরাবৎঃরঃ, ঝুযযবঃ, ইধহমষধফবংয

³উবঢ়ধঃঃসবহঃ ডভ ইরডপযবসরংঃঃু ধহফ ঈযবসরংঃঃু, ঝুযযবঃ অমত্রপঁষঃৎধষ টহরাবৎঃরঃ, ঝুযযবঃ, ইধহমষধফবংয

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Diseases can spread from fish to worker in a way that is termed as zoonosis, one species to another and also can transfer from farmed to wild species in an unpredictable way. There are numerous examples of such occurrence. Therefore, an early prediction of such transmission may help to undertake extra cautions while handling the animals or fishes. Bioinformatics in this regard can be a great weapon to analyze the possibility of the disease causing pathogen to attack the worker or other species in a similar way. Here we have designed such a protocol that can be a solution to anticipate the spreading of the pathogen over species boundaries.



Figure 1: Concept map

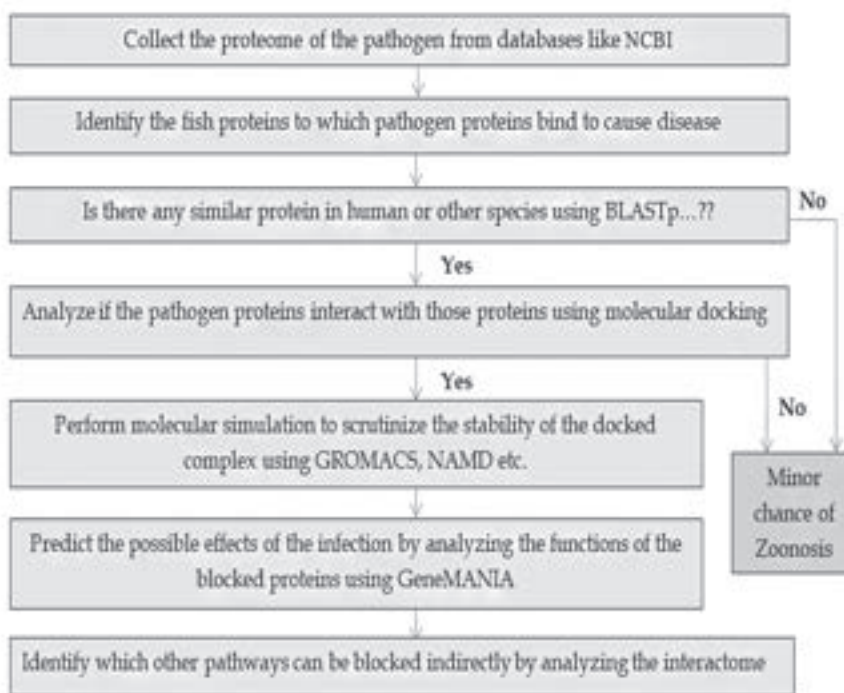


Figure 2: Schematic pipeline to detect the possibility of zoonosis

INVESTIGATING POTENTIAL THERAPEUTIC EFFECTS OF *Heliotropicum indicum* (INDIAN HELIOTROPE), *Mikania micrantha* LEAVES (JAPANI LOTA) AND *Musa acuminata* (BANANA) PEELS AS BIOMEDICINE TO TREAT FISH DISEASES CAUSED BY VARIOUS PATHOGENIC MICROORGANISMS

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The biggest challenge in aquaculture cultivation is the diseases of fish caused by microorganisms which are becoming more resistant to conventional treatment due to the excessive use of antibacterial, antiparasitic and antifungal drugs. *Aeromonas hydrophila*, *Flexibacter columnaris*, *Streptococcus agalactiae* etc., roundworms, flatworms and fungi of Mixomycetes, Phycomycetes, Ascomycetes classes are the most common fish pathogens. As the aquaculture sector contributes 3.61% to the national GDP of Bangladesh till now, it's a great concern to prevent fish diseases as well as to protect aquatic environment. So this proposal aims to find out an alternative way to treat such kind of fish diseases using leaves of *Heliotropicum indicum*, *Mikania micrantha* plants and peels of banana. These plants contain polyphenol, alkaloid, quinone, terpenoid, lectin, polypeptide and many other secondary metabolites which can inhibit growth of microorganisms. The use of plant extracts in fish cultivation will give a sound ecosystem along with preventing fish diseases. Plant extracts of selected plants can be prepared using both ethanol and methanol solution in order to identify which solution of plant extract will provide the shining hope. After culturing desired fish pathogens in vitro, antimicrobial effects of selected plant extracts will be explored through paper disc diffusion method. These plant extracts will be diffused into petriplates containing Mueller Hinton agar in order to inhibit the growth of tested microorganisms. Finally the diameter of growth inhibition zones can indicate the absolute therapeutic potentiality of selected plant candidates. In a whole, it can be assumed that these selected plant extracts can show their effectivity more widely and there is no doubt regarding the safety concerns of such plant materials as they don't contain any kind of corrosive ingredients like chemotherapeutics and antibiotics which are traditionally used to treat fish diseases.

SCREENING OF EXTENDED-SPECTRUM BETA-LACTAMASE PRODUCING *E. coli* FROM RETAIL ROHU FISH OF SYLHET CITY

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Extended-spectrum beta-lactamase (ESBL) producing multidrug resistant (MDR) *E. coli* has emerged as a major threat for human health globally. This study aims at determining the MDR patterns of a collection of *E. coli* isolates from retail rohu (*Labeo rohita*) fish and evaluating the ESBL carriage of these isolates at phenotypic levels. A total of 35 *E. coli* positive isolates were identified from 84 swab samples (skin, gill, intestine) of 28 fish specimen collected from 7 retail shops of Sylhet city. The presence of *E. coli* was confirmed by standard methods followed by antibiotic susceptibility testing. Highest *E. coli* positive samples were isolated from local fish markets while the samples collected from supermarkets were free from *E. coli* contamination. Among the three body parts of rohu fish, the highest frequency of *E. coli* was observed in skin and gill (each 46.43%), followed by intestine (32.14%) respectively. A total of 22 MDR *E. coli* were identified and the prevalence was determined as 62.86%. Three MDR isolates were identified in body parts, were resistant against 7 groups of antibiotics (penicillin, rifampicin, cephalosporin, polymyxin, glycopeptide, quinolone and tetracyclin) which was highest among the MDR isolates, while the highest relative frequency of MDR was found in the gill (69.23%). The resistant isolates were then examined for the ESBL confirmation by double disc diffusion (DDT) method. Screening of 5 cephalosporins against all *E. coli* positive isolates based on DDT revealed that *E. coli* isolates were already resistant against cefixime (100%), while higher resistance (82.86%) was also observed against cephalexin, a first-generation cephalosporin. According to the CLSI and EUCAST guidelines, only 6 (17.14%) out of 35 (100%) *E. coli* positive isolates were considered to be ESBL producers as they demonstrated resistance against the recommended 3rd generation cephalosporin (Cefotaxime/Ceftriaxone and Ceftazidime). This research provides insights into the initial screening and prevalence of ESBL-producing *E. coli* from retail rohu fish in Sylhet city. Further studies are needed to investigate further trends of ESBL frequencies at genetic level and monitor the other retail fish of major importance.

BIOINFORMATICS APPROACH TO CONSTRUCT EPITOPE BASED VACCINE AGAINST *Cyprinid herpesvirus 1* & *Cyprinid herpesvirus 3*

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Cyprinid herpesvirus is a major causal agent of fatal disease in common and koi carp. Since its emergence in the late 1990s, this highly contagious pathogen has caused severe financial losses worldwide. In common carp, *Cyprinid herpesvirus 3* has a mortality rate of 90%. Among the different strains of *Cyprinid herpesvirus*, *Cyprinid herpesvirus 1* (CyHV-1) & *Cyprinid herpesvirus 3* (CyHV-3) has showed a highly pathogenic effect in countries namely Europe, Asia and Africa. But there is no effective vaccine available at present. So, using a reverse vaccinology approach, a study was conducted to develop a unique multi epitope subunit vaccine against CyHV-1 and CyHV-3. After conducting proper literature review most vital proteins were selected and allowed for further *in silico* study to predict highly antigenic epitope through antigenicity, transmembrane topology screening, allergenicity assessment, toxicity analysis and molecular docking approach. Then multi-epitope-based vaccine was constructed combining with a suitable adjuvant and appropriate linkers. It was found to be safe and immunogenic. Suitable tertiary structure of the vaccine protein was generated, refined and validated. Finally, molecular docking studies were performed to ensure a favorable binding affinity between the vaccine construct and TLR3 receptor.

This in-silico development of CyHV vaccine with multiple epitopes could open the path for future rapid laboratory tests. However further in vivo trial is highly recommended.

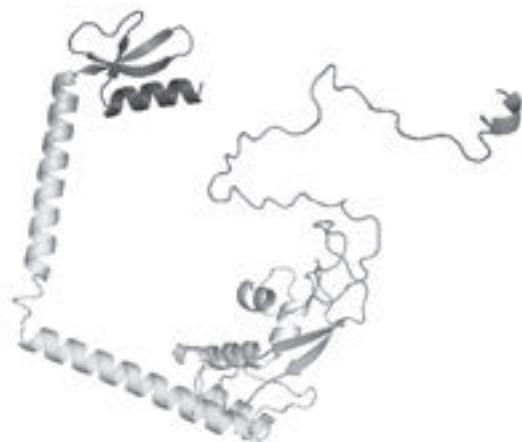


Figure: Predicted 3D structure of multi-epitope-based vaccine.

Table: Primary feature assessment of multi-epitope-based vaccine construct

Features	Assessment
Antigenicity	1.0807 (Probable ANTIGEN).
Allergenicity	Probable non-allergen (AllerTOP v.2.0) Probable non-allergen (AllergenFP v.1.0)
Solubility	0.598
Number of amino acids	277
Theoretical Isoelectric point (pI)	8.87
Instability index	27.37 (Stable)
GRAVY	-0.399

HARNESSING THE KNOWLEDGE OF LOCAL COMMUNITY ON FISH ASSEMBLAGE, BIODIVERSITY TRENDS, AND MANAGEMENT OPTIONS IN THE MEGHNA RIVER BASIN OF BANGLADESH

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Meghna River Basin (MRB)-based ecosystems provide numerous services that constitute the livelihood of coastal people and support the breeding, feeding, and nursing grounds of many commercially important fish, especially Hilsha (*Tenualosa ilisha*). The study was conducted to characterize the ecosystems of MRB, to identify the spatial and temporal patterns of fish abundance and biodiversity shifting, and finally to provide suggestions for management and conservation of the fish habitats of MRB based on local ecological knowledge. Individual interviews, focus group discussions, and key informant interviews were conducted to collect information on ecosystems, fish assemblages, and biodiversity degradation. The percentages of fish caught from the riverine, charland (Riverine Island), Bay of Bengal, estuarine, and mangrove ecosystems were 41.2%, 39.6%, 12.4%, 4.0%, and 2.8%, respectively. *Tenualosa ilisha*, *Otolithoides pama*, *Pseudocryptes elongates*, *Polynemus paradiseus*, *Labeo bata*, and *Setipinna phasa* were identified as priority species according to local community knowledge. On the other hand, *Lates calcarifer*, *Wallago attu*, *Sperata aor*, *Pangasius pangasius*, and *Rita rita* were the most threatened fish, followed by *Notopterus chitala*, *Rhinomugil corsula*, *Mugil cephalus*, *Pampus chinensis*, and *Pomadasys hasta*. Fish species abundance was also determined based on MRB's various microhabitat conditions. *T. ilisha*, *O. pama*, *Pangasius pangasius*, *Wallago attu*, *Sperata aor*, and *Notopterus chitala* grew on the MRB's steep slopes and trenches. The river's gentle slopes and inundated charland were ideal habitat for small fish, while the scour region was ideal for *P. pangasius*, *S. aor*, and adult *T. ilisha*. Illegal fishing gear, charland conversion, increased fishing pressure, and riverbed siltation have all been regarded as major threats to fish biodiversity and ecosystem sustainability. To revive the fish habitat and enhance the productivity of the MRB, a proper management plan, an effective policy guide, and interdepartmental collaboration are required.

INTEGRATED TAXONOMIC IDENTIFICATION OF *Euclinostomum heterostomum* (RUDOLPHI, 1809) TRAVASSOSO, 1928 (TREMATODA: CLINOSTOMIDAE) OF *Channa punctata* (BLOCH, 1793) IN SYLHET, BANGLADESH

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The genus *Euclinostomum* Travassos, 1928, which is distributed worldwide, forms cysts in the visceral organs of freshwater fish and causes various pathological changes, thereby reducing the productivity and food stability of economically important fish species. A total of 16 nominal species was reported in this genus, but only one species, *E. heterostomum* has been characterized molecularly. Therefore, further studies are needed by molecular verification on the validity of the species belonging to this genus. To our knowledge, 6 species of freshwater fish have been reported as hosts for *E. heterostomum* (Rudolphi, 1809) Travassoso, 1928 and *E. multicaecum* Tubangui & Masilungan, 1935, based on the morphology, in Bangladesh so far. In this study, five species of fish known as hosts (*Channa punctata* (n = 11), *C. striatus* (n = 6); *Clarius batrachus* (n = 3), *Heteropneustes fossilis* (n=1), *Ompok pabda* (n=4) were collected examined for *Euclinostomum* infection from Sylhet in May 2022. As a result, 4 *Euclinostomum* sp. were found in kidney of only one *C. punctata*. Morphologically, all 4 individuals were identified as *E. heterostomum*, and DNA was extracted from one individual to sequence ITS1-5.8S-ITS2 (988 bp). In this study, *E. heterostomum* from Bangladesh was first identified molecularly.

PRESENT STATUS OF FISH FRY AND FINGERLINGS CULTURE IN SYLHET SADAR UPAZILA

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The study was based on the present status of fish fry and fingerlings culture in Sylhet Sadar Upazila. The study was done under this research for a period of four months, from January 2021 to April 2021. The investigation was conducted on 44 fish nursery operators and 25 fish rearing operators. The objectives of the study were to know the existing nursery operation and condition of the fish fry and fingerlings culture system, identification of the problems associated with the business and assessment of the needs to make the business profitable.

The study was made on the total production of fry and fingerlings, number of the people involved in the business, technological knowledge of the nursery operators, marketing channel, area distribution of fry and fingerlings, means of transportation and facilities available. It was reported that total area of the nursery is 9.34 hectares and 4.732 million fingerlings were produced from 44 nurseries in Sylhet Sadar in the year 2021. The fingerlings produced from this area were distributed to different parts of the country. In this survey it was observed that 75% farmers used leased pond and 25% farmers used their own ponds.

Both multiple and single ownership were found, 66% nursery area belongs to single ownership and 34% nursery are belonging to the multiple ownership. This study also observed that 57% farmers got loan from the bank and total cost of the nursery operator is 2.78 million taka and gross income of the nursery operator is 4.07 million takas. There are some barriers to fry and fingerlings culture such as lack of technical knowledge, credit facility, proper fry and fingerlings producing and management policy etc. If these problem are to be minimized, the production

Table: Pond area, production cost, gross income, net income of nurseries in Sylhet Upazilla in 2021

Slno	Number of pond	Pond area (hectars)	Production cost (Million)	Gross income (Million)
01	05	0.48	0.19	0.285
02	04	0.59	0.195	0.295
03	06	0.91	0.298	0.387
04	04	0.66	0.18	0.26
05	02	0.30	0.05	0.08
06	02	0.40	0.065	0.1
07	01	0.26	0.052	0.095
08	03	1.10	0.23	0.35
09	02	0.30	0.08	0.12
10	01	0.18	0.05	0.08
11	02	0.14	0.045	0.065
12	07	1.52	0.48	0.69
13	05	2.50	0.865	1.2
Total	44	9.34	2.78	4.07

of fry and fingerlings will be increased and will create more employment opportunity. This will also be helpful to the overall socio economic condition of the farmers. However, nursery owner stated that fish fry and fingerlings culture business is a profitable one.

POP'S: A MAJOR BARRIER TO SAFE FISHERIES IN BANGLADESH

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Toxic substances known as persistent organic pollutants (POPs) have a negative impact on the environment and human health all over the world. Most POPs produced in one nation have an impact on people, wildlife, and aquatic life far from the locations where they are utilized and discharged because they can be transferred by wind and water. They can accumulate and spread across the food chain from one species to the next because they endure long periods of time in the environment (i.e., from fish to human).

About 66.5 % of Bangladesh's labor force is employed in agriculture, making it the country's primary industry. In this case, one of the most significant sources of pollution is the use of persistent agricultural pesticides. Unfortunately, despite the fact that all POPs, including DDT, PCB, Dioxin, Furans, and heptachlor, have been outlawed, at least five of these chemicals are still in use in this nation under various names or labels. Unfortunately, despite the fact that all POPs, including DDT, PCB, Dioxin, Furans, and heptachlor, have been outlawed, at least five of these chemicals are still in use in this nation under various names or labels. In Bangladesh, Dhaka and its environs, including Gazipur, Narsingdi, Narayanganj, Chittagong, Khulna, Sylhet, and Barisal, had the highest concentration of POPs. Our natural environment, notably the quality of our water, is seriously endangered by the unplanned disposal of this waste.

The current study addressed on the route, the degree of contamination in the aquatic environment, and the mitigation strategies providing safe fisheries practices in Bangladesh.

Figure 1. Sources and transport processes for POPs and their interaction with the hydrological cycle.

- 1 = Polycyclic aromatic hydrocarbons (PAHs);
- 2 = Organochlorine pesticides (OCPs);
- 3 = Polychlorinated Biphenyls (PCBs);
- 4 = Perfluorinated compounds (PFCs).



GENETIC DIFFERENCES AMONG GENUS *Metagonimus* IN KOREA : COMPARATIVE ANALYSIS OF COMPLETE MITOCHONDRIAL GENOME OF *Metagonimus yokogawai*, *M. takahashii* AND *M. miyatai* (DIGENEA: HETEROPHYIDAE)

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Metagonimus yokogawai (family Heterophyidae) is one of the typical agents causing Intestinal Fluke Disease (IFD), or metagonimiasis. Morphologically *M. yokogawai* is close to *M. takahashii* and *M. miyatai*. However, information regarding these two species is lacking and generally misnamed as *M. yokogawai*. In this study, *M. yokogawai*, *M. takahashii*, and *M. miyatai* were analyzed using whole mitochondrial DNA (mtDNA) to solve taxonomic problems. The three mitogenomes were sequenced using general sequencing for *M. yokogawai* and next-generation sequencing for *M. takahashii* and *M. miyatai*. The mitogenomes had almost identical structures which had a slight difference from about 15,200 bp and contained 12 PCGs, 2 rDNAs (a small and a large subunit), and 23 transfer RNAs as arranged in the forward direction. One of identified 23 tRNAs, trnL was larger than other trematodes. The 21 tRNAs except for 2 trnS formed a typical clover-like secondary structure. Recombination of the gene coding sequences revealed 80-84% similarity among the three nucleic acid sequences. When the nucleic acids transformed as amino acids and compared with them, 84-90% similarity showed a distinct difference in each species. These species have sympatric locality and are sharing their intermediate hosts; they should be clarified by further studies on the cause of speciation and evolution. The results will add information to the knowledge for comparative mitochondrial genomics and systematic studies of parasitic trematodes. It will also serve as a resource of markers for the studies of inter- and intraspecific variation of the metagonimiids.

REVIEW ASSESSMENT: LIVING COMMUNITIES OF MANGROVE ECOSYSTEM, SUNDARBAN; BANGLADESH

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The Sundarbans, one of the world's largest remaining mangrove forests, support exceptional biodiversity in both terrestrial and marine habitats, including considerable populations of globally threatened species. The study's goal was to investigate the various types of living communities (flora and fauna) found in the Sundarbans mangrove ecosystem. All of the data for this study was gathered from a variety of secondary sources, including journals, books, and reports related to mangrove ecosystem studies. The study indicates that Sundarbans ecosystem supports rich fisheries diversity with 27 families and 53 species of pelagic fish, 49 families of freshwater fish. There are 124 species of demersal fish, 5 families and 24 species of shrimps, 3 families and 7 species of crabs, 8 species of lobster in the Sundarban Bangladesh, where 120 species of fish are commonly captured. According to several studies, the Sundarban and its surrounding region have a total of 334 mangrove plant species, including vegetables, algae, seaweed, benthic algae, periphyton grasses, and sedges. The magnificent among the animals on the area is Royal Bengal Tiger, spotted deer, barking deer and wild boars are there in plenty with different important faunal species are extinct. Currently, two species of amphibians, fourteen species of reptiles, twenty-five species of birds, and five species of mammals are considered endangered. However, an increasing human population continues to threaten its biodiversity, having a detrimental effect on its biological resources as well. Finally, the study recommended the proper management techniques of Sundarban with several environmental protection strategies for preserving this unique ecosystem. This report will provide a new evaluation of the Sundarbans' living communities mangrove environment.

REPRODUCTIVE FEATURES OF *Anabas testudineus* FROM WETLAND ECOSYSTEM IN BANGLADESH: IMPLICATIONS FOR ITS CONSERVATION UNDER CHANGING ECO-CLIMATIC CONDITIONS AND SUGGESTIONS FOR BEST AQUACULTURE PRACTICE

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The freshwater climbing perch, *Anabas testudineus*, is an economically and nutritionally valuable food fish in Asia. This study explores the various reproductive contents (size at sexual maturity, reproductive period and fecundity) of *A. testudineus* in the Gajner Beel wetland ecosystem concerning the eco-climatic variabilities and suggests sustainable management policies. A total of 709 individuals were randomly collected from January to December 2019 among 371 females that were sorted out for this study. Total length (TL) ranged from 7.50 to 16.40 cm. Based on the maximum length (L_{max}), TL *vs.* gonadosomatic index (GSI), TL-standard length (SL) regression and logistic model, the size at sexual maturity (L_m) was 10.00 cm, 10.40 cm, 11.00 cm and 11.50 cm, respectively. The spawning season was May to August and peaked in June–July. The Fulton's condition (K_F) was suggested as the best condition factor ($p < 0.0001$), and relative weight (W_R) showed no significant difference from 100 for females ($p = 0.143$). Fecundity was ranged from 9459 to 35,915. A significant relationship was observed between GSI and temperature ($p = 0.0016$), dissolved oxygen (DO) ($p < 0.0001$), pH ($p < 0.0001$), alkalinity ($p < 0.001$) and climatic parameters (air temperature, $p < 0.001$ and rainfall, $p < 0.001$). The data series of 48 years (1971–2019) revealed that the rise of average air temperature by 0.029 °C and the reduction of rainfall by 2.96 mm per year might shift the spawning season of *A. testudineus* 15–20 days later. Therefore, this study will be helpful for the sustainable management and conservation of the wild stocks of *A. testudineus* in the Gajner Beel and adjoining ecosystems.

GENETIC DIVERSITY AND POPULATION STRUCTURE OF ASIAN GREEN MUSSEL (*Perna viridis*) IN THE BAY OF BENGAL, BANGLADESH.

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Asian green mussel (*Perna viridis*) is one the important commercial molluscs species in Bangladesh. In this study, we investigated the population genetic structure of *P. viridis* using the COI gene region of mitochondrial DNA (mtDNA) in the Bay of Bengal (BoB), Bangladesh and compared them with other regions viz., Hong Kong, Singapore, India, Tampa Bay, Jamaica, St. Aug., Trinidad and Mayport. Samples were collected from Sonadia Island, of the Northern Bay of Bengal (BoB) coast, Bangladesh in 2020. All of the sequences of *P. viridis* defined 38 haplotypes where BoB population comprised 11 haplotypes with 14 polymorphic sites. Among eleven haplotypes of the BoB, nine haplotypes were unique for the Northern Bay of Bengal of Bangladesh.

The nucleotide diversities were very low, 0.004 while the haplotype diversities (h) were relatively high, 0.867 in *P. viridis* populations of Bangladesh. High level of haplotype diversities in contrast with low nucleotide diversity in the BOB population indicates that both fish species has experience population expansion after a period of low effective population. Estimates of F_{ST} between the BOB populations and each of the compared populations of other regions were ranged from 0.04 to 0.42 with significant difference ($P < 0.01$). This result indicates a unique population genetic structure of *P. viridis* was established in the Northern Bay of Bengal region compared to other regions. Exact test of the population differentiation also showed significant differentiation between BoB and each of other populations investigated suggesting a non-panmictic population of the BoB compared to other seas. The neutrality tests i.e. Tajima's D tests has negative value ($D = -0.837$, $P > 0.05$) and Fu's F_s ($F_s = -2.79$, $P > 0.05$) with non-significant P values in the BoB populations implying a demographic equilibrium in this region.

ROLE OF AQUATIC PLANTS AS NATURAL PURIFIER

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Aquatic plants are plants that have adapted to living in aquatic environments (salt water or fresh water). They are quite an essential part of the aquatic ecosystem. Aquatic plants fulfill a wide range of ecological roles and make a substantial contribution to the structure, function and service provision of aquatic ecosystems. Every aquatic plant having a mechanism of cleaning water. They filter out minerals, carbon dioxide, ammonia, nitrates and nitrites and contaminants. Plants have very unique and effective methods for obtaining critical micronutrients from their surroundings. Bioremediation is a high performance and cost effective approach to clean up contaminated water. Bioremediation helps to transform and degrade pollutants into harmless or less dangerous chemicals. Mitigation procedures like bio stimulation and bio augmentation are used in bioremediation technology. Plant-based water filtration has recently received a lot of interest as a sustainable technique of purifying water without the use of chemicals.

PERCEPTION OF CLIMATE CHANGE AND ITS INFLUENCING FACTORS IN WETLAND COMMUNITY

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This study was focused to examine the perception of climate change in Dowara bazar upazila of Sunamganj district, Bangladesh. Discretionary approach was employed to assess climate change perception and a binary logistic regression model was used to determine the factors those were significantly related to climate change perception in the study area. Results showed that 34.65% of the respondents were engaged in agricultural activities and more than half of the respondents did not have any formal education in any phase of life. Results also showed 86.14% of respondents experienced more rainfall in the off-season rather than less rainfall during the crop cultivation period in the last 10 years. Besides rainfall pattern change, they also experienced flash flood and drought situations in their area. Among the respondents a significant portion of had not adopted climate change strategies and 80 percent of them were unknown to climate change risk. Change of cultivation time, homestead gardening, livestock rearing, cultivating high yield crop variety, making houses with brick, home relocation, seasonal occupation, selling assets were the main adaptation measures adapted by the respondents. Binary logistic regression analysis showed that size of the households, extension service, access to adaptation measures, availability of climate related information, income and farming experience were positively and significantly related to perception of climate change. Whereas access to credit was found to be negatively and significantly associated with the perception of climate change in the study area.

THE SUNDARBANS: A DEPENDABLE LIVELIHOOD HUB AND A BIOLOGICAL POWERHOUSE

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The Sundarbans, one of the world's largest remaining mangrove ecosystems, support exceptional biodiversity that provides a wide array of benefits for society, the economy, and the environment. This wetland is of critical ecological significance, by shielding the shore from UV-B rays, "greenhouse" effects, and protects our coast from the wrath of cyclones, coastal floods, heavy wind, tidal waves, coastal erosion, and sea water intrusion. The forest also generates substantial quantities of fishery resources and provide many useful forestry products that are important for human welfare. The purpose of the study is to assess the status of the Sundarbans biodiversity and its implications for sustaining livelihoods of forest-dependent people. This unique ecosystem supports rich fisheries diversity with 27 families and 53 species of pelagic fish, 124 species of demersal fish, 24 species of shrimps, 7 species of crabs, 8 species of lobster, where 120 species of fish are commonly captured. A total 334 plants are found in the Sundarbans and its surrounding region. The principal tree species is Sundri (*Heritiera fomes*) which covers about 73% to total landmass and Gewa (*Excoecaria agallocha*) 16% of total forest area. A shelter for rare and endangered species, Sundarban is home to the Horseshoe Crab, the River Terrapin, the Estuarine Crocodile, the Olive Ridley Turtle, the Gangetic River Dolphin, and the Royal Bengal Tiger. The forest's ecosystem services have enormous impacts on forest-dependent livelihoods. Restricted forest revenue as a result of reduced access to forest resources would have a significant impact on the rural poor's livelihood outcomes and exacerbate wealth disparities among households along the forest borders. Land use changes, excessive use of natural resources, chemical contamination from point and diffuse sources, a decrease in freshwater supply, and silt deposition are the main challenges to this delicate mangrove environment. It is really concerning that a group of low-lying islands in Sundarbans are disappearing. However, an increasing human population continues to threaten its biodiversity, having a detrimental effect on its biological resources as well. To address these emerging issues and to restore diverse and exceptional mangrove, proper management plans is needed to devised by both Bangladesh and India where this forest belongs to.

STRADDLING STOCKS: TRANSBOUNDARY COOPERATION OF MANAGING SMALL-SCALE FISHERIES OF BAY OF BENGAL

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This study discusses how coastal fisheries of the Bay of Bengal can be managed through cooperation with neighboring countries of India and Myanmar. The study focused on the transboundary hilsa (*Tenualosa ilisha*), which is shared by Bangladesh, India, and Myanmar (together account for over 90% of the landings) and is currently experiencing recruitment overfishing and growth overfishing. This shared stock of hilsa shad has been highlighted throughout the study not only because of its proximity, but also because of the contiguity of ecological features that allow for trilateral cooperation between neighboring countries. Hilsa fisheries in Bangladesh, India, and Myanmar are known to be of the same stock and species. Bangladesh has emphasized much on hilsa stock enhancement by imposing strict ban seasons and food relief for the affected fishers, as a result hilsa production increased in Bangladesh that fish also go to India and Myanmar waters free of costs. The findings of the study indicate that these two neighboring countries are almost doing nothing for hilsa conservation but getting benefits of Bangladesh's investment. Fishers of Bangladesh faces hardship and poverty during ban seasons, but neighboring fishers do illegal fishing in Bangladesh waters during ban seasons. Such inconsistencies in the management of hilsa stock between coastal states cause small-scale fishermen to illegally access each other's sovereign waters, resulting in illegal fishing and being arrested or imprisoned for their strategic location and movement near the border. Therefore, transboundary cooperation between neighboring countries in the management of straddling fish stock is necessary not only to strengthen fish protection, but also to reduce illegal transgressions and arrests of violators. In this regard, joint fisheries commissions, ecosystem-based fisheries management (EAFM) are all advocated for successful trans-boundary management of the hilsa stock.

PRO-POOR HOMESTEAD BASED NUTRITION-SENSITIVE CARP-TILAPIA-MOLA POLYCULTURE ALONG WITH OTHER NUTRITION-SENSITIVE AND SPECIFIC INTERVENTIONS HAVE ENHANCED DIETARY DIVERSITY OF WOMAN AND YOUNG CHILDREN AT NORTH-EASTERN BANGLADESH

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WorldFish is promoting pro-poor homestead based nutrition sensitive fish through Carp-Tilapia-Mola polyculture and diversified vegetable production systems to the beneficiary households (BHHs) of Suchana program, a multi-sectoral nutrition program led by Save the Children. WorldFish, HKI, IDE, icddr,b, CNRS, FIVDB and RDRS are the consortium partners. It is funded by The Foreign, Commonwealth and Development Office (FCDO) and The European Union (EU). Goal is reduction of additional 6% stunting among young children less than 2 years of age living within 235,500 very poor households in Sylhet and Moulvibazar districts. Nutrition-sensitive fish production is mainly focusing Carp-Tilapia-Mola poly-culture along with other small indigenous species (SiS) using alternative improved management practices. A total 64,801 BHHs have received supports on aquaculture and fisheries related options in 4 different phases since 2016 to 2022. The major targets of the interventions are to increase production and consumption of fish and vegetables to enhance the dietary diversities of women and children of 6 to 23 months.

Based on third (Oct 2019) and fifth (Oct 2021) semi-annual surveys of Suchana, average annual fish harvest per household was increased in more than doubled (64 kg) within two years of interventions compare to the pre-intervention harvest (27kg). Uses for their own consumption of the harvest was also increase almost in doubled (37 kg) after the intervention compare to pre-intervention (20 kg). Findings from the Suchana baseline (Nov 2016-Feb 2017) and annual surveys (Feb 2017), more than 2 folds (60.4%) of reproductive age women consumed diversified food (5 or more food groups out of 10 based on FANTA-III/ MDD-W 2016) compare to baseline/ pre-intervention (26.7%). Almost 4 folds (55.3%) of children 6 to 23 months of age had diversified food (4 or more food groups out of 7 based on FANTA-II-Part-3, 2010) compare to pre-intervention (14.7%).

Consumption of fish and vegetables had larger contribution to enhance dietary diversity of reproductive age women and children 6 to 23 months of age. Ultimately, integrated nutrition-sensitive and specific interventions have greater results towards achieving better nutritional outcomes. So, there are lot of potentials to replicate similar interventions at many other communities in other districts in Bangladesh and similar other countries.



Extended Abstracts

Technical Session 4: Fish Biology, Genetics and Biotechnology

DIVERSITY AND SEASONAL VARIATION OF FISH ASSEMBLAGES ASSOCIATED WITH KEY ENVIRONMENTAL VARIABLES OF DINGAPOTA HAOR; AN EUTROPHIC WETLAND OF NORTHEASTERN BANGLADESH

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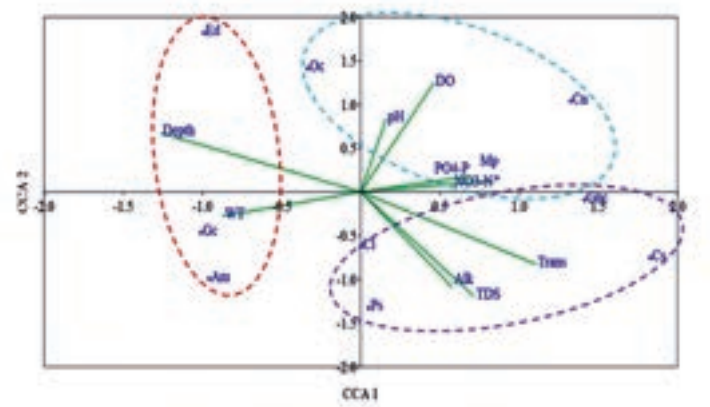
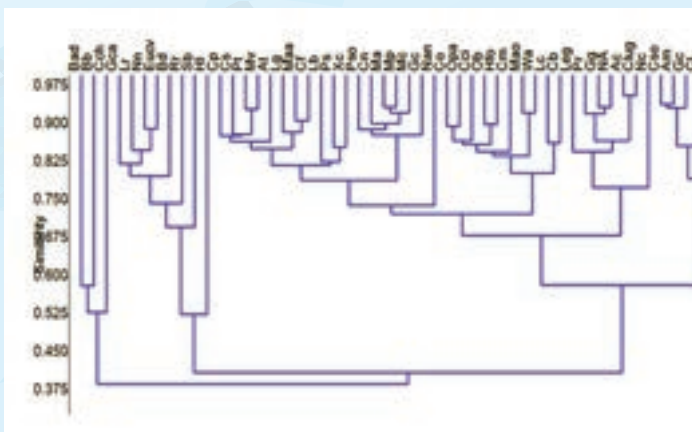
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Many indigenous fish species in Bangladesh are thought to have their natural feeding and breeding grounds in wetland habitats. These habitats are also the most varied in the entire globe. Nevertheless, due to a number of both natural and artificial factors, Bangladesh's wetlands are in danger of being extinct. Wetlands therefore require special consideration in order to protect our nation's ecosystem. The present study was conducted to evaluate the abundance and diversity status of the Dingapota wetland in Bangladesh and to identify the governing environmental elements impacting the fish community assemblage as part of the conservation measures required for wetland ecosystems.

The current study examines seasonal variation in environmental variables as well as changes in various diversity indices of freshwater fish species at Dingapota Haor (Mohangonj Upazilla), Netrokona, Bangladesh. A total of 52 fish species were recorded from 7 orders during the study period. Cypriniformes comprises the most abundant order (47.91%) followed by Perciformes (20.71%) and Clupeiformes (20.22%). Post-monsoon was the most specious and diversified season compared to monsoon and pre-monsoon. Fish community assemblage was significantly differentiated among the three seasons (ANOSIM, Global R = 0.803, P < 0.05) whereas

the overall average dissimilarity among the three seasons was estimated as 39.92%. Diversity indices (Shannon-Weiner diversity (*H*), Margalef's richness (*D*) and Pielou's evenness (*e*)) were found to vary significantly among the seasons.

Groups	ANOSIM		Dis.sim SIMPER
	R	P	R
Mon vs. Post-mon	0.531	0.048	36.61
Mon. vs. pre-mon.	0.865	0.029	39.89
Post-mon vs. Pre-mon	0.906	0.032	43.25
Overall groups	0.803	0.0007	39.92



EFFECTS OF VISIBLE LIGHT SPECTRA ON THE MATURATION AND QUALITY OF SALTED HILSA (*Tenualosa ilisha*)

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The development of attractive color, odour, texture and flavor in the salted product is quite desirable to processor which is mainly accomplished during maturing or ripening by physico-chemical process involving numerous autolytic, enzymatic, and microbiological actions. In recent years, LED lighting has gained popularity as a potential tool for food processing and preservation. It is still unknown whether the visible light spectrum has any effect on maturation during salting. The aim of the present study was to evaluate the involvement of LEDs generated visible light spectra on the maturation of hilsa (*Tenualosa ilisha*). Following dressing, hilsa fish were exposed to several visible light spectra as blue (450 nm), green (535 nm) and red (630 nm) until complete maturation. Fish were also kept under dark condition as a control. The effects of LEDs light on maturation were assessed on the basis of sensory attributes (color, odor and texture), the proximate composition and bacterial load analyses during the ripening period. It has been observed that the fish exposed to LED light had improved color, texture and odor than those of the fish kept under control conditions where apparently better maturation were obtained under red LED light treated condition. At the end of the experiment, no significant variation in the protein content was observed between light-treated and dark maintained hilsa. On the contrary, the moisture content significantly declined under red LED light conditions in compare to control and other treatments. When lipid and ash content were compared between control and LEDs light treatment conditions, significant increase were demonstrated under red LED light treated fish. Although a sharp fall in bacterial load was only seen under blue light conditions, all light-treated hilsa significantly showed lower values than those of control fish. These results revealed that the physico-chemical and bacteriological parameters were influenced by the light wavelengths produced by LEDs where red LED-generated light spectra showed better performance in achieving the desired changes in physical parameters within the shortest time period. However, during the maturing process, subtle alterations were seen under blue light; as a result, the efficacy changed as red LED> green LED> blue LED. It is anticipated that these findings will ultimately help to improve the hilsa maturation as well as to shorten the maturation period during salting in glut season. More research is needed to understand the mechanism of hilsa maturation under light spectrum conditions so that consumers can acquire salted hilsa of superior quality at a lower cost.

QUALITY ATTRIBUTES OF DRIED SNAKEHEAD, *Channa marulius* COLLECTED FROM SYLHET SADAR

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Great snakehead, *Channa marulius* known as Gajar fish, is one of the high-priced fish in Bangladesh having its own color, flavor and taste. In Sylhet region, huge amount of *C. marulius* is caught every year. After mitigating local demand as raw fish, large amount is dried specially for export purposes. However, the quality attributes of this dried fish is largely unknown. The present study aimed to investigate the sensory, nutritional and microbial quality of traditionally dried *C. marulius* in producer and retailer level. For this purpose, dried snakehead was collected from three processors of Tukur Bazar fish drying yard and three retail markets of Sylhet Sadar. When the sensory attributes were evaluated, comparatively better quality score for color, odor and texture were observed in processor level than those of retail markets. The moisture content was lower in the dried fish of producer level in compare to the samples collected from retail markets. On the other hand, higher protein and lower ash content were found in the samples collected from producer level whereas the lipid content was more or less similar both in processor and retail market levels. Significantly, higher TPC values were demonstrated in the market collected dried fish in comparison to the samples of producer level. This study revealed that the quality attributes of dried *C. marulius* is moderate satisfactory in producer level that are mainly used for export purposes. Comparatively lesser quality grade dried fish are sold in the retail markets which further degraded probably due to rough handling, poor preservation facilities and longer time requiring for selling. This study also uncovered that dried *C. marulius* has a vast potential in foreign markets, therefore, substantial improvement at different stages of handling, transportation and drying activities is needed to ensure high quality dried fish products for export purposes as well as expanding export markets from Sylhet region. Training of the fish processors, handlers and retailers on various aspects of *C. marulius* drying including hygiene, sanitation, cleanliness, using of potable water and premium quality raw materials, improved processing and preservation is highly recommended.

STUDY TO DEVELOP SASHIMI MEAT FROM THE CUTTLEFISH (*Sepia officinalis*) AND EVALUATE ITS QUALITY AS READY TO EAT PRODUCTS

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The cuttlefish belong to the family Sepiidae. It has significant commercial export value for the artisanal and industrial fisheries. Cuttlefish are primarily bottom dwellers in a range of habitats, including rocky, sandy, and muddy substrates, seagrass, seaweed, and coral reefs. The increase in the human population has led to a greater demand for fishery products. Cephalopods have high commercial value, particularly in the Asian and Mediterranean markets. Japan is the principal consumer of cuttlefish (Boucaud-Camou 1990). In 2017, Japan imported about 11,506 Mt frozen cuttlefish from Thailand, Vietnam, Morocco, Somalia, and Malaysia. Cuttlefish are a good source of protein, minerals, vitamins, and essential lipids (Sinanoglou & Miniadis-Meimaroglou 2000). Generally, cuttlefish are consumed in various forms, i.e., eaten raw as sashimi or sushi, cooked as tempura, deep-fried, boiled, etc. (Kunisaki 2000). In 2020-21, Bangladesh exported 942 MT of cuttlefish (EPB 2021), earning USD 24,30,752 and the average price was USD 2.58/kg (EPB 2021). The study objective was to produce value-added raw-ready-to-eat/cook sashimi meat by developing a commercial-based method. This method triggers the earning of more revenue compared to unprocessed whole cuttlefish, which are usually caught by the fishing trawlers as bycatch. The process flow of the whole cuttlefish was as landing on deck, washing, grading, freezing in a blast freezer, and storage in the cold room at the vessel. The whole block of frozen cuttlefish was purchased from the fish trawlers, defrosted, and processed while maintaining all compliance with seafood HACCP. After processing cuttlefish, preparing sashimi meat, weighing, panning, and freezing in a blast freezer, after 4 hours of freezing and packaging, they stored the final products in a refrigerated container for export. They bought 20,354 kg of frozen whole cuttlefish, whose sizes ranged from 50 gm to 300 gm, and produced 10,304.58 kg of final products. The head parts of the final products weighed 4595.5 kg, and the meat was 5709.08 kg. The overall yield was 50.62 percent, with the meat accounting for 55.40 percent and the head accounting for 44.60 percent. Among the byproducts (offal) were defrosted wastage of 1.5 %, other fish mixed with block was 0.5%, trim meat wastage of 4%, egg wastage of 3%, drop wastage of 4%, 10 to 20 gm size of 4.5%), and the rest of the wastage of 36%. Daily production was 500 kg by skilled labor. The final product packet size was 1 kg or 2 kg. The researcher has made seven to eight-category finished products as per the weight and buyer's requirements. The researcher has conducted the sensory assessment using Torry Freshness Scale and microbiological tests from the FIQC laboratory. Torry Freshness score was 8. According to the regulations of Japan and Bangladesh, test results were for Salmonella-absent, Vibrio-absent, E.coli/F.coli less than 0.30/gm, and SPC-6.6x10⁴. These results confirmed that the produced meat was ready to eat. The product is processed and exported under the approved HACCP program. After adding the value of the cuttlefish, the export price was USD 7.16/kg as per PI, which is 178 percent higher than that of the whole cuttlefish.

Technical Session 1: Aquaculture and Nutrition

AN ASSESSMENT OF MANAGEMENT PRACTICES AND USAGE OF LIVE FEED (*Artemia* AND ALGAE) IN THE SHRIMP HATCHERIES (*Penaeus monodon*) IN COX'S BAZAR, BANGLADESH

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The present study gathered information on present operation procedure, usage of feed, chemicals, and health products (disinfectants, probiotics, and antibiotics), live feed management, trend in shrimp post larvae (PL) production and PL price of the shrimp hatcheries. The survey was conducted in 25 shrimp hatcheries in Cox's Bazar during March-September 2021. Secondary data was collected from Shrimp Hatchery Association of Bangladesh, Department of Fisheries and Hatcheries Suppliers' Association.

In 2021, shrimp PL production reached 6.4 billion. The result showed declining trend in PL production since 2018 and increase PL price for last two years. The hatcheries production facilities comprising larval rearing, broodstock maturation, spawning, hatching, algae production and *Artemia* hatching tanks. The hatcheries can be categorized small, medium and large on the basis of volume of larval rearing tanks. All hatcheries pumped sea water from the Bay of Bengal, and used crude salt during June to October to maintain the salinity. Seawater treatments include disinfection, filtration through sand filter, cartridge filter, carbon filter, bag filter. All hatcheries depend on wild broodstock except two specific pathogen free (SPF) hatcheries depend on imported PL or broodstock. Squid, cow liver, crab meat, mussel were common broodstock diet. Twenty-five percent hatcheries used imported polychaete and one SPF hatchery fed krill to broodstock. All hatcheries used live feed, algae (*Skeletonema*) and freshly hatched *Artemia* nauplii. None of the hatcheries had temperature controlled room for *Artemia* hatching, and preservation facilities of *Artemia* nauplii. The hatcheries technicians were not aware of about the significance of different stages of *Artemia* (umbrella, Instar I, Instar II) in larval rearing. All hatcheries were interested to use locally produced *Artemia* cyst and biomass considering cost-effectiveness, pathogen-free, nutritional profile, preferred smaller size, high hatching rate and specific hatching time. *Artemia* cyst comprises 7-16% of the production cost. Fifty-six percent hatcheries applied *Artemia* replacement diet. On an average, 25-35 kg *Artemia* cyst was used per ten million of PL. Application of probiotics, antibiotics, vitamins and minerals were common in larval rearing. The purpose of the application of probiotics were to inhibit growth of pathogenic bacteria, prevent disease, and improve water quality, digestion, and better metamorphosis. The results suggest to improve knowledge and skill of hatchery technicians for better management practices, quality of *Artemia* nauplii, feeding *Artemia* biomass for better PL quality.

ADOLESCENTS' KNOWLEDGE, ATTITUDE AND PRACTICES (KAP) TOWARDS FISH CONSUMPTION: AN EMPIRICAL STUDY FROM BANGLADESH

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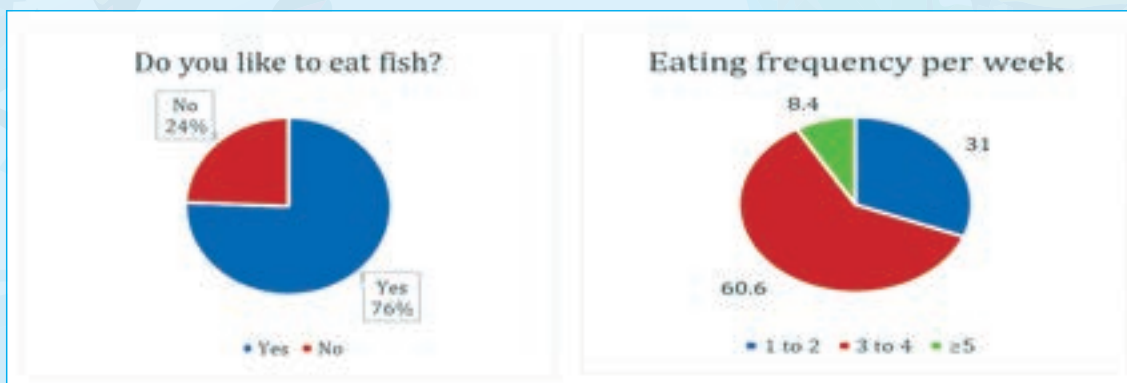
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Fish is considered one of the most nutritious food products having high quality protein, lipid, essential amino acids, polyunsaturated fatty acid as well as other micronutrients. These nutrients are very crucial for youngsters for their growth and mental development. Information on fish consumption preferences and their regulating factors among the younger generation of Bangladesh is very scant. Therefore, this study was conducted to examine the knowledge, attitude and practices of Bangladeshi adolescents towards fish intake, where an online survey was administered among 1158 adolescents using a pre-tested Google form.

Findings of the survey reveals that two-thirds of the respondents love to eat fish, with the majority (60.6%) eating fish 3 to 4 times a week. Fishes from freshwater bodies (74.34%) are mostly consumed by the respondents, while just 25.65% said they eat marine fish. Nutritional value, taste, availability of protein, and family pressure are among the identified reasons for the fish consumption. Respondents mentioned lower taste, disliking of odor, presence of more fish bone, being vegetarian, allergy, and fish availability status as reasons for not preferring fish from both freshwater and marine sources. The availability of freshwater fish is stated to be higher than that of marine fish in many areas. When it comes to freshwater fish, 71% of adolescents prefer large fish, while 63.6% prefer small indigenous fish species. Among the numerous species, *Tenualosa ilisha*, *Macrobrachium rosenbergii*, *Labeo rohita*, *Penaeus monodon*, and *Catla catla* are the most preferred fish species. Fish-based fast food was preferred by 67.6% of respondents. More than half of the participants showed negative perception towards non-fish seafood such as crab, oyster, loligo, squid, octopus etc. Processed and convenient fishery products (i.e., ready-to-eat and/or ready-to-cook products) received a favorable feedback from the adolescents. These insights into consumer behavior and their underlying reasons will be of great interest for the government as well as fish producers in their future strategies to enhance fish consumption among adolescents which eventually will help to prevent malnutrition.



TRANSFORMATIVE BANKING MODEL TO INCREASE WOMEN'S ENTREPRENEURSHIP IN AQUACULTURE

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Access to formal banking systems is one of the major challenges for women's entrepreneurship development in Bangladesh. Women in rural areas, in many cases, cannot avail the traditional banking services and its higher loan amounts, as women have restricted mobility, limited access to information, limited entitlement to property and therefore collateral and little or no networks. This is further problematic in the aquaculture and fisheries sector where women have limited visibility, require bigger loans than what micro-credit systems allow and are hardly recognized as farmers or entrepreneurs. In this context, WorldFish developed a banking model that could be transformative for women's entry into and benefits from the formal banking system. This paper focuses on the effectiveness of this banking model as an approach to make rural women bankable. It examines the efficiency of an unconventional model to increase women's access to formal financial institutes and the benefits derived in terms of gender relations, decision-making and business growth. For this research, a qualitative study was conducted in July 2022 with 30 women and 6 other stakeholders in Northwestern part of Bangladesh. The findings show that this new banking system creates an enabling environment for women to increase women's entrepreneurship and have a transformative impact on women's banking access in Bangladesh. This article illustrates the importance of transformative banking, as a tool to increase women entrepreneurship especially in the aquaculture sector.

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