Aquaculture and Fisheries for Achieving SDGs

BOOK OF ABSTRACTS

8th Biennial Fisheries Conference & Research Fair 2019

30-31 March

BFRF Bangladesh Fisheries Research Forum

Bangladesh Fisheries Research Forum (BFRF)

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Bangladesh Agricultural Research Council (BARC)
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Book of Abstracts

Aquaculture & Fisheries for Achieving SDGs

Fisheries Biology, Genetics & Biotechnology
Aquatic Resources
Aquaculture & Mechanization
Nutrition & Aquatic Health Management
Marine Biology & Oceanography
Post-Harvest Processing & Value Addition
Gender in Aquaculture & Fisheries
Socio-economics & Policy Issues

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Editorial Board

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Foreword

In the quest of deploying all possible means for further increment of fisheries production in the country, we have found ample opportunities to avail and measures to adopt. Both fisheries and aquaculture have got new dimensions in the country due to achieving self-sufficiency in fish production. By 2050, on the other hand, the country needs to feed extra 80 m people. So, present fish production needs to be increased 2 folds. It will not be difficult if we plan adequately and execute effectively, considering utilization of all possible resources and means in useful manners.

BFRF has been able to maintain a functional bridge between the researchers, policy makers and private sectors because of various stakeholders' participations and interactions in its activities. Biennial conference and research fair organized by the BFRF is the only national conference in the country that platforms all stakeholders of fisheries and gather them in a large table. In this 8th Biennial conference, out of 200 abstracts submitted, about 70 have been selected for oral and 50 other for poster presentations. Best oral and poster presentations will be awarded. In addition to that, BFRF has launched best scientist of the year award in fisheries from this year, evaluated based on publication performance in the highest impact factor journals given by Thomson Royter. BFRF also introduced lifetime achievement award in international category for outstanding contribution in the development of fisheries in Bangladesh. We are also planning to award best fisheries students of different universities. All these have been done for encouraging the existing and future scientists to make them able to play functional roles in the development of fisheries of the country.

In our modest journey of doing all positive ventures, we sought and received enormous supports from our well-wishers, partners, private sectors, policy makers, donors and NGOs, which are gratefully acknowledged. I am thankful to our EC members for their untiring assistance in making this two-day event a gorgeous one. Organizing a scientific event is not an easy task if you have very limited resource. This scarcity was replenished by the heart-full support of the EC members, friends and well-wishers. I bow head to those who have raised the head of BFRF up. Finally, our guests, presenters and participants are our blood circulatory system, who have kept all organs alive, made the conference lively and created the take-away message meaningful. My sincere gratitude to all of them.

Dr. A K M Nowsad Alam
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Keynote Paper

DEVELOPMENT PRIORITIES AND STRENGTHENING OF R&D LINKAGE FOR SUSTAINABLE AQUACULTURE DEVELOPMENT

Dilip Kumar[1]

The inter-relationships between poverty and nutrition are well known. Poverty restricts access to adequate quantity and quality of food required to meet daily requirements thus leading to malnutrition. On the other hand malnutrition can adversely affect physical and mental including educational capacity leading to decline in efficiency and economic attainments, thus perpetuating poverty. Eradicating poverty and hunger are integrally linked to boosting food production, agricultural productivity and rural income. The protein, lipids and other nutrient content of fish as food, the role of fisheries and aquaculture activities as a source of income and livelihoods and the relative efficiency of fish to produce/transform proteins are the fundamental aspects which underlines the importance of fisheries and aquaculture. For poor communities fish is both, a source of nutrition and a source of income.

Small farms measuring less than 2 hectares constitute 85% of the total operated farms in the world. Overwhelming majority of these small farms are located in Asia (87%) followed by Africa (8%) and Europe (4%). In Asia, China accounts for half of the world's small farms followed by India. Global trends indicate a decline in small farms in developed countries, while there is an increase in small farms in developing countries[i]. A UN report has been cited by Robert Evans (2011), in favour of small farms with better productivity. *"Evidence has shown that for most crops of the optimal farm is small in scale and that is at this level that most gain in terms of both sustainable productivity increases and rural poverty reduction can be achieved*". The thrust of the UN Report is that Governments must work towards a major shift towards small scale farming if endemic food crisis are to be overcome and production boosted to support the global population. The NSS data has been cited in favour of small farms having higher productivity (Chand Ramesh *et al.,* 2011[ii]).

There is significant fragmentation of operational holdings in India. Around 85 percent of the operational holdings in the country are small and marginal, i.e., that is holdings of less than 2 hectares each. Between 2000-01 and 2010-11, the number of small and marginal holdings have increased but by contrast, the medium holdings dropped by 3 per cent and large holdings by almost 11 per cent[iii]. It is estimated that the average size of land holding, which at present is 1.15 hectare, is likely to reduce further by 2020-21[2].

The scenario is not different in Bangladesh. There are about 16.3 million farm holdings in Bangladesh out of which small (0.05-1.49 Acres), medium (1.5 -7.49 acres) and large farmers (bigger than 7.5 Acres) constitute 78.6%, 13.1% and 1.43% respectively. Similarly aquaculture is being practiced in freshwater ponds of about 0.1 ha and making total of about 3.7 lakh ha. Besides, shrimp and prawn culture area covers about 2.75 lakh ha. In addition to this aquaculture is also being practiced in pens and cages covering an area of over 2000 acres of

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[2]As per the classification followed in the Agricultural Census, marginal holdings covers holdings with less than 1 hectare; small holdings from 1 to 2 hectare; semi-medium with 2 to 4 hectare; medium with 4 to 10 hectare; and large holdings with area of 10 hectares and above.

water area. Culture based fisheries, on the other hand, is practiced in about 5.5 thousand acres of baor. Aquaculture has made tremendous success in Bangladesh by attaining average yield of 4,110 kg/ha/y in freshwater ponds, 786 kg/ha/y in brackishwater, about 1,200 kg/ha/y in baor and about 2 tons/ha/y in cages thus contributing over 55% to the total fish production[iv]. I remember the figure of mid nineties when the average yield from about 1.5 million ponds was to the tune of about 1.5 tons/ha/y. The above figures clearly indicate that the government has put adequate emphasis on improving the productivity and production of Small Scale Aquaculture (SSA).

Bangladesh has also made highly impressive improvement in hilsha fisheries. Production of hilsha has doubled in last one decade in Bangladesh due to successful implementation of seasonal ban on catching the fish during the breeding season, an opening example of benefiting from implementation of FAO CCRF[v].

India has also witnessed significant growth in fisheries sector. From 0.75 million tonnes in 1950-51, total fish production of India touched 12.24 million tonnes in 2017-18 with a contribution of 8.6 million tonnes (70.26%) from inland sector. The sunrise fisheries sector contributes about 0.92 % to National Gross Value Added (GVA) and 5.43% to agricultural GVA (2015-16) while engaging over 14.5 million people (2003 census) at the primary level and almost twice the number along the value chain. During 2017-18 the export of marine products that includes production from aquaculture reached 13,77,244 tonnes valued at INR 45106.89 crore (US $ 6.93 billion). The inland sector grew at a compounded annual growth rate (CAGR) of nearly 6% between 1979 and 2015, while overall fish production witnessed 4.1% growth, which is double the growth rate of food grains production in India.

Priorities for future course of development and strengthening of R&D linkages

Except for shrimp aquaculture and few patches of freshwater aquaculture in Andhra Pradesh and some other states, where aquaculture is practiced on commercial-scale using relatively high input-based semi-intensive aquaculture in relatively large drainable ponds, elsewhere in India, it is a small-scale household-based food farming activity for family consumption and supplementing cash income for family through sale of surplus fish. The bulk of fish is produced by small-scale aquaculture (SSA) are locally consumed thus contributing significantly to the national, local and family level food and nutritional security. In the context of India, where more than one third of children and mothers do suffer from serious malnutrition, promotion of SSAs deserve highest priority. It is also interesting to note that a large part of the commercial-scale aquaculture activities are based on technologies accessed by entrepreneurs themselves from elsewhere.

Our R&D efforts need to focus on developing sustainable practices including both production and consumption and must be pursued from a holistic and integrated perspective. It is equally important that the R&D organizations realize the present contribution and untapped potential of SSA and give priority focus that this sub-sector rightly deserve. From SSA farmers' perspective, enabling policies would mean reorienting the role and functions of various State Departments of Fisheries (DOFs) that are presently focused on revenue generation, regulation and distribution of subsidies. There has to be a paradigm shift from DOF as the predominant legal/regulatory authority to an agency for promoting aquaculture for development. More importantly, the larger goal of economic development shall not prioritize commercialization, export earning, maximizing production, but rather poverty reduction, rural livelihood development, food and nutritional security following a sustainable and inclusive growth strategy that reduces gap between rural

and urban, and the resource poor and well-off sections of society. Public-funded research institutions have also to redefine their goals and objectives and prioritize their research agenda to suit to the needs of SSA producers. Commercial farmers have the means and capacity to access and use technologies developed elsewhere and pay for technical services rendered by private experts. However, there is great opportunity to harness the strength of commercial farmers for the development of SSAs using appropriate strategy.

One of the essential ingredients in addressing the concerns of SSA farmers is developing and making available appropriate technologies that are low cost, required inputs are locally available and to make use of household/farm outputs to greater extent, are simple to comprehend and apply. It shall have short gestation period so that it produces outputs to meet times of family needs and emergencies while at the same time meets the local demand and catches good price. These technologies should have low level of perceived risks in order to be easily adopted by SSA farmers. Lack of mainstreaming of social sciences, emphasis on publications, inadequate field trials are some of the shortfalls of the present R&D environment which have to be reformed if we need to seriously address the concerns of SSA farmers.

The following few lines from the address of the Prime Minister of India is quite appropriate in setting the context.

"...Unfortunately there is an impression among many that the National Agricultural Research System has become somewhat insular over time and responds less well to specific demands from those in the field. You must never lose sight of the fact that your main client is the Indian farmer. Unless you engage with farmers and their problems, you will not succeed in transforming new knowledge into higher productivity and better incomes for our farmers. You must get your research questions primarily from the farmers. This is perhaps the most difficult of the challenges that you must overcome in the years ahead and which can test your commitment and ability".

- *PM's Address at 83rd Foundation Day of ICAR, New Delhi, 16 July, 2011*

In this context the statement "Doubling Farmers' Income by 2022 is our Mission" of PM Narendra Modi of India further emphasis on the issue.

Currently R&D institutions are suffering from "performance race" syndrome where performance is evaluated largely on publications and number of technologies developed. As a result technologies are often released half-baked and techniques are claimed as technologies. All these have resulted in drastic reduction in technology flow from R&D institutions to SSAs. The paper emphasizes on the need for developing comprehensive policy for fisheries and aquaculture research to ensure enhanced flow of sustainable technologies and practices which are relevant to the majority of primary producers and in harmony with national and state level fisheries and aquaculture policies. Several measures and approaches are discussed to strengthen R&D linkages.

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EFFECT OF STRESS ON ONTOGENY OF HUMORAL IMMUNITY IN CATLA

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In the present study, crowding and handling stress with increased Cortisol production and its effect on growth and ontogeny of humoral immunity in *Catla catla* has been studied. In comparison to low stocking density group T1 (3000/ m^2) high stocking groups showed reduction in both average length and weight 6th day onwards up to 40th day. The results of T4 (18000/m^2) showed drastic reduction up to 12th day and died after 12thday. In comparison to groups T1 and T2 (6000/m^2) the reduction in growth of group T3 (12000/m^2) has been observed throughout the study period up to 40thday. In handling stress treatment, the stressed groups showed reduction in average length and weight in comparison to control throughout the study period up to 40thday. The results of ELISA for crowding stress showed that immunoglobulins were detectable in the spawn from 3DPH. For the stressed groups with high stocking density treatment T3 has showed less IgM production 24thday onwards in comparison to low stocking densities T1 and T2. In response to handling, all the stressed groups showed significant decrease in immunoglobulin production in comparison to control 18 DPH onwards. Observation on 40thday showed that there is slow recovery in all the stressed groups, but still the values remain lesser than the control.

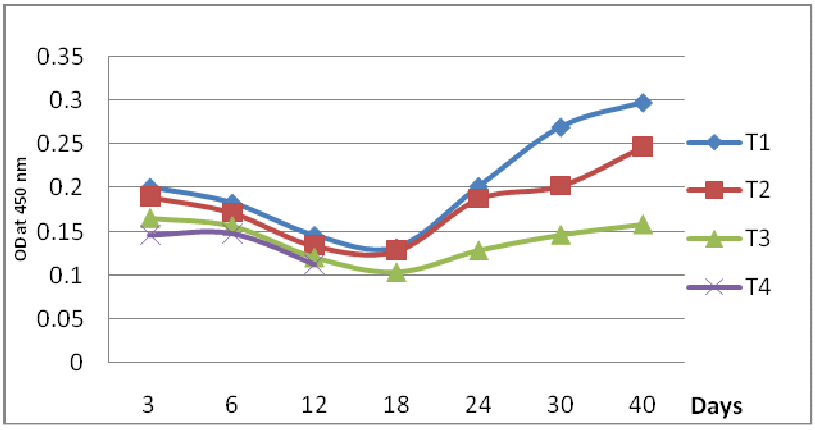

Fig.1. Immunoglobulin levels (OD) in different crowding stress treatments during different life history stages of Catla.

EFFECTS OF DARSBAN 20 EC, ENVOY 50 SC AND KINALAX 25 EC ON CHANGES IN HISTOPATHOLOGICAL, HAEMATOLOGICAL AND BRAIN ACETYLCHOLINESTERASE ACTIVITIES OF SILVER BARB (*Barbonymus gonionotus*) AND STINGING CATFISH (*Heteropneustes fossilis*)

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Use of pesticides or insecticides can be highly toxic to aquatic life forms due to leaching and agricultural runoff, rains or flood. The aim of this study was to evaluate the changes in some histological, haematological parameters and the brain acetylcholinesterase activities of the fresh water fish *Barbonymus gonionotus* and *Heteroneustes fossilis* due to effects of three commonly used pesticides i.e. Darsban 20 EC, Envoy 50 SC and Kinalax 25 EC. The LC_{50} values of three pesticides were also determined. The LC_{50} values of Darsban 20 EC, Envoy 50 SC and Kinalax 25 EC were estimated as 0.016, 0.00403 and 0.071 ppm, respectively for *B. gonionotus.* Histological bio-assay of gill, liver and kidney of *B. gonionotus* were performed to evaluate the effects of these three pesticides in cellular level. These pesticides abruptly affected the fish tissues and altered their normal structure and their major alterations included missing of gill lamellae, gill clubbing, hyperplasia, nuclear hypertrophy, vacuolation, glomerular expansion, increasing the diameter of renal tubules, hemorrhage, necrosis and pyknosis. RBC of *H. fossilis* were counted and observed under microscope to assess the blood cell morphological changes of erythrocytes. Several changes in peripheral nuclear erythrocyte included large lymphocyte, dead cell, fusion of cell, binucleated cell, tear-shaped cell, ghost cell, senile cell and abnormal shape of cell were found. The RBC count was significantly lower ($P>0.05$) in higher doses compared to lower doses. The AChE activities in *H. fossilis* brain were significantly decreased ($P>0.05$) in pesticides treated fish compared to control. The result of this study reveals that the synthetic organophosphorus pesticide adversely affects the histology, haematology and activities of brain acetylcholinesterase of the freshwater fish *B. gonionotus* and *H. fossilis*.

MOLECULAR CHARACTERIZATION OF SALT REGULATORY GENES IN TILAPIA USING MICROSATELLITE DNA MARKERS

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Polymorphisms in the simple sequence repeat (SSR) motifs present in the salt regulatory genes such as prolactin and transferrin have been found to show differences in the expression levels of the genes and growth performance in tilapia. The SSR (microsatellite) loci of the prolactin and transferrin genes were characterized by genotyping the loci. Genomic DNA was isolated from fin tissue of 45 Mozambique tilapia, *O. mossambicus* and 33 Nile tilapia, *O. niloticus*. Five sets of microsatellite primers (Prl1, Prl1 (L-K), Prl-MS01 (Chi), TFA, and TFB) for two salt-regulatory genes of *O. mossambicus* and *O. niloticus* were amplified by polymerase chain reaction. The alleles were separated by polyacrylamide gel electrophoresis and 3% agarose gel and visualized by ethidium bromide staining. The prl1 locus in both *O. mossambicus* and *O. niloticus* samples and Prl1 (L-K) locus in *O. mossambicus* were found to be monomorphic and the locus TFB was found to be monomorphic in *O. mossambicus*. The size of prl1 allele in *O. niloticus* was 487 bp while that in *O. mossambicus* was 500 bp. The Prl1 (L-K) and TFB loci of *O. mossambicus* were 254 bp and 188 bp respectively. On the other hand, Prl1 (L-K), Prl1-MS01 (Chi), TFA and TFB loci in *O. niloticus* and Prl1-MS01 (Chi), TFA loci of *O. mossambicus* were found to be polymorphic. The genotypes in Prl1 (L-K) locus of *O. niloticus* and Prl1-MS01 (Chi) locus of *O. niloticus* and *O. mossambicus* were 253/281, 260/285, 286/320, respectively. The genotypes in TFA and TFB loci of *O. niloticus* and TFA loci of *O. mossambicus* were 296/320, 166/254 and 310/340, respectively. The average observed heterozygosity of TFA and TFB (H_o) value in *O. niloticus* (0.485) was higher than that in *O. mossambicus* (0.329) populations. The average observed heterozygosity (H_o) value of Prl1 (L-K) and Prl1-MS01 (Chi) in *O. niloticus* (0.453) was higher than that in *O. mossambicus* (0.378) populations. Except locus Prl1 (L-K) in *O. mossambicus* population, the fixation index (1 - (H_o / H_e)) values was positive in the Prl1 (L-K) loci of *O. niloticus* which means that these populations (*O. niloticus*) had deficiency of heterozygosity. Except locus TFB in *O. mossambicus* population, the fixation index (1 - (H_o / H_e)) values were negative in the Prl1-MS01 (Chi), TFA and TFB loci which means that both the two populations (*O. niloticus* and *O. mossambicus*) had excess of heterozygosity as a result of the presence of over-dominant selection or the occurrence of outbreeding or Wahlund effect. The TFA locus of *O. mossambicus* and *O. niloticus* was found to be significantly deviated from Hardy-Weinberg expectations. Deviation at TFB locus of *O. niloticus* and *O. mossambicus* were insignificant.

GROWTH AND REPRODUCTION OF *Barbonymus gonionotus* IN THE FRESHWATER ECOSYSTEM OF NORTHWEST BANGLADESH

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The present study was conducted in a freshwater ecosystem at Rajshahi, the northwest Bangladesh during January - August 2017 to know the growth and reproduction of *Barbonymus gonionotus* in natural condition. Fishes were sampled on monthly basis and a total of 321 fishes were collected during the study period. Total length (TL) of the fish was varied from 11.76±1.47 cm to 22.47±1.39 cm, fork length (FL) 10.02±1.32 cm to 19.12±1.17 cm, standard length (SL) 8.87±1.23 cm to 16.83±1.08 cm, body weight (BW) 19.89±9.35 g to 167.81±31.29 g. During the study, a positive allometric growth pattern was observed both for length-length and length-weight relationship of the fish and the relationships were TL = 1.1759 FL - 0.035, TL = 1.338 SL - 0.0002, FL = 1.0988 SL + 0.6557 and BW = 0.0051 $TL^{3.347}$. Gonadal observation revealed that the sexuality of the fishes was initiated in the month of April and highest maturity was observed in the month of May. Spawning extends during May to July with a peak in June. During the study, the sex ratio was 1:1.42. The gonado-somatic index (GSI) was ranged from 3.72 (July) to 32.39 (May). The fecundity was ranged from 46145 (July) to 353969 (May) which was correlated with total length and body weight. The results of this study would be beneficial for fishery scientists as well as resource manager for the sustainable management and conservation of this fish species in the natural ecosystem.

HIGH TEMPERATURE ALTERED GROWTH PERFORMANCE, HEMATO-BIOCHEMICAL PARAMETERS AND STRUCTURE OF ERYTHROCYTES IN ROHU *Labeo rohita*

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Global warming is expected to affect the aquatic ecosystem and aquaculture industry. In the current experiment, we have observed the effects of high temperature on growth, blood glucose, hemoglobin level, RBC (red blood cell), WBC (white blood cell) and nuclear & cellular abnormalities of blood cells in rohu, *Labeo rohita*. In these circumstances, fish were exposed to three different temperate regimes such as 30ºC, 33ºC and 36ºC and sacrificed at 7, 15, 30 & 60 days of exposure. The growth performance such as weight gain, % weight gain, specific growth rate (SGR) and feed conversion ratio (FCR) was much better at 30ºC and 33ºC rather than 36ºC. From the study, it was also revealed that blood glucose level and WBC was significantly increased at 36ºC on the 7 days but showed opposite consequence on 60 days. In the similar time, hemoglobin level and RBC were remarkably decreased at 36ºC on 7 days. Frequencies of erythrocytic nuclear abnormalities (ENA) and erythrocytic cellular abnormalities (ECA) were found to be significantly elevated with increasing temperature. Dissolved oxygen and free CO_2 have shown inversed relationship with increasing temperature. However, pH and total alkalinity of water were almost similar throughout the experimental period. The current study demonstrated that rohu fish feel better condition at 30ºC and 33ºC, while higher temperature 36ºC seems to be stressful.

STATUS OF MONOSEX TILAPIA (*Oreochromis niloticus*) SEED PRODUCTION USING ANDROGEN HORMONE IN BANGLADESH

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Tilapia (*Oreochromis niloticus*) has become a popular fish species and a fast growing industry in Bangladesh. There are about 400 tilapia seed production hatcheries and these are producing about 4.0 billion of monosex seeds every year to support over 6000 commercial tilapia farms in Bangladesh. Although there are plenty of tilapia hatcheries in our country, there are various problems in respect to brood fish management, stock replacement and hormone treatment in these hatcheries. A survey was conducted during the period from September to October, 2018 to investigate the existing practices of tilapia seed production and associated issues of this sector in Mymensingh, Jashore and Cumilla districts. A total of 18 hatcheries from 3 districts were randomly selected for collecting data using a structured questionnaire. Own hatchery produced fish was used as brood fish by 50% hatcheries in Cumilla followed by 44% in Mymensingh and 33.33% in Jashore. Brood fish was also collected from nearby hatcheries by 33.33% hatcheries of both Jashore and Cumiila followed by 27.78% in Mymensingh. Some hatcheries also collected brood fish from BFRI, WorldFish Centre and Abroad. Average weight of brood fish was found 200-250 gm in 50% hatcheries of Mymensingh followed by 33% in both Jashore and Cumilla but average weight of brood fish was found 250-300gm in 50% hatcheries of Jashore followed by 33.33% in Cumilla and 13.33% in Mymensingh. Some hatcheries also used brood fish of 300-350gm.Most of the hatcheries of Mymensingh (50%) and Jashore (83%) maintained 1:2 (male and female) sex ratio but in Cumilla 50% hatcheries maintained 1:1 (male and female) sex ratio for breeding. Half of the hatcheries of studied areas performed hormone treatment for 28 days, but 16.33%, 50% and 33.33% hatcheries in Mymensingh, Jashore and Cumilla respectively performed treatment for 21 days. Average dose of hormone (17α-methyltestosterone) was found 77.50 mg/kg feed, 57.50 mg/kg feed, 51.00mg/kg feed in Mymensingh, Jashore and Cumilla respectively. Average survival rate of fry after hormone treatment was found highest (76.66%) in Mymensingh followed by 75% in Jashore and 62.83% in Cumilla. The average sex reverse rate to become monosex was found highest (92.50%) in Mymensingh followed by 89.16% in Jashore and 83.33% in Cumilla. To conclude, different doses of hormone were used in the survey areas resulting different sex reverse and survival rates. Therefore, further study is recommended to optimize the hormone dose (17α-methyltestosterone) is required to produce quality monosex tilapia seed for sustainable production of tilapia.

Table 1. Mean hormone dose, treatment days, survival rate and rate of becoming monosex in 3 districts

Survey area	Mean dose of hormone (mg/kg feed)	Mean treatment days	Mean survival rate (%)	Mean rate of Monosex (%)
Mymensingh	77.50	27.33	76.66	92.50
Jashore	57.50	24.5	75.00	89.16
Cumilla	51.00	22.66	62.83	83.33

OPTIMIZATION OF 17A-METHYLTESTOSTERONE DOSE TO PRODUCE QUALITY MONO-SEX NILE TILAPIA (*Oreochromis niloticus*)

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Mono-sex male tilapia production has several advantages in aquaculture regarding enhanced growth and control of superfluous reproduction that is why desirable cultural species of mono-sex population is extremely required in Bangladesh. The present study was conducted to identify the most efficacious dose of 17α-methyltestosterone (17 α-MT) through oral administration of feed for production of mono-sex male Nile tilapia (*Oreochromis niloticus*). Therefore, eggs were collected from the mouth of female brood fish and transferred to the plastic jars where continuous aeration accelerated the hatching of eggs and hatched out after 3-5 days at 28 ± 1°C temperature. Five treatments with three replications using 17 α-MT *viz.* 0 mg (T_1), 50 mg (T_2), 60 mg (T_3), 70 mg (T_4) and 80 mg (T_5) in per kg commercial feed were used over a period of 28 days and each replication contains 500 hatchlings. After the hormone treatment fry were reared in separate synthetic hapas for further 90 days. Gonad squashing aceto-carmine staining method and gonadal histology were performed to reveal the sex ratio of 90 days reared *O. niloticus*. The highest (94.8%) mono-sex male production was found at T_3followed by T_5(91.4%), T_4 (90.7%), T_2 (88.7%) and T_1 (53.5%)(Fig.1). The highest mean body weight (9.85gm) and the highest mean length (71mm) was observed in T_3. The highest survival rate (84%) was found in control group(T_1) followed by T_3, T_2, T_4 and T_5(Fig.2). Finally, the study revealed the optimum dose as 60mg 17 α-MT /kg feed for production of mono-sex male tilapia.

Fig. 1. Effect of 17α-methyltestosterone on sex reversal in Nile tilapia.

Fig. 2. Survival rate of fry at different doses with control after 90 days rearing.

STUDIES ON THE COMPARATIVE EFFICACY OF PG AND OVAPRIM IN INDUCED BREEDING OF KALIBAUS (*Labeo calbasu*)

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The present study compared the effectiveness of Pituitary gland extract (PGE) and Ovaprim in induced spawning of an endangered Indian major carp Kalibaus, *Labeo calbasu* using reproductive output such as, ovulation rate, latency period, fecundity, fertilization rate and hatching rate. Experiments were conducted in Uma hatchery, Chanchra, Jessore on twenty four (24) male and forty eight (48) female fishes with a mean weight of 1518.47±129.28g during April 2014 - June 2015. In the present study, GSI value of *L. calbasu* varied from 18.44 to 22.32% and fecundity were varied from 540869 to 701391. For female fishes 5, 7 and 9 mg/kg body weight of PG and 0.4, 0.5 and 0.6 ml/kg body weight of Ovaprim were used. For male fishes 2 mg/kg body weight of PG and 0.3 ml/kg body weight of Ovaprim were used. Single dose of Ovaprim and double doses of PG were used. Fishes treated with Ovaprim showed better ovulation rate (95.24%) than PG treated fish (71.42%). Fertilization rate (75.27%) of Ovaprim treated fishes were significantly higher *($P<0.05$)* than that of PG treated fish (62.37%). Hatching rates also followed the same trend, where significantly higher *($p<0.05$)* hatching success (69.50%) were recorded in Ovaprim induced fishes than PG induced fishes (61.21%). Ovaprim at a dose of 0.5 ml/kg body weight showed significantly higher *($p<0.05$)* fertilization rate (83.48%) & hatching rate (77.76%) than any other doses of PG and Ovaprim. The present findings can be used in induced breeding of *L. calbasu* for the development of hatchery propagation and save the species from extinction.

MORPHOMETRIC AND MERISTIC CHARACTERISTICS OF *Heteropneustes fossilis* IN GAJNER BEEL WETLAND ECOSYSTEM

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The present study revealed the first complete information on meristic counts covering various fin rays and morphometric characteristics using multi-linear dimensions of *Heteropneustes fossilis,* including length-weight relationships (LWRs) and length-length relationships (LLRs)of *H. fossilis* from the Gajner *beel,* a wetland ecosystem in northwestern (NW) Bangladesh. A total of333 individuals of *H. fossilis* were captured by different traditional fishing gears such as cast net, square lift net, gill net, and conical trap during July 2017- June 2018. For each individual, total numbers of fin rays were counted by using a magnifying glass. Body weight (BW) was measured by digital balance and various lengths (TL, SL, PrDL etc.) were taken using digital slidecalipers to the nearest 0.01 g and 0.01 cm, accuracy, respectively. BW ranged from 3.50-105.23 g and TL varied from 6.70-26.80 cm. The fin formula of *H. fossilis* is: dorsal, D. 6; pectoral, Pc.1/6-7; pelvic, Pv. 6; anal, A. 64-69; and caudal, C.16-18. All LWRs were significantly correlated ($p<0.001$), with r^2values ≥0.949. The calculated *b* values showed positive allometric growth in combined sexes ($b> 3.00$). LLRs were also highly correlated ($p < 0.001$) with r^2 values ≥ 0.989. Our findings should be very effective for species identification, stock assessment, and proper management of this species in the Gajner *beel* of Bangladesh and surrounding ecosystems.

CHANGES IN HAEMATOLOGICAL PARAMETERS OF SILVER BARB (*Barbonymus gonionotus*) DUE TO PESTICIDES EXPOSURE

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The study was carried out to investigate the changes in haematological parameters of silver barb (*Barbonymus gonionotus*) due to exposure of pesticides, lamda-cyhalothrin and dimethoate in glass aquaria. In this study, three batches of fish were kept in clean water treated as control fish (T1); six batches of fish were exposed to two concentrations of lamda-cyhalothrin as 0.001 ml/L (T2) and 0.003 ml/L (T3); and six batches of fish were exposed to two concentrations of dimethoate as 0.001 ml/L (T4) and 0.003 ml/L (T5) for 96 hours. During this study, physico-chemical parameters (temperature, oxygen and pH) of test water, behaviour and haematological parameters (WBC, RBC, Hb, PCV, MCV, MCH and MCHC) of the fish were analyzed. Physico-chemical parameters of test water were within the productive ranges. When the fish exposed to pesticides, they showed less activity, loss of equilibrium, motionlessness, erratic swimming and loss of appetite. WBC, RBC, Hb, PVC and MCV were found significantly decreased and MCHC insignificantly increased (Tables 1 and 2). MCH was found decreased insignificantly in lamda-cyhalothrin exposed fish but significantly in dimethoate exposed fish. Therefore, the study stated that lamda-cyhalothrin and dimethoate pesticides produce an adverse effect in haematological parameters which might affect normal physiology and immunity of fish.

Table 1. Changes in haematological parameters due to lamda-cyhalothrin exposure

Parameters	Treatments		
	T1	T2	T3
Total WBC ($10^4\times$ mm^{-3})	5.78±0.21^a	5.39±0.14^b	4.63±0.18^c
RBCs ($10^6\times$mm^{-3})	1.53±0.08^a	1.33±0.11^b	1.27±0.09^b
Hb (g/dl)	3.20±0.19^a	2.75±0.23^b	2.58±0.19^b
PCV (%)	8.67±0.27^a	7.29±0.18^b	6.71±0.23^c
MCV (fl)	56.67±1.10^a	54.88±1.03^b	52.83±1.05^c
MCH (pg)	20.91±0.38^a	20.67±0.43^a	20.31±0.57^a
MCHC (g/dl)	36.90±1.85^a	37.72±1.64^a	38.45±1.67^a

Table 2. Changes in haematological parameters due to dimethoate exposure

Parameters	Treatments		
	T1	T4	T5
Total WBC ($10^4\times$ mm^{-3})	5.78±0.21^a	3.41±0.46^b	2.48±0.21^c
RBCs ($10^6\times$mm^{-3})	1.53±0.08^a	1.17±0.17^b	1.06±0.13^b
Hb (g/dl)	3.20±0.19^a	2.25±0.21^b	2.05±0.35^b
PCV (%)	8.67±0.27^a	6.02±0.46^b	5.29±0.34^c
MCV (fl)	56.67±1.10^a	51.45±1.78^b	49.91±1.52^b
MCH (pg)	20.91±0.38^a	19.23±0.39^b	19.33±0.26^b
MCHC (g/dl)	36.90±1.85^a	37.37±1.43^a	38.75±1.87^a

* Values in the same row with different superscripts are significantly different (*P≤0.05*).

IDENTIFICATION OF MORPHOLOGICAL MARKERS FOR PURE BREED OF TWO INDIAN MAJOR CARPS, ROHU (*Labeo rohita)* AND CATLA (*Catla catla*) AND THEIR HYBRIDS (*Labeo rohita* ♀ x *Gibelion catla* ♂) FOR SUSTAINABLE AQUACULTURE

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Morphometric characteristics of two Indian major carps, rohu (*Labeo rohita*) and catla (*Catla catla*) and their hybrids (*L. rohita* ♀ x *C. catla* ♂) have been studied to identify morphological markers for identification of pure breeds for quality seed production. For this, morphometric characteristics of 102 individuals of which 68 individuals were pure breeds of rohu and catla and 34 individuals were hybrids of rohu (♀) and catla (♂). All the value of correlation coefficients (r^2) for Length-Length Relationships (LLRs) ranged from 0.102-0.967 in rohu, 0.044-0.942 in catla and 0.045-0.935 in hybrid. Among rohu, catla and hybrid, there was a significant difference in standard length ($p=0.0004$), head length ($p=0.0001$), head depth ($p=0.001$), body depth ($p<0.0001$), dorsal length ($p=0.04$), pectoral length ($p=0.003$), dorsal fin base length ($p<0.0001$), opercular length ($p = 0.002$) and operculum length ($p = 0.01$). The LLRs of total length and standard length ($p=0.08$), dorsal length ($p=0.001$), dorsal fin base length ($p=0.001$), pectoral length ($p=0.001$), head depth ($p=0.001$), head length ($p=0.0002$), body depth ($p=0.0004$), opercular length ($p=0.0002$) and operculum length ($p=0.02$) of *L. rohita* were significantly different from *C. catla*. Between catla and hybrid, there was a significant difference in standard length ($p=0.001$), head length ($p=0.01$), head depth ($p=0.01$), body depth ($p=0.0001$), dorsal fin length ($p=0.05$), dorsal fin base length ($p<0.0001$), and operculum length ($p=0.04$). On the other hand between rohu and hybrid, a significant difference was occurred in standard length ($p<0.0001$), dorsal fin base length ($p=0.001$) and body depth ($p<0.0001$). The growth form of fish was determined by using the length-weight relationship (LWR) method. The total length and body weight of rohu ($r^2=0.937$) and catla ($r^2=0.942$) were highly correlated, whereas in hybrid were not ($r^2=0.486$). The rohu and hybrid exhibited a negative allometric growth ($b<3$) which indicated that the fish became lighter with increasing length. Catla demonstrated an isometric growth ($b=3$), which indicated that the shape of the fish would not change with increasing weight and length. In rohu, catla and hybrid, the condition factor was greater than 1, thereby indicating the wellbeing of the fish (rohu, catla and hybrid). From the result of this study, it could be said that, hybrids tend to show the morphological markers more towards the rohu (maternal parents) and possess a smaller head than that of catla ($p=0.01$) and almost similar head as rohu ($p=0.9$) and wider body than rohu ($p<0.0001$), but not as much as catla ($p=0.0001$), which could be helpful to fish farmers to easily identify hybrids from the pure breed for quality seed production for sustainable aquaculture.

EFFECT OF ORIGIN OF BROODSTOCKS OF GIANT FRESHWATER PRAWN, *M. rosenbergii* ON GROWTH PERFORMANCE OF THEIR F_1 PROGENIES

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For the study, F_1 progenies of three brood stocks of Giant freshwater prawn, *M. rosenbergii*, were used. A brood stock, designated as 'Developed brood stocks (DB)', was developed by rearing wild juveniles, collected from the Bulla river, a branch of the Meghna river, in earthen ponds at Southern Agro-Fisheries and Allied Ltd. (SAFAL), Subarnachar, Noakhali. Wild brood stocks were collected from the Halda river (designated as HB) of Chittagong district and captive reared brood stocks were collected from a 'gher' (designated as GB) of Bagerhat district. Berried females of each brood stock origin were brought to Upakul Freshwater Prawn Hatchery (UFWPH) of Noakhali.F_1 PL of each brood stock origin were produced at UFWPH. For convenience, F_1 progenies of HB, DB and GB origin was designated as F_1HB, F_1DB and F_1GB respectively. Growth performance of F_1 progenies of each brood stock origin was studied at two phases- i) Nursery and ii) Grow out phases. At 'Nursery phase', F_1 PL of each brood stock origin were reared up to juvenile stage for eight weeks with two replications in six separate earthen ponds each having area of 600 $m^2$and 1 m depth. Stocking rate was 25 PL/m^2. A commercial feed, namely CP nursery feed (35% protein content), was supplied as feed for PL daily. At the end of 'Nursery phase', juveniles were harvested by netting and pumping out of water from the ponds. At 'Grow out phase', F_1 juveniles of same three brood stocks were stocked at a density of 1 juvenile/m^2in earthen ponds each having area of 600 m^2 and 1 m depth at SAFAL. Juveniles were provided with a prepared feed containing 32% protein daily and reared for 240 days. At 'Nursery phase', initial weight (g) of F_1 progenies (PL) of three brood stock origin was same (0.03±0.00). However, final weight (g) of F_1HB was highest (3.72±0.15) followed by F_1DB (3.65±0.01) and F_1GB (3.49±0.10). Survival rates of F_1HB (64.94±0.59) and F_1DB (60.88±1.13) were significantly higher (p<0.05) than that of F_1GB (35.28±1.49).At 'Grow out phase', though there was no significant difference in initial weight (g) of F_1 progenies of three brood stocks, final weight (g) of F_1 progenies of HB (102.03±0.34) and DB (104.58±2.88) were significantly (P<0.05) higher than that of F_1 progenies of GB (85.53±3.88). Survival rate (%) of F_1 progenies of GB (35.33±0.50) was significantly (p<0.05) lower than that of F_1 progenies of HB (72.00±1.83) and DB (69.33±1.65). Net production (kg/ha) of F_1 progenies of GB (284.09±17.85) was also significantly (p<0.05) lower than that ofF_1 progenies of HB (704.32±21.46) and DB (696.45±25.93). Production performance of F_1 progenies of GB origin was lower than those of HB and DB origin at both Nursery and Grow out phases indicates poor quality of F_1 progenies of brood stocks sourced from 'ghers'. On the other hand, F_1progenies of two brood stocks of wild origin, HB and DB, did not exhibit significant (p>0.05) difference in their production performance at nursery and grow out phase suggests that freshwater hatchery managers should develop their own brood stocks by rearing wild PL or juveniles in ponds with proper feeding and management in lieu of sourcing wild berried females from rivers which is often uncertain. Developing and breeding of such brood stocks may, in one hand, ensure steady and timely supply of berried females for production of quality PL and, on the other hand, will help to conserve the nature.

ALTERATION OF PERIPHERAL ERYTHROCYTES AND THEIR RECOVERY PATTERNS IN ZEBRA FISH (*Danio rerio)* EXPOSED TO SUMITHION

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An experiment was conducted to assess the effects of an organophosphorous pesticide sumithion on peripheral erythrocytes and their recovery patterns of zebrafish (*Danio rerio).* The experiment was conducted with four treatments, each having three replications. Treatment one (T_1) was used as control (0 ppm) and three concentrations, such as 0.8 ppm, 1.6 ppm, and 3.2 ppm were used as Treatment two (T_2), Treatment three (T_3), Treatment four (T_4), respectively. Fish were sacrificed at 1, 3, and 7 days after start of exposure. Subsequent recovery patterns were assessed allowing the exposed fish in sumithion free water for the same period that they were exposed to sumithion. To observe the peripheral erythrocytes, blood was collected from the caudal region after cutting the caudal fin. The results revealed that with the progression of time and concentration, treated fish showed significantly (p<0.05) higher level of erythrocytic nuclear abnormalities (ENA) such as -micronuclei, bi-nuclei, blebbed nuclei, notched nuclei, nuclear bridge and nuclear bud and also erythrocytic cellular abnormalities (ECA)such as -echinocytic, elongated, fusion, spindle, tear-drop, crescentic shaped and twin shaped cells. The present investigation highlighted that sumithion had significant effects on the alterations of the (ENA), and (ECA) of the erythrocytes. Therefore, the alterations of these parameters can be used to assess the toxic levels of pesticides on aquatic organisms.

Table 1. Frequency of ENA in the blood of zebrafish after exposure and after recovery from sumithion

	Dose (%)	Control	Exposure time (days)			Recovery time (days)		
			1	3	7	1	3	7
Abnormalities (%)	10	0.57± 0.05	0.70 ± 0.02^{a}	1.10 ± 0.09^{ab}	1.52 ± 0.10^{b}	0.62 ± 0.06^{x}	0.80 ± 0.07^{x}	0.88 ± 0.0^{x}
	20		0.90 ± 0.03^{a}	1.40 ± 0.03^{b}	2.02 ± 0.07^{bc}	0.79 ± 0.09^{x}	1.12 ± 0.06^{xy}	1.37 ± 0.1^{y}
	40		1.12 ± 0.06^{ab}	1.80 ± 0.10^{b}	2.92 ± 0.14^{c}	1.00 ± 0.08^{x}	1.52 ± 0.12^{y}	2.12 ± 0.2^{z}

Different superscripts of letters showed significant differences among exposure and recovery days (p<0.05). Values are means ± SD.

Table 2. Frequency of ECA in the blood of zebrafish after exposure and after recovery from sumithion

	Dose (%)	Control	Exposure time (days)			Recovery time (days)		
			1	3	7	1	3	7
Abnorm-alities (%)	10	0.95±0.09	1.23 ± 0.02^{a}	1.82 ± 0.16^{a}	2.34 ± 0.13^{b}	1.04 ± 0.04^{x}	1.35 ± 0.09^{x}	1.30 ± 0.07^{x}
	20		1.42 ± 0.06^{a}	2.19 ± 0.21^{b}	2.75 ± 0.13^{c}	1.22 ± 0.09^{x}	1.75 ± 0.08^{y}	1.70 ± 0.05^{y}
	40		1.93 ± 0.12^{ab}	2.89 ± 0.20^{c}	4.35 ± 0.25^{d}	1.70 ± 0.13^{y}	2.42 ± 0.23^{z}	2.99 ± 0.12^{z}

Different superscripts of letters showed significant differences among exposure and recovery days (p<0.05). Values are means ± SD.

GROWTH PATTERN, CONDITION FACTOR, FOOD AND FEEDING HABIT OF THE MINOR CARP *Cirrhinus reba* OF PADMA RIVER, RAJSHAHI

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The growth pattern including length-length and length-weight relationship, food and feeding habit and condition factor (K_F) of a minor carp, *Cirrhinus reba* from Padma River, northwestern Bangladesh were studied by examining 360 individuals collected during November 2012 - April 2013.One experiment was also developed the diet for rearing of this species under semi-intensive culture system. A feeding trail was conducted with diets with 16 (VAF-1), 25 (VAF-2) and 32% (VAF-3) of crude protein in the earthen ponds. For each individual, different lengths (e.g., TL, SL, FL) was measured to slide calipers and whole body weight (BW) was taken on an electric balance with 0.01 g accuracy. Fishes were ranged from 8.44 - 15.29 with mean ± SD of 11.88±1.76 cm in TL, 6.89-12.46 cm in SL, 7.38-13.92 cm in FL and 4.45 -30.14 with mean ± SD of 14.55±7.03 g in weight The length-frequency distribution (LFD) showed that the 12.0-12.90 cm TL size group was numerically dominant and constituted 20.87% of the population. The relationship between length and weight (LWR) was calculated using the expression: $W = a*L^b$. The coefficient *b* of the LWRs indicated positive allometric growth (b>3.00) for *C. reba* in the Padma River. The results also indicated that the LWRs were highly correlated (r^2> 0.981). The calculated Fulton's condition factor (K_F) values ranged from 0.53-0.98. During the study period the fish was found as an omnivorous. The fish was found to be taken 7 groups of food, among these food groups, higher plant was the most dominant food item by percentage of occurrence (65.53%). The GaSI was highest in the month of March (6.38±0.79) and lowest in the month of January (3.63±0.80). The pattern of feeding on percentage occurrence of food items the peak feeding intensity observed during March. The highest percentage of emptiness was recorded in January (90%). Seasonal pattern of feeding on percentage occurrence of food items are higher plants, detritus and debris, sand and mud, algae, crustacean, protozoa, and insect etc. During experimental periods, water temperature and dissolved oxygen parameters were suitable ranges for fish growth and development. The best growth performance and survival rate were found in fish group fed diet VAF-3. In terms of growth, food conversion ratio, specific growth rate and survival diet were showed significantly (p<0.05) better of the fish with fed VAF-3 diet in comparison with the fish fed on other diets containing lower protein levels. This study would be effective for conservation of wild populations. Also later part, experiment will be helpful for further intensive culture of *C. reba* in the earthen ponds.

FUCOXANTHIN AND ITS DERIVATIVE FUCOXANTHINOL FROM THE PHAEOPHYTE *Undaria pinnatifida* AT TENUATE OXIDATIVE STRESS IN HIPPOCAMPAL NEURONS

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Age-related brain disorders are of major concern among elderly individuals, as life expectancy is increasing dramatically. Oxidative stress in the brain is a prime initiator in almost all age-associated neurological diseases, including Alzheimer's, Parkinson's, and Huntington's diseases. In the present study, an ethanol extract of *Undaria pinnatifida* (UPE) concentration-dependently increased neuronal viability in both hypoxia-induced oxidative stress and normoxic cultures. UPE, at an optimal concentration of 15 µg mL-1, significantly reduced reactive oxygen species formation, DNA fragmentation, early and late apoptosis rates, and mitochondrial membrane dysfunction against hypoxia. In addition, the most active neuroprotectant in UPE was identified as fucoxanthin (Fx) by reverse-phase high-pressure liquid chromatography (RP-HPLC), which concentration-dependently increased the number of viable neurons. To clarify these effects in *in vivo* condition, fucoxanthinol (FxOH), a metabolite after enzymatic hydrolysis of Fx, was purified by RP-HPLC, and confirmed the purity by comparison with reference Fx for *in vitro* studies. FxOH significantly preserved the number of cultured neurons and provided protection from neurite breakage even under hypoxia conditions. In addition, these results were similar with those of the effects of UPE and Fx. The findings suggest that the neuroprotective effect of UPE and its active component Fx as well as FxOH have provided a great contribution to its protection on central nervous system neurons through anti-excitatory and anti-oxidative actions, and could be used as drug and/or functional food supplements for treating or preventing age-related neurological disorders.

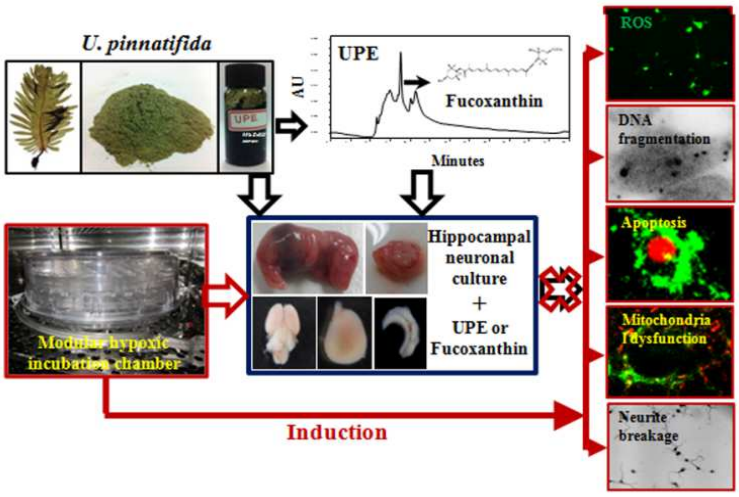

Fig. 1. Graphical abstract used in the study.

LENGTH-WEIGHT RELATIONSHIP AND GEOMETRIC MORPHOMETRIC VARIATION OF NATURAL *Cirrhinus reba* STOCKS OF BANGLADESH

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Cirrhinus reba, locally known as Bhagna, belongs to the Cyprinidae family, is one of the most popular minor carp species, which were abundantly available in the past. This fish is distributed in South-East Asian countries including Bangladesh. Now a days it has become endemic in some selected regions of Bangladesh. Hence, attempts were taken in this study to know the present status of wild *C. reba* of Bangladesh through length-weight relationship, condition factor and geometric morphometric variation. Samples of wild *C. reba* were collected from Atrai river of Dinajpur, Jamuna river of Bagura, Berogobindo hoar of Jashore, and the Old Bhramapurtra river of Mymensingh districts, carried to the laboratory in iced condition. The total length and weight of each individual samples were taken in nearest cm and gm respectively. Then the images of each sample were captured by Canon Power shot SX510 HS Digital Camera (4000 × 3000 megapixels).The geometric morphometric analyses were done using TPS (Thin Plate Spline) and PAST (Palaeontological Statistics) software. The overall b value ranged from 1.22 to 4.69 where the lowest (1.22) was found in the Jamuna river sotck (Bogra) and followed by 3.07 from Bhramaputra river (Mymensingh), 4.44 from Bergobindapur baor (Jashore) and 4.69 from Atrai river (Dinajpur). A total of 22 principal components were identified in the shape analysis where the highest Eigenvalue (553078) and percent variance (45.478%) for all populations were found on the PC-1. In overall geometric analysis, variations of four wild stocks were observed at lower demarcation level. Further, variations of stocks in pair wise study were found. Finally the UPGMA Cluster analysis of wild *C. reba* of four different regions showed stock differentiation among the regions though few overlapping were observed. The findings from the present study will help for brood development as well as conservation measures.

OPTIMIZATION OF 17β ESTRADIOL HORMONAL DOSE AND INCUBATION PERIOD FOR THE PRODUCTION OF ALL FEMALE SHING (*Heteropneustes fossilis*)

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Heteropneustes fossilis (Shing) is one of the important commercial aquaculture species in Bangladesh due to its fast growth, tolerance to high stocking densities, ability to survive in oxygen-low waters, low fat, high protein and iron content and medicinal values. The females of this species are considerably larger in size than the males of the same age. Female fish of *H. fossilis* provide 40-50% extra production than the male. Production of mono sex population offers several advantages in fish culture, including enhanced growth and production. With this view the present study is designed to develop the techniques for producing all female population of *H. fossilis* through direct hormonal manipulation and determine the optimal dose of estrogen hormone (17β-Estradiol) for the production of mono-sex female *H. fossilis.* Ten treatments were used as, T_1 (200µg/l, 30 mins**)**, T_2 (300µg/l, 30 mins), T_3 (400µg/l, 30 mins), T_4 (200µg/l, 45mins), T_5 (300µg/l, 45mins), T_6 (400µg/l, 45mins), T_7 (200µg/l, 1hr), T_8 (300µg/l, 1h), T_9 (400µg/l, 1h) and T_{10} (control). After incubation with hormonal solution the larvae were reared in hapa net for 120 days. After that 50 fishes from each treatment were sexed by using aceto carmine method. The highest number (84%) of female species was found at T_5 (300 µg/l, 45mins) and the lowest (52%) number of female fishes was found in T_1 (200 µg/l, 30 mins) and T_{10} (control). The highest average weight and length gain were found in $T_5$and the lowest average weight and length gain were found where control of hormone solution was used. The highest survival rate was found in control where and the lowest survival rate was found in T_5.In this study it has been observed that there was a positive relation between fish growth and hormone dose but there was a negative relation between hormone dose and survival rate. From this study it is clear that sex of *H. fossilis* can be effectively altered by using 17 β-estradiol. More study should be carried out to find out the exact dose of hormone where the growth and survival rate will be optimum.

EFFECT OF TEMPERATURE ON THE EXPRESSION OF GnIH, GnIH RECEPTOR, GH AND PRL GENES IN THE GRASS PUFFER DURING THE SPAWNING SEASON

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Gonadotropin-inhibitory hormone (GnIH) plays an important role in the reproduction of fish through regulation of various pituitary hormones. To know the role of temperature in the regulation of reproductive function, previously we investigated the expression of *kiss2*,*kiss2r*, *gnrh1, gnrh2* and *gnrh3*in the brain and *gpa*, *fshb* and *lhb*in the pituitary of sexually mature male grass puffer exposed to three different temperatures (14, 21, 28°C) for 7 days. In parallel to gonadosomatic index, the *kiss2* and *kiss2r* mRNA levels were significantly decreased by the low (14°C) and high (28°C) temperature exposures, concomitant with the decrease in *gnrh1*, *fshb* and *lhb* expressions. The plasma levels of cortisol were significantly increased in low temperature but remain unchanged in high temperature. In this study, we examined changes in expression of *gnih* and *gnihr* in the brain and pituitary along with growth hormone (*gh*) and prolactin (*prl*) genes in the pituitary of grass puffer exposed to the three temperature conditions. The levels of *gnih*and *gnihr* mRNA were significantly decreased in both low and high temperature conditions compared to normal temperature condition. Similarly, the *gh*mRNAs were significantly decreased in both low and high temperature conditions. The *prl* mRNAs were drastically decreased at low temperature but showed no significant changes at high temperature. The fish were considered to be under stress as the plasma levels of cortisol were significantly increased at low temperature. Taken together, the present results indicate that anomalous temperature has an inhibitory effect on reproductive function through the suppression of *gnih*/*gnihr*/*gh*/*fshb* and *lhb* expression in the grass puffer and these changes may occur in a normal physiological response (at high temperature) as well as in a malfunctional stress response (at low temperature).

IDENTIFICATION, ANNOTATION AND COMPARATIVE ANALYSIS OF HSP GENES (HEAT SHOCK PROTEIN 70 AND 90) FROM GILL TRANSCRIPTOME OF THREE FRESHWATER CRAYFISH

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Response to environmental stresses, mainly thermal stress are largely maintained by a set of proteins called heat shock protein (HSP) which are encoded by HSP genes. Among those HSP70 and HSP90 play a key role in heat stress regulation. We identified and annotated all these genes from gill transcriptome of three commercially important freshwater crayfish, *Cherax quadricarinatus*, *C. destructor* and *C. cainii*. The sequences were made publicly available to NCBI GenBank. Comparative molecular analysis of these genes across the species were also carried out. The HSP70 obtained from the species *C. quadricarinatus*, *C. destructor* and *C. cainii* were named as CqHSP70, CdHSP70 and CcHSP70; and CqHSP90, CdHSP90 and CcHSP90 accordingly. The deduced proteins encoded by CqHSP70, CdHSP70 and CcHSP70 contained 643 amino acids; and those encoded by CqHSP90, CdHSP90 and CcHSP90 were 732, 741 and 742 aa. HSP70 obtained from our study shared high similarity with HSP70s from crabs *Homarus americanus* (96%), *Callinectes sapidus* (93%) and *Scylla paramamosain* (93%) and *Portunus trituberculatus* (93%); with prawn *Litopenaeus vannamei* (94%), *Macrobrachium rosenbergii* (92%); and with shrimp *Penaeus monodon* (94%), *Metapenaeus ensis* (93%). A total of 43 nonsynonymous mutation (amino acid replacement) and 43 synonymous mutations were observed in HSP70s from three crayfish species, while 10 nonsynonymous mutation and 43 synonymous mutation were found in HSP90s across the species. However, all the changes were outside the functional sites. All the active sites in HSP70 and HSP90 were highly conserved across the species suggesting their important conserved functions in response to environmental stress. Findings of the study will assist in further molecular analysis and gene expression study.

IDENTIFICATION OF THREE SPECIES OF THE GENUS *Barilius* THROUGH GEOMETRIC MORPHOMETRIC AND DNA BARCODING ANALYSES

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The genus *Barilius,* belongs to the Cyprinidae family are locally known in Bangladesh as Koksa, Jaya and Bouiralietc. Throughout the world 33 species under the genus are identified, among them 6 species are reported in Bangladesh based on morphological traits. Currently, identification of fishes is confirmed through molecular makers, of which Cytochrome C Oxidase Subunit I (COI) is mostly used. Therefore, in this study attempts were taken to confirm taxonomic identification of the species under the genus *Barilius* through COI based DNA barcoding analyses. Samples of three species of the genus were collected from the Kankra and Atrai rivers of Dinajpur during January - December 2017. The geometric morphometric analyses were done using TPS (Thin Plate Spline) and PAST (Palaeontological Statistics) software. The geometric morphometric study of 12 landmarks based on the principal component analysis, scatter plot and UPGMA cluster analysis separated the species into three clusters. From the identified three clusters, 3 individual of each were taken for the DNA barcoding in order to confirm the species. The DNA extraction for amplification of COI gene was followed by PCR amplification, electrophoresis, purification and sequencing. The sequences were edited and submitted to the gene bank database (NCBI accession number: MG988394, MG988395, MG988396) and analyzed using MEGA (version 6.0) software. Sequences of each group were subjected to confirm with BLAST homology searching tools at NCBI and found that our group represented *B. barila*, *B. barna* and *B. bendelesis*. The phylogenetic trees based on three methods showed that the taxa were closely related and formed sister groups. The findings confirmed the availability of *B. barila*, *B. barna*, and *B. bendelesis* species in the northwestern part of Bangladesh. Further studies are required to confirm all the available species from the water body of the country under this genus using COI gene.

PRODUCTION OF MONOSEX ALL-FEMALE POPULATION OF SILVER BARB (*Barbonymus gonionotus*) THROUGH CHROMOSOME MANIPULATION

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The research work was carried out for induction of diploid meiotic and mitotic gynogenesis in silver barb *(Barbonymus gonionotus)* through heat shock treatment in order to produce monosex all-female population. Optimal UV-irradiation achieved when the sperm suspension containing 8×10^8 ml^{-1} was exposed to a UV dose of 196 µW cm^{-2} for 1.5 min. Diploidization of gynogenetics was done by heat shock at 40 ºC for 1min after 1.5min of fertilization that produced 40.36 ± 3.46% meiotic gynogens. Similarly, mitotic diploidization was achieved using the same heat shock treatment after 27.5min of fertilization that yielded 33.80 ± 2.84% mitotic gynogens. The gynogens were identified by karyotype, gonad identification through sexing and microsatellite DNA analysis. The karyological analysis revealed haploid set of chromosomes (N=23) inthe haploids and diploid sets of chromosomes (2N = 46) in the meiotic and mitotic gynogens and controls. Sexing of fish demonstrated that the meiotic and mitotic gynogens were nearly all-female, ranging 98.18 to 100% and 96.77 to 100% female sex respectively, while the control group contained a mean sex ratio of 54.4:52.8 female and male. DNA microsatellite analysis revealed that the meiotic gynogens contained the alleles same as their mother and the mitotic gynogens became homozygous by fixing any of the two maternal alleles. None of the gynogens had paternal inheritance. Sex-reversed meiotic and mitotic gynogenetic males (XX) were produced by feeding masculinizing hormone (17α-methyl testosterone, 30mg/kg of feed) treated feed for a period of 28 days started from first feeding stage and the sex-reversed males are known as neomales. Upon crossing with ordinary females the neomales produced all-female population which showed significantly (p<0.05) higher growth than the control (mixed-sex) group. The net production of monosex all-female group (4021.74±59.74 kg/ha) was significantly (p<0.05) higher than the control (3275.82±89.62 kg/ha), i.e. 22.77% more production was obtained from monosex all-female population. From the outputs of the study, it is suggested that the technology developed for production of monosex all-female population of *B. gonionotus* though gynogenesisis much valuable and need to be disseminated among the hatchery operators for commercial seed production.

MERISTIC AND MORPHOMETRIC VARIATIONS OF ENDANGERED BUTTER CATFISH, *Ompok pabo* INHABITING THREE NATURAL SOURCES OF SOUTH-WESTERN BANGLADESH

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The present study focuses to examine the meristic and morphometric variations of *Ompok pabo* from three populations namely, Bergobindapur *baor* (BB), Bhairab River (BhR) and Kapotaksha River (KR) in Bangladeshi freshwaters using the landmark-based truss network analysis. Truss protocol used in the present study based on seven general morphometrics and eight landmarks points constructed by interconnecting them to form total 16 truss measurements. Meristic counts were compared among three populations and no significant differences were observed in non-parametric Kruskal Wallis test. Univariate statistics (ANOVA) showed 5 [standard length (SL), post-orbital length (PsOL), maximum body depth (MBD), length of left barbel (LLB) and length of right barbel (LRB)] of seven morphometrics measurement and 8 (2-3, 3-4, 6-7, 2-7, 2-6, 3-6, 3-5, 2-8) of the 16 truss measurements significantly differed to varying degrees ($p<0.05$, $p<0.01$, $p<0.001$) among samples. Cannonical discriminant function analyses were done among the samples and the populations were fully separated. In case of both morphometric and truss measurements, the first and second discriminant function (DF) accounted for 76.3% and 23.7% respectively in group variability explaining 100% of the total among group variability. A dendrogram was drawn for three populations of BB, BhR and KR based on the morphometric and truss measurements where two clusters were mainly formed in which BB and BhR formed one cluster and KR formed a separate cluster. Based on the morphometric measurements, 91.7%, 95.2% and 100% of original grouped cases were correctly classified. The preliminary information derived from the present study may be useful to manage and conserve the *O. pabo* populations in three aforementioned ecological niches.

EFFECTS OF SAMCUP 50 EC ON CHANGES IN CELLULAR AND ENZYMES LEVELS OF COMMON CARP (*Cyprinus carpio)*

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The extensive use of organophosphate pesticides increases the possibility of its undesirable toxicity on non-target organisms. Organophosphorus pesticides (ops) are widely used in agricultural activities; however, the mechanism of immunotoxicity of these substances is unclear. Samcup 50 EC is a commonly used organophosphate insecticide in agricultural field worldwide. Agricultural run-off, pest control sprays are the major sources of exposure to this pesticide for freshwater aquatic organisms. In this study, the impact of toxicity of Samcup 50 EC on biochemical, haematological and histological responses were investigated on *Cyprinuscarpio*. After 96 h of exposure to pesticide the median lethal concentration (LC_{50}) was 7.390 ppm. The fish were exposed to different doses of Samcup 50 EC for 14 days and histological assessment of gill, kidney and liver tissues are done. Histopathology showed dose dependent changes in gill, kidney and liver tissues compared to control. Blood smearing of erythrocytes showed abnormal shaped cells of fish exposed to Samcup 50 EC compared to control. The fish were exposed to sub-lethal concentrations of Samcup 50 EC and significant ($p<0.01$) alterations were in the biomarker enzymes acetylcholinesterase activity (ache), plasma glutamate oxalacetate transaminase (PGOT), plasma glutamate pyruvate transaminase (PGPT). Reduction of ache activity indicates neurotoxicity of Samcup 50 EC towards *C. Carpio*. Increased activities of transaminase enzymes (PGOT, PGPT) of blood plasma indicate hepatic tissue damages. Blood samples were collected for glucose and calcium levels. Fish exposed to different doses of Samcup 50 EC showed decreased blood glucose level indicating increased energy demand. A progressive decrease was observed in plasma calcium levels after exposure to Samcup 50 EC. These results clearly indicate the intoxication of Samcup 50 EC towards C. Carpio and haematological, biochemical and histopathological responses prove that Samcup 50 EC hampers the normal physiology, growth and survival rate of fish.

STUDIES ON MOLECULAR DIFFERENTIATION AND COLOUR VARIATION IN THE HIGH-VALUE ORNAMENTAL FISH, OSCAR *Astronotuso cellatus*

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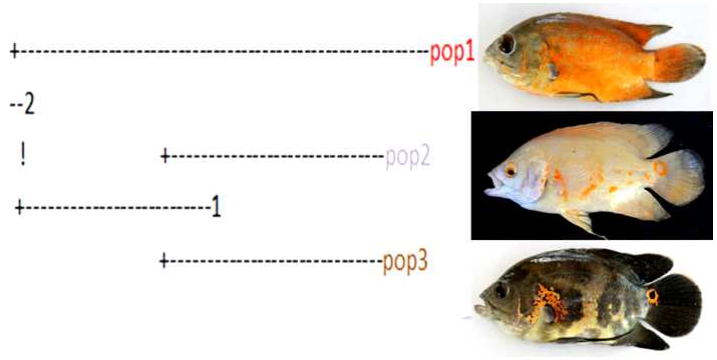
The nomenclature *Astronotuso cellatus* includes a number of varieties of Oscar with differences in colouration and patterns over the body, reported to be under a single genus and species. There has been no report on the phenotypic variation of colour with culture periods and the exact taxonomic status of the reported varieties of Oscar. In this context, an experiment of 90 days duration was conducted to assess the colour variation in three different varieties of oscar (albino, common and red oscar), fed on non-carotenoid based diet and their subsequent molecular differentiation. The different dimensional characteristics of colour appearance (hue - *H˚ab* and chroma – *C*ab*) were calculated from the pectoral and caudal regions of each variety at 30 day intervals, wherein, no significant ($p \leq 0.05$) differences were recorded in the parameters throughout experimentation in albino oscar indicating stability of the yellow spectrum. However, common oscarrecorded significant variation ($p \leq 0.05$) in the chroma and hue angle values between initial and subsequent period of experimentation. Red oscarrecorded increasing trend in chroma and hue values, indicating decrease of red spectrum with time. Therefore, yellow spectrum in wild phenotypes may be concluded to be more stable than the red spectrum and such varieties having a larger proportion of the yellow spectrum (such as the albino) may be profitably cultured on non-carotenoid based diets. Stability of colour for longer periods without the supplementation of carotenoids is a subject for future research.

The molecular differentiation of different strains (albino, common and red oscars) using barcode and RAPD reveals genetic distance among the strains. The albino and common oscarshow similar GC3 values (39.2) and red oscar shows variation from these values (38.6). The Nei's genetic distance clearly indicate that the red oscar is a different strain and genetically distant from both albino and common oscars (0.6161 and 0.5007 respectively). The present molecular study helps to resolve the ambiguity over the pure strains and hybrid varieties in this high value ornamental cichlid and will be helpful during selective breeding programs for identifying different strains. Attempts have been initiated to establish the exact taxonomic position of the fish using other specific markers.



GROWTH PATTERN, CONDITION INDEX AND BIOCHEMICAL COMPOSITION OF BIVALVE MOLLUSK *Parreysia corrugata* IN THE PADMA RIVER, NORTHWEST BANGLADESH

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The present study was conducted in the Padma River of northwest Bangladesh during January 2017 to December 2017to know growth pattern, condition index and biochemical composition of the freshwater bivalve *Parreysia corrugata*. During the study monthly mean shell length was ranged from 45.05±5.98 cm to 65.28±18.78 cm and body weight was ranged from 16.65± 6.85 g to 39.99±12.92 g. The length – length relationship followed a linear growth pattern and the length – weight relationship followed a non –linear growth pattern. During the study period shell length – shell breadth, shell length – shell depth, shell length – body weight, shell length –shell weight, shell length – tissue weight relationships were SB = 0.3996SL + 13.617, SD = 0.243SL + 8.2792, BW = $0.004L^{2.1972}$, SW = $0.0448L^{1.3711}$ and TW =$0.0012L^{2.2158}$ respectively. The b value of length-weight relationships was ranged from 1.3711 to 2.2158, indicates negative allometric growth pattern of the mussel during the study period. Condition index showed some seasonal fluctuations and the highest value observed (13.57) in March and lowest in December (6.33). All the biochemical components showed significant monthly fluctuation ($p< 0.05$). During the study the protein content ranged from45.30%to 54.62%, lipid from 6.81%to 13.21% and carbohydrate from 10.64% to 20.37%.The findings of the present study would be beneficial for fishery biologists or resource managers to impose suitable regulations for sustainable management of *Parreysia corrugata* in the riverine ecosystem of Bangladesh.

INTRODUCTION OF EXOTIC FISH SPECIES IN BANGLADESH: THREAT OR BLESSING?

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Impacts of introduction of exotic fish species in Bangladesh have been examined in this paper. Exotic fish introduction programmes have been undertaken mainly to develop aquaculture sector in Bangladesh in the belief that such programmes will improve the quality and quantity of fish production. All introductions were done intentionally. A total of 16 fish species have been introduced in Bangladesh. This list did not include the fish species, which have introduced as ornamental purposes. Most introduced species did not establish themselves in the wild. In Bangladesh introduced fish species contributed 3 to 8% in total inland production. Exotic fish species exerted ecological, pathological and genetic impacts on native fish species. Currently, no guidelines are available for fish introduction and fish hatchery operations. Quarantine mechanism is very weak. Recommendations are made to combat illegal fish introductions and to formulate guidelines for introduction of exotic fish species.

HEAVY METALS POLLUTION IN SURFACE WATER AND SEDIMENTS: A PRELIMINARY ASSESSMENT OF MEGHNA RIVER, BANGLADESH

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The study was conducted to investigate the physicochemical parameters of water and heavy metals concentration in water and sediments of the Meghna river during the period from April to December 2018. The water and sediments samples were collected monthly throughout the Wet (April to June) and Dry (October to December) seasons from three sampling stations namely as St-1 (Kauriapara), St-2 (Nagoriakandi) and St-3 (Kamargoan). The temperature, transparency, pH, electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), biochemical oxygen demand (BOD), hardness and alkalinity of water samples were analyzed in the laboratory of the Department of Environmental Science and Resource Management, Mawlana Bhashani Science and Technology University, Tangail.The concentration lead (Pb), copper (Cu), zinc (Zn) and Manganese (Mn) in surface water and concentration of Pb, Cu, Zn and iron (Fe) in surface sediments were analyzed in the laboratory of Soil Resource Development Institute (SRDI), Dhaka, Bangladesh. The result of the study showed that the physicochemical parameters such as temperature, pH, EC, TDS, TSS, DO, BOD, transparency, hardness and alkalinity of surface water varied from 17.1 to 32.5°C, 7.44 to 8.50, 121 to 869 µS/cm, 74 to 418 mg/l, 0.27 to 1.98 mg/1, 2.1 to 8.4 mg/1, 34.60 to 39.43 cm, 110.0 to 309.6 mg/l and 110 to 243 mg/l, respectively. In terms of heavy metal pollution, concentration of Pb, Cu, Zn and Mn in water were varied from 0.001 to 0.0.021, 0.000 to 0.026, 0.001 to 0.082 and 0.003 to 0.062 mg/l, respectively. The study depicted that Zn was the most abundant in water during the both seasons as Zn is normally associated with a variety of other metal activities and mining. In sediments, the concentrations of Pb, Cu, Zn, and Fe were varied from 6.34 to 20.46, 2.14 to 28.06, 81.30 to 98.90 and 22745.28 to 34623.10 mg/kg, respectively. The concentrations of Fe in all sediment samples were found above the EPA guidelines and revealed highly polluted sediments, whereas, the concentration of Cu and Zn were found in the moderately polluted range. Among the studied heavy metals in sediments Fe was the richest, because Fe is the most reactive and cycling material, and can quickly precipitate upon reaching the water body. The result of the study concluded that the Meghna river is subjected to anthropogenic disturbances; resulting in heavy metals pollution to some extent and all together the Meghna river are not safe for aquatic organisms. Thus, proper management initiatives through regular monitoring of water quality should be carried out to maintain the healthy aquatic environment of the Meghna river, Bangladesh.

CONCENTRATION OF TOXIC METALS IN WATER AND SEDIMENT OF PASUR RIVER IN BANGLADESH

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Rapid urbanization and population growth in fast growing cities leading to industrialization poses a major threat of Heavy metal pollution for Bangladeshi rivers flowing through the cities.This experiment was conducted to assess the levels of toxic metals like arsenic (As), chromium (Cr), cadmium (Cd), and lead (Pb) in water and sediments of the Pasur River in Bangladesh. The ranges of Cr, As, Cd, Pb in water were 25.76–77.39, 2.76–16.73, 0.42–2.98 and 12.69–42.67 µg/L and in sediments were 20.67–83.70, 3.15–19.97, 0.39–3.17 and 7.34–55.32 mg/kg. The level of studied metals in water samples exceeded the safe limits of drinking water, indicating that water from this river is not safe for drinking and cooking. Certain indices, including pollution load index (PLI) and contamination factor (C_i^f) were used to assess the ecological risk. The PLI indicated progressive deterioration of sediments by the studied metals. Potential ecological risks of metals in sediment indicated low to considerable risk. However, the C_i^f values of Cd ranged from 0.86 to 8.37 revealed that the examined sediments were strongly impacted by Cd. Considering the severity of potential ecological risk (PER) for single metal (E_r^i), the descending order of contaminants was Cd >Pb> As>Cr. It is therefore recommended that the environmental monitoring agencies should enforce more stringent and regular monitoring on the riverside industries. Also, measures to regulate the indiscriminate dumping of domestic waste as well as agricultural and raw sewage runoff into the river should be adhered more rigorously.

RISK ASSESSMENT OF TRACE METALS IN SEDIMENT AND WATER FROM AN INDUSTRIALLY POLLUTED RIVER OF BANGLADESH

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Industrialization process in combination with rapid population growth and agricultural activities has brought the risk of increasing the pollution index in natural environments, such as water, soil, air, etc. Karnaphuli River is one of the major river surrounded by different types of industries including the biggest sea port. The objectives were to evaluate the water quality parameters, levels of heavy metals in water and sediment, and the level of contamination. A total of 10 sampling sites from Karnaphuli River were selected to collect the sediment and water samples in summer and winter. Trace metals (As, Cr, Cd, and Pb) concentration of sediments and water were determined by atomic absorption spectrophotometer. The decreasing trend of metals were observed in water as Cr > As > Pb > Cd and in sediment Cr > Pb > As > Cd. The studied water samples exceeded the safe limits of drinking water, indicated that water from this river is not safe for drinking and cooking which could pose risk to the riverine environment. Contamination factor (CF) indicated that the sediment samples were moderately to highly contaminate by As, Cd and Pb. The pollution load index (PLI) values were above one (> 1) also indicated advanced decline of the sediment quality. Our data showed moderate to higher concentration of these metals in sediment and water; and this might be toxic to the aquatic organisms directly or by extension to humans that frequently consumed the contaminated aquatic species in this waterbody. So, the occurrence of some trace metals that discharged directly from man-made activities without treatment could result in some serious environmental problems of this river in the near future.

TRACE METALS IN IMPORTED FISHES OF BANGLADESH AND HEALTH RISK ASSESSMENT

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Trace metals (Ni, Cu, As, Co, Mn) concentrations are investigated in the muscle of imported fishes. 11 fish species are collected from Bhomora, Benapole and Chattrogram land port with invoice list. The origin of those fishes are India, Myanmar, Dubai, Oman, UAE. 3 different types of canned fishes are collected from Agora, Shwapno, Almas super shops of Dhaka. Bangladesh is one of the leading fish producing country with a total production of 41.34 lakh MT. The total amount of import fishes are increasing every year. These fishes contain harmful pollutants which is a big issue. According to 2016-17 fiscal year about 1 lac ton of fishes were imported. Trace metals are analyzed at Institute of National Analytical Research and service, Bangladesh Council of Science and Industrial Research (BCSIR), Dhaka by Atomic Absorption spectrometry. After analyzes exceed level of As recommend by FAO/ WHO 1984 are found in *Arius maculatus* fish which is known as cat fish and originated from Dubai. Low level concentration of trace metals are found in canned fishes. The Target Hazard Quotient index is estimated and which found less than 1. This analysis is indicated that low-level of risk is found to human health.

HEAVY METAL CONTAMINATION IN FEED BASED TILAPIA (*Oreochromis niloticus*) CULTURE IN RAJSHAHI

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As heavy metal contents in fish muscle are increasing day by day through different ways, the study was conducted on heavy metal contamination in feed based Tilapia (*Oreochromis niloticus*) culture in Puthia, Rajshahi for period of six month from March to August, 2017. In this study, the heavy metals, lead (Pb), cadmium (Cd), Nickel (Ni) and chromium (Cr) concentrations in sediment soil and water of the study ponds, fish feed used by the farmers and the accumulations of these metals in muscle were estimated. For this study, the sediment soil and water, fish feed and fish muscle samples were collected from the study ponds in regular intervals. The collected samples were preserved and prepared for analysis with standard methods. The concentrations of Pb, Cd, Ni and Cr in the samples were estimated through wet digestion at BCSIR Lab, Rajshahi and atomic absorption spectrophotometer (AAS) techniques at Central Lab, University of Rajshahi, Rajshahi. During the study period, the mean concentrations of Pb, Cd, Ni and Cr in the sediment soil were found as 16.71±3.55, 0.48±0.18, 11.53±2.05 and 5.30±1.08µg/g; in the water sample were 0.09±0.02, 0.01±0.00, 0.07±0.01 and 0.04±0.01 µg/g; in the fish feed sample were 16.13±1.59, 0.60±0.18, 15.07±1.6 and 6.05±0.16 µg/g; and in the fish muscle samples were 18.08±1.09, 0.74±0.03, 13.30±1.15 and 7.14±0.20µg/g, respectively. From this study, it was observed that the concentration of Pb, Cd and Cr were found comparatively higher in the fish muscle samples and the lower in the water samples whereas, the concentration of Ni was higher in the fish feed sample and lower in the water samples. From the present results and FAO/WHO approved standard levels and other related studies, it can be said that heavy metals were hardly being accumulated in the fish's body from sediment soil and water rather accumulated in large amount by the fish feeds.

HEAVY METAL CONTAMINATION IN FEED BASED CARPS CULTURE IN RAJSHAHI: A HUMAN HEALTH CONCERN

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A study was conducted to investigate the heavy metals contamination in carp fish culture system in Rajshahi region for a period from February to June 2018. In this study, cadmium (Cd), chromium (Cr), lead (Pb) and nickel (Ni) content in the feeds used by the farmers, sediment soil and pond water, and the accumulations of these metals in muscle, gill, kidney and intestine of four species of carp fish (*Catla catla*, *Labeo rohita*, *Cirrhina mrigala* and *Cyprinus carpio*) were estimated. The fish feed, soil and water, fish muscle, gill, kidney and intestine samples were collect from two farmer ponds (FP-1 and FP-2) from Harian under Paba Upazila, Rajshahi. The collected samples preserved, prepared and digested for metal analysis with standard methods. The concentrations of Cd, Cr, Pb and Ni were estimated through the atomic absorption spectrophotometer technique. During the study period, the mean values of Cd, Cr, Pb and Ni in the fish feed sample was 1.857±0.328µg/g and 1.857±0.328µg/g, 15.63±2.5µg/g and 1.857±0.328µg/g, 16.19±0.00µg/g and 24.34±1.62µg/g, 15.63±2.5µg/g and 1.857±0.328µg/g; in the soil sample was as 0.902±0.04µg/g and 1.304±0.049µg/g, 4.153±0.064µg/g and 10.19±0.029µg/g, 13.02±0.039µg/g and 18.98±0.5µg/g, 11.04±0.099µg/g and 15.08±0.079µg/g; in the water sample was 0.848±0.005ug/ml and 0.912±0.058 ug/ml, 6.465±0.019 µg/ml and 0.17±0.099µg/ml,3.215±0.029µg/ml and 6.514±0.024µg/ml, 10.12±1.23µg/ml and 10.38±0.069µg/mlFP-1 and FP-2 respectively. In *C. catla*, the grading of Cd, Cr, Pb and Ni content in muscle, gill, kidney and intestine wasPb>Ni>Cr>Cd, Pb>Ni>Cr>Cd, Pb>Ni>Cr>Cd and Pb>Ni>Cr>Cd inFP-1, and Pb>Ni>Cr>Cd, Ni>Cr>Pb>Cd, Ni>Pb>Cr>Cd, Pb>Ni>Cr>Cd in FP-2, respectively; in *L. rohita* wasPb>Ni>Cr>Cd, Pb>Ni>Cr>Cd, Pb>Ni>Cr>Cd and Pb>Ni>Cr>Cd inFP-1, and Ni>Cr>Pb>Cd, Pb>Ni>Cr>Cd, Pb>Ni>Cr>Cd and Pb>Ni>Cr>Cd in FP-2, respectively; in *C. mrigala* was Pb>Ni>Cr>Cd, Ni>Pb>Cr>Cd, Ni>Pb>Cr>Cd and Pb>Ni>Cr>Cd in FP-1, and Pb>Ni>Cr>Cd, Pb>Ni>Cr>Cd, Pb>Ni>Cr>Cd and Cr>Ni>Pb>Cd in FP-2,respectively; in *C. carpio* was Pb>Ni>Cr>Cd, Pb>Ni>Cr>Cd, Pb>Ni>Cr>Cd and Ni>Pb>Cr>Cd in FP-1, and was Pb>Cr>Ni>Cd, Cr>Ni>Pb>Cd, Ni>Cr>Pb>Cd and Cr>Ni>Pb>Cd inFP-2, respectively. The estimated heavy metals in the fish feeds, sediment soil and water of the study pond, fish muscle, gill, kidney and intestine samples were compared with FAO/WHO approved standard levels and other related studies and it can be said that heavy metals are hardly being accumulated in the fish's body from soil and water rather accumulated in large quantity through the feeds. This study showed that the fish samples examined were found to contain heavy metals above the FAO/WHO standard levels which may cause problems on the human health.

AVAILABLE FISH SPECIES IN THE FISH LANDING CENTER OF CHATTAGRAM, BANGLADESH

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The study was conducted in the fish landing center of Chattagram from February 2018 to June 2018 to record the available fishes found in the landing center. Data and fish samples were collected from the selected site of fish landing center, taking photographs of fishes, interview of the fisherman and sample collection. During the study period, only 61 species of fish were found in the landing center. Out of 61, 58 species belonged to fin fish and the rest 3 species to crustacean. Amongst the fish species, 17 were fresh water species and 41 marine water species were available. Among these freshwater fishes, 4 were exotic species and from marine water fishes, 8 species were imported from other countries. The highest number of species (23) were belong to the order perciformes. Among the total number of species recorded, 1 species were critically endangered (CR), 16 species were data deficient (DD), 3 species were endangered (EN), 3 species were least concern (LC), 2 species were vulnerable (VU) and 33 species were not threatened (NO) according to the IUCN red list of fishes. The marine fish and freshwater fish composition in the study area were 70.7% and 29.3% respectively. Oman, Mayanmar, India and China were the main source of imported fish species in the fish landing center. The qualities of this imported fishes were not maintained properly. Therefore, it is necessary to provide institutional and organizational support, government support and extension services on fish preservation, handling, icing and curing for the development of fish quality and availability status.

Table 1. Fish species found from different sources

Status of fish	Source of fish		Total
	Freshwater	Marine water	
Local Fish	13	33	46
Exotic Fish	4	0	4
Imported Fish	1	7	8
Crustacean	1	2	3
Total			61

POPULATION BIOLOGY OF *Puntius sophore* IN THE GAJNER *BEEL* WETLAND ECOSYSTEM (NORTH WESTERN BANGLADESH)

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The present study describes the population biology including length-frequency distributions (LFDs), length-length relationships (LLRs), length-weight relationships (LWRs), condition factors (Allometric, K_A; Fulton's, K_F; Relative condition, K_R; Relative weight, W_R), form factor ($a_{3.0}$) and sexual maturity (L_m) of *Puntius sophore* in the Gajner *beel*, northwestern Bangladesh. Sampling was carried out using traditional fishing gears like fash Jal (Gill net), khepla jal (cast net), thela Jal (push net) etc. during August 2017 to July 2018. All the lengths including total length (TL), fork length (FL) and standard length (SL) were measured to the slide calipers and total body weight (BW) was measured using an electronic balance with 0.01 g accuracy. The LWRs was calculated using the expression: $W= aL^b$, where the W is the body weight (BW in g), L the total length (TL in cm), a and b are the regression parameters. Fulton's condition factor (K_F) was calculated using the equation: $K_F =100\times (W/L^3)$, where W is the total body weight (BW, g) and L is the total length (TL, cm). A total of 506 specimens from the Gajner *beel*, ranging from 4.2 cm to 9.9 cm TL (total length) and 0.08 g to 15.87 g BW (body weight) were analyzed in this study. The LLRs were highly significant with all r^2 is $\geq$ 0.978. Also, the LWRs were highly significant with all r^2 values is $\geq$ 0.939. The allometric coefficient *'b'* of LWRs relationship indicated positive allometric growth of the species as *'b'* value was more than 3.0. The Fulton's condition factor (K_F) showed highly significant relationship for TL *vs.* K_F (Pearson's correlation test, $P < 0.001$). The relative weight (W_R) also showed highly significant corelated for BW *vs.* W_R ($P <0.001$) during the study. The calculated form factor ($a_{3.0}$) was 0.0215 in the Gajner *beel* for *P. sophore* suggesting that, this fish can be classified as elongated which is characteristic of many riverine fishes. In the present study the first sexual was 6.21 cm in TL. The results of the study would be an effective tool for fishery biologists, managers and conservationists to initiate early management strategies and regulations for the sustainable conservation of the remaining stocks of this species in the Gajner *beel* and surrounding ecosystems.

THE FIRST RECORD OF THREE SPECIES OF MARINE GASTROPOD *Indothais rufotincta*, *Turritella bacillum* and *Natica spadicea* FROM BANGLADESH USING MORPHOLOGICAL AND GENETIC ANALYSIS

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Molluscs are morphologically mega diverse faunal group in the marine ecosystem, exhibiting enormous diversifications in body plan and habitat preferences and playing critical ecosystem roles. Our current knowledge of species diversity is based almost exclusively on the recognition of morphological variability. Unfortunately, the subtle morphological characters that differentiate species of this group are not easily discerned by non-specialists and sometimes misidentified. Molecular methods like DNA-barcoding enable the quick identification of species when the recognition of diagnostic characters is not possible. Present study aims to assess the diversity of marine gastropods commonly found in the shore of Saint Martin's island and off Chittagong-Cox's Bazar coast. A new record of three species *viz. Indothais rufotincta* under family Muricidae, *Turritella bacillum* under family Turritellidae and *Natica spadicea* belongs to the family Naticidae have been identified initially based on its morphological characteristics and then confirmed by matching their sequence of mitochondrial COI gene fragments with the DNA barcode sequence data of NCBI and BOLD database using BLAST search. First two specimens were collected from Saint Martin's island, Bangladesh on December 2017 and third one is found from the cruise of Meen Shandhani research vessel of DoF in February 2019.

ASSESSING AQUATIC BIODIVERSITY OF THE SUNDARBANS, BANGLADESH THROUGH DNA BARCODING AND METABARCODING

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DNA barcoding and metabarcoding are the advanced molecular tools to identify unique, cryptic and new species from aquatic ecosystems and reveal undisclosed biodiversity than previously estimated. Sundarbans, the largest mangrove forest of the world and a UNESCO world heritage site, is a transition zone between freshwater of the Ganges river system and saline water of the Bay of Bengal, composing a large assemblage of unrivaled aquatic biodiversity. Present study aims to assess the marine and brackish water faunal biodiversity of Sundarbans, Bangladesh through morphological characteristics, and DNA barcoding and metabarcoding by mtDNA COI barcoding gene. The specimens were collected from the aquatic environment of Sundarbans from November 2015 to August 2017. In this study, we conducted morphologic analysis to identify the specimen up to species level before DNA sequencing. A total of 324 individuals of aquatic fauna including 118 species of fishes, 11 species of prawn and shrimps, 8 species of crabs and 6 species of mollusks have been successfully barcoded. The study provided first record of eight fish species in Bangladesh and discovered one world new species *Chelonodontops bengalensis*. Moreover, we initiated the application of DNA metabarcoding using high throughput technology (i.e. next generation sequencing, NGS) to assess the diversity of zooplanktons in aquatic habitat of the Sundarbans for the first time in Bangladesh. Result shows a total of 224 numbers of OUTs (operational taxonomic units) and their seasonal diversity variation from 11 sampling sites of Sundarbans. The present study suggests that using of DNA single barcoding and metabarcoding techniques could be vital tools for management of aquatic lives and habitats in Bangladesh which can contribute to achieve SDG-14by 2030. The study also contributes as an important step in building reference inventory of marine and brackish water faunal species for the world natural heritage Sundarbans in Bangladesh.

IMPACT OF SHRIMP (*Penaeus monodon*) FRY COLLECTION ON THE BIODIVERSITY OF COASTAL WATERS IN PATUAKHALI, BANGLADESH

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The study was conducted in Kuakata sea beach of Patuakhali district from September 2017 to August 2018 to assess the abundance of black tiger shrimp (*Penaeus monodon*) post larvae (PL) and to quantify the damage of different aquatic fauna during collection of *P. monodon* PL. Observation was also made on the distribution of aquatic organisms with the variation of water quality parameters and seasons. Insignificant variation in water temperature and pH was found but salinity and hardness showed great fluctuation during the study period. Regression analysis shows that the abundance of *P. monodon* PL was significantly ($p<0.05$) related to water temperature, pH, salinity and hardness. During the survey period around 1.55 million man days/year were estimated to be involved in shrimp PL collection activities and on average 216million of *P. monodon* PL were collected annually from the studied area. It was found that about 37 other shrimp larvae, 11 fin–fishes, 31 other macrozooplankton were killed during the period of collection for only one PL of *P. monodon*. It was also calculated from the present study that about 17,064 million of other shrimp species, fin–fishes and macro zooplankton were destroyed annually by shrimp seed harvesting process in Kuakata beach. Therefore, the results obtained from the study imply that present seed collection practice caused severe damage of other valuable aquatic fauna, which directly affect the biodiversity of tidal waters, natural productivity, improvement of natural stock and congenial environment of coastal and marine ecosystem.

POPULATION PARAMETERS OF *Botia dario* (CYPRINIDAE) IN THE PADMA RIVER FROM NORTH WESTERN BANGLADESH

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The threatened (endangered) carp, *Botia dario*, is an important, nutritionally valuable food fish in south Asian countries *i.e.*, Bangladesh, Bhutan, India and Nepal. The present study describes the first complete, inclusive description on life-history traits of *B. dario,* including – sex ratio, length-frequency distributions (LFDs), length-weight relationships (LWRs), length-length relationships (LLRs), condition factors (allometric, K_A; Fulton's, K_F; relative, K_R), relative weight (W_R), form factor ($a_{3.0}$), size at first sexual maturity (L_m) and natural mortality (M_W) in the Ganges River, northwestern (NW) Bangladesh. Samples were collected occasionally using multiples traditional fishing gears, including cast net (mesh size 1.5–2.0 cm), square lift net (mesh size ~1.5) and gill net (mesh size 1.8–2.2 cm) from July 2013 to June 2014. A total of 142 individuals of *B. dario* were collected, where 42.0% were males and 58.0% were females. The overall sex ratio did not differ significantly from the expected 1:1 ratio ($\chi 2 = 4.06$, $p>0.05$). Total length was varied from 5.59 to 12.87 cm and body weight ranged from 3.40 to 27.87 g. All LWRs were highly significant ($p<0.001$), with all r^2 values exceeding 0.97. The calculated allometric coefficient (b) indicated negative allometric growth in male, female, and combined sexes ($b<3.00$, $p<0.001$). All LLRs were highly significant ($p<0.001$), with coefficients of determination (r^2) values exceeded 0.98. Among the condition factors, K_F is the best index for assessing the well-being of this species in the Ganges River. The W_R was not significantly different from 100 for males ($p = 0.298$) and females ($p = 0.650$), indicating that habitat was still in good condition. The calculated $a_{3.0}$ was 0.0120 and 0.0103 for male and female, respectively. The L_m for male and female *B. dario* were 7.32 cm and 7.90 cm in TL, respectively. Moreover, M_W for this population was estimated as 1.09 y^{-1} in the Ganges River, NW Bangladesh. The findings of this study would be very effective for the sustainable management of this threatened carp in Bangladesh and also neighboring countries.

RISK MANAGEMENT, DISASTER RISK MANAGEMENT AND CLIMATE CHANGE ADAPTATIONS FOR RESILIENT FISHERIES IN BANGLADESH

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Climate change and disaster outbreak, with a close cause-and-effect relationship, have become a serious global concern in present days. It is more prominent in Bangladesh. Risk Management (RM), Disaster Risk Management (DRM) and Climate Change Adaptation (CCA) are three identical key management and adaptation tools for climate resilient fisheries worldwide. These tools in Bangladesh came into play since early seventies through different projects. Lessons and experiences learnt from projects with technical and financial support in this regard with Fisheries Rehabilitation Programme (NORAD 1972-75), ii. Mechanization of Country Fishing Boats (USSR- JICA 1974-78) iii. Boat Building and Mechanization (DANIDA 1974-80), iv. Empowerment of Coastal Fishing Communities for Livelihood Security (BGD/97/017, UNDP, 1999-2006); v. Bangladesh Marine Fisheries Capacity Building Project (IDB 2007-2017)and vi. Emergency 2007 Cyclone Recovery and Rehabilitation Project(WB, 2009-14)are worth mentioned. The most important effects of climate change in fisheries i.e., open water capture fishery are i. Change in habitat, ii. Loss of habitat; iii. Disease outbreak, iv. Hindranceto migration routes, v. Loss of genetic diversity and vi. Reduced biodiversity, vii. Reduced reproduction and viii. Reduced production.

Impacts of climate change on fisheries starts with cyclones, tidal surges, inland and coastal flooding, droughts, salinity intrusion, changes of river beds due to sedimentation and morphological processes which in turn affect fish and fisheries at different levels. Climate change imparts adverse impact on the outbreak of new diseases (IPCC 2001). Erratic and irregular rainfall and change in temperature affect the readiness, maturity, gonadal development and ovulation of fish followed by reduced hatching and survival rate of spawns, growth and recruitment which, in turn reduces fishery. The people of Bangladesh from the very beginning have been adapted to RM, DRM and CCA to the risk and effects of floods, droughts and cyclones. Promotion of salt-tolerant and short-endured HYV, fencing and dyke raising of ponds, aquaculture in floating net cages and introduction of innovative climate-smart aquaculture systems are climate resilient adaptations to aquaculture, and mechanization, redesigning of fishing boats, dredging of river beds and support from Climate Change Resilient Fund to the poor fishers aims to capacitate them for climate resilient fisheries in Bangladesh.

SUSTAINABLE MANAGEMENT OF SMALL INDIGENOUS FISHES IN THE PADMA RIVER CONSIDERING THE EMERGING CLIMATE CHANGE

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The SIFS (small indigenous fish species) is a food resource crucial in preventing malnutrition, and mineral deficiencies among the rural people. This highly diverse fish assemblage is declining gradually that has been largely overlooked by fisheries scientist. It is, therefore, the proper time to take appropriate measures to conserve these small fish species through suitable management policies. The objective of this study is to (i) analyze the status, (ii) estimate spawning season and longevity, assess the stock, identify the main threats and provide recommendations for the conservation of available SIFS in the Padma River considering the emerging climate change. Samples were collected from the fisherman catch during July 2010 to June 2018 in Pabna and Rajshahi region. The samples were immediately placed in ice, and then fixed in 10% formalin for laboratory work. The fixed specimens were sexed, weighed with 0.01 g accuracy, and measured to the nearest 0.01 cm. *Spawning season was estimated using GSI. T*he longevity was estimated from the time series of LFD. Stock of SIFS were assessed using several models. Information for threats to SIFS were collected through the survey to the fishers, fish farmers, traders, experienced persons, researchers, GO and NGO personnel and available literatures. A long data series of climate change were collected from Metrological department. A total of 78 species of fish under 9 orders and 25 families were recorded from the Padma River and Cyprinidae was the most dominant group, where 33 species were recorded as threatened. Among them, 11(33.3%) were vulnerable, 15 (45.5%) were endangered and 7 (21.2%) were critically endangered. The spawning season was April to August for *Mastasembelus armatus*, May to September for *Ompok pabda* and *Clupeisoma garua*, and April to September for *Pethiaticto*in the Padma River. Total mortality was 2.27 $year^{-1}$ for males and 2.19 $year^{-1}$ for females of *M. armatus*, 1.72 $year^{-1}$ for males and 1.92 $year^{-1}$ for females of *O. pabda*, and 2.67 $year^{-1}$ for males and 7.14 $year^{-1}$ for females of *P. ticto*. Also, the exploitation rate was around 0.30 $year^{-1}$ (30%) for males and females of *M. armatus,* 0.24 $year^{-1}$ (24%) for males and 0.45 $year^{-1}$ (45%) for females of *O. pabda,* and0.58 $year^{1}$ or 58% for males and 0.62 $year^{-1}$ or 62 % for females of *P. ticto* in the Padma River. The construction of Farrakka barrage by India in the Padma River and subsequent withdrawal of waters from the Padma River are the major causes for destroying its fish biodiversity. The present study can support fishery managers in designing their management plans and managing the fishery. For sustainable management, regular monitoring should be continued on first sexual maturity, spawning season, conditions of fish and water-body, growth performance and longevity, total, natural and fishing mortality, also the man-made and natural causes which may decline the fish diversity especially the SIFS in the Ganges River. The analysis of climate data (1964–2016) signified temperature is increasing by 0.025°C/year and rainfall is decreasing by 3.07 mm/year in the Rajshahi region and GSI shows significant correlation with temperature (p=0.0304) and rainfall (p=0.0049) which alarmingly predict the shifting of spawning season which should be considered for its future management.

STOCK ASSESSMENT OF GREEN BACK MULLET, *Planiliza subviridis* IN THE SHIBSA RIVER, SOUTHERN BANGLADESH

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The present study illustrates the stock' status of *Planiliza subviridis* with emphasizing on length-weight relationships (LWRs), condition factors, form factor, pre-predator status (based on relative weight, W_R), growth parameters (asymptotic length, L_∞; asymptotic weight, W_∞;growth co-efficient, K; age at zero length, t_0), growth pattern, growth performance index (φ), life-span (t_{max}), relative weight (W_R), formfactor ($a_{3.0}$), size and age at sexual maturity (L_m), total-(Z), natural (M), fishing (F) mortality and exploitation rate (E) of *P. subviridis* in the Shibsa river, Southern Bangladesh. A sum of 317 individuals of *P. subviridis* was sampled during July to December 2018 using traditional fishing gears like set bag net (mesh size ranges: 1.0-1.5 cm).For each individual, total length (TL) was measured to slide calipers and whole body weight (BW) was taken on an electric balance with 0.01 g accuracy. The relationship between length and weight (LWRs) was calculated using the expression: $W = a*L^b$. The size at first sexual maturity (L_m) of this species in the Shibsa river was calculated using the equation, log (L_m) = -0.1189 + 0.9157* log (L_{max}). Total length (TL) and body weight (BW) was ranged from 6.50-19.70 cm and 2.90 – 93.20g.The allometric co-efficient (b) values of LWRs were found3.02 for combined sex. The overall b value of LWR (TL *vs.* BW) indicated positive allometric growth (b<3.0). The mean W_R was not significantly different from 100 for the populations of *P. subviridis* indicating the habitat was quite suitable. The estimated L_∞, W_∞; K; t_0 were 20.79 cm, 93.20g, 1.02 years, 0.015 years, respectively and $t_{max=}$2.93 with the growth performance index φ=2.64,size at first sexual maturity 11.65 cm in TL. The calculated formfactor was ($a_{3.0}$) 0.0122.In addition, the total mortality Z was 2.23 year^{-1} for *P. subviridis* populations. The *M,F* and *E* were obtained as 1.57, 0.66 and 0.30 year^{-1}, respectively. Therefore, these results of this study would be very effective for wild stock management of *P. subviridis* in Shibsa river and adjoining countries of Bangladesh.

POPULATION BIOLOGY OF THE MINOR CARP *Labeo bata* IN THE GANGES RIVER OF NORTH WESTERN BANGLADESH

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The Minor carp, *Labeo bata* (Cyprinidae) is an important fish species in northwestern (NW) Bangladesh. This study illustrates the population biology of *L. bata* i.e., population structure (length-frequency distributions; LFDs), growth (length-weight relationships, LWRs; length-length relationships, LLRs), condition factors (allometric, K_A; Fulton's, K_F; relative, K_R; relative weight, W_R), form factor ($a_{3.0}$), reproduction (length at first maturity, L_m) and natural mortality (M_w) in the Ganges River, NW Bangladesh. Samples were collected occasionally between July, 2017 to June, 2018 using different fishing gears i.e., gill net (mesh sizes: 2.5-3.5 cm) and cast net (mesh sizes: 1.5-3.0 cm). A total 157 individuals of *L. bata* were collected, where sixty-nine were males, and eighty-eight were females. The sex ratio did not fluctuate significantly from the anticipated 1:1 ratio (df =1, χ^2=2.30, $p > 0.05$). Total length varied from 7.9 to 25.2 cm and body weight ranged from 4.68 to 181.35g. All LWRs were highly significant (p<0.01), with all r^2 values ≥0.984. The analysis of covariance (ANCOVA) revealed no extensive differences in LWRs between genders ($p > 0.05$). The allometric coefficient (b) indicated positive allometric growth in both sexes ($b > 3.00$, $p < 0.01$). All LLRs were highly correlated ($p < 0.001$), and most of the r^2 values were ≥0.992. Among four condition factors, K_F was the best fitted, and can be used as indicator of safe life for *L. bata* in the Ganges River. Wilkoxon Sign Ranked Test for W_R showed no considerable dissimilarity from 100 for male (p=0.295) and female (p=0.057). The $a_{3.0}$for both sexes was 0.0108. The L_m for male and female population was 14.12 cm and 14.60 cm in TL, respectively. The M_w for the population of *L. bata* was 0.86 year^{-1} in the Ganges River. This result would be effective for a sustainable management of this Minor carp in Bangladesh and its adjoining ecosystems.

POPULATION BIOLOGY OF ASIAN STINGING CATFISH, *Heteropneustes fossilis* IN A WETLAND ECOSYSTEM

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The Stinging catfish, *Heteropneustes fossilis* is a commercially important fish species in Asia. The present study revealed the population biology of *H. fossilis* including population structure (length-frequency distribution, LFD), growth pattern (length-weight relationships, LWRs; length-length relationship, LLR),conditions (Allometric,K_A; Fulton's,K_F;Relative condition, K_R), prey-predator status (relative weight, W_R) and natural mortality (M_W) of *H. fossilis* from the Gajner *beel,* wetland ecosystem in northwestern Bangladesh. Also form factor ($a_{3.0}$) and size at first sexual maturity (L_m) were calculated in world-wide wild populations. A total of 912 individuals of *H. fossilis* were captured by various types of traditional fishing gears such as cast net, square lift net, gill net and conical trap during July 2017 to June 2018. For each individual, total length (TL) and standard length (SL) were taken using digital slide calipers and body weight (BW) was measured by digital balance to the nearest 0.01cm and 0.01 g, accuracy. TL was varied from 6.50 to 26.80 cmand BW was ranged from 1.34 to 140.69 g. All LWRs were significant (p<0.001),with r^2 values ≥0.968. The calculated allometric coefficient(b) showed positive allometric growth in combined sexes (b>3.00). The LLR was significant (p<0.001) r^2 value> 0.985. The $a_{3.0}$ was 0.0051 and L_m was 15.45 cm TL for *H. fossilis* in the Gajner *beel*. Moreover, the mean M_W for this population was estimated as 1.09 year^{-1}. These findings would be very effective for further stock assessment and management of this fishery in the Gajner *beel* wetland ecosystem and adjoining ecosystems.

MOLECULAR IDENTIFICATION OF ZEBRA FISH (*Danio rerio*) IN BANGLADESH USING DNA BARCODING TECHNIQUE

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DNA barcoding has been recognized as an excellent and well established tool for the identification of fish species. In this experiment, a model animal in biological research zebrafish (*Danio rerio*, Hamilton, 1822)of different regions of Bangladesh has been morphologically and genetically identified using cytochrome oxidase subunit I (COI) to develop a baseline story of zebrafish identification and sequence variation. The genetic variation and relationship were assessed by constructing neighbor joining Phylogenetic tree and evolutionary distances were compared by Maximum Composite Likelihood method using MEGA 7 software. The samples showed 99% sequence likeness compared with deposited sequences of public database (NCBI). The overall sequence alignment similarity among our sampled specimens was 95.38% and the divergence among fishes of Cumilla-1,Cumilla-2, Netrakona-1, Netrakona-2, Rangpur-1,and Rangpur-2 was about 4.62%. Fishes of Cumilla, Netrakona, and Rangpur showed 2.89%, 1.31% and 2.18% intra-regional diversity respectively.

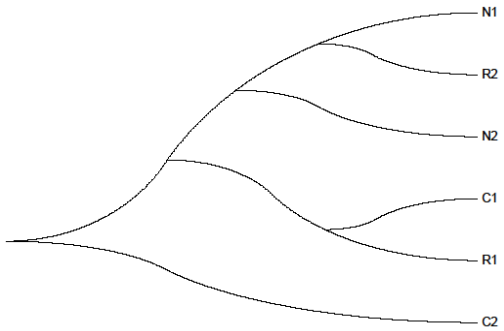

Fig.1. Curve phylogenetic tree showing the intra-relationship and genetic variance among 6 zebrafish samples. The samples from Rangpur are abbreviated as R1 and R2. The samples from Netrokona are abbreviated as N1 and N2. The samples from Cumilla are abbreviated as C1 and C2.

From phylogenetic the tree, it was found that Cumilla-1 and Rangpur-1 have the closest genetic distance and shows the highest similarity (Figure 1). On the other hand, the two fishes of Netrakona-1 and Cumilla-2 the highest genetic distance. This result demonstrates a significant role to the global barcode reference as well as regional zebrafish identification. In addition, the knowledge of the molecular identification and genetic variation of zebrafish could help in formulating more effective strategies for managing this aquaculture species and also in evaluating the potential genetic effects induced by hatchery operations for selective breeding.

HUMAN HEALTH RISK ASSESSMENT OF HEAVY METALS CONTAMINATED SHRIMPS *Penaeus monodon* CULTURED IN BANGLADESH

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Heavy metals are not only the threat to aquatic environment but also they can pose risk to human health through the consumption of aquatic products especially fish and shrimp. Concentrations of five heavy metals namely cadmium (Cd), lead (Pb), copper (Cu), nickel (Ni) and chromium (Cr) in cultured shrimp (*Penaeus monodon*) were estimated in south-west region of Bangladesh to evaluate contamination levels and health risks for Bangladeshi people. The analyzed concentration of metals in shrimp samples varied among region to region (Morrelganj, Mongla and Satkhira Sadar), organ to organ (shell, head and muscle). Metals like Cd, Pb, Cu and Ni in shrimp were higher than the respective maximum allowable concentrations (MAC), whereas Cr was found below determination level.

Table 1. Target Hazard Quotients (THQ) (above)and Carcinogenic risk (CR) (below)estimated from pre-monsoon heavy metal concentrations in shrimp (Bold indicate THQ > 1)

Heavy Metals	Rural			Urban		
	SatkhiraSadar	Morrelganj	Mongla	SatkhiraSadar	Morrelganj	Mongla
Cd	0.3893	0.533723	0.490213	0.50915	0.698035	0.64113
Pb	0.361558	0.518347	0.850201	0.472868	0.677925	**1.111944**
Cu	**1.605958**	**1.557065**	**1.45907**	**2.100369**	**2.036423**	**1.908259**
Ni	0.137274	0.088818	0.329886	0.179535	0.116161	0.431445
Cr	0	0	0	0	0	0

The non-carcinogenic and carcinogenic health risks associated with this metal intake were evaluated in terms of dietary intake (EDI), target hazard quotients (THQs) and carcinogenic risk (CR). The THQ values for individual metals (Cd, Ni, and Cr) were below 1, whereas the higher THQ of Cu and Pb confirmed non-carcinogenic health hazards which indicates the potential risk to consume the contaminated shrimp. Also, the estimation confirmed that the carcinogenic risk (CR) of lead was within the acceptable level for shrimp. From the health concern view, this study showed that the inhabitants who consume studied shrimps at current accumulation level are exposed chronically to metal pollution with carcinogenic and non-carcinogenic consequences.

Heavy metal	Rural			Urban		
	SatkhiraSadar	Morrelganj	Mongla	SatkhiraSadar	Morrelganj	Mongla
Pb	1.07564E-05	1.54208E-05	2.52935E-05	1.4067E-05	2.01683E-05	3.30803E-05

IMPACT OF SANCTUARY ON BIODIVERSITY AND PRODUCTION OF FISHES IN DEKAR *HAOR* OF SUNAMGANJ, BANGLADESH

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An investigation was carried out to ascertain the impact of sanctuary on fish biodiversity, production and conservation of fishes in the Dekar *haor*, Sunamganj over a period of six months from September 2017 to February 2018. Data on species diversity, fish production and protection of aquatic organisms were collected through catch monitoring, catch assessment survey, focus group discussion, questionnaire interview, key informant interview with fishers and relevant stakeholders and also crosscheck interview. A total of 64 species belonging to 46 genera including finfishes (57), freshwater prawns (2), crabs (1) and mollusks (4) was recorded during the study period. Of 57 freshwater fishes, 52 species were indigenous and rest 5 species were exotic, which belonged to 8 orders and 22 families. Catfishes were found to be the largest group (23%) among the other common groups like as carps, barb and minnows, loach, perch, mud-skipper, gars, eel, snake-head, feather-backs and puffer-fish. Cypriniformes was the most dominant order with 33% of total fishes followed by perciformes (32%), siluriformes (23%), both osteoglossiformes and clupeiformes (3%), and each of synbranchiformes, beloniformes and tetraodontiformes (2%). Cyprinidae was occupied the highest position in fish population (17%) among the recorded families. Fifteen (15) species were found as threatened in Dekar *haor*, which were categorized into critically endangered (1), endangered (8) and vulnerable (6). Small indigenous species (SIS) contributed the highest amount (1936.5 kg)from the view point of production. The average production of fish in sanctuaries obtained as 4.98 ton/ha. Results of the study reveal that fish sanctuary has positive impact on fish biodiversity and production in the *haor*. Therefore, it may be concluded that restoration of threatened species, fish diversity and overall fish production would be increased in wetlands and floodplain by establishing sanctuary with the help of active participation of fishermen community and intensive care/cooperation of the local government as well as non-government authority.

POPULATION BIOLOGY OF GANGETIC LEAFFISH, *Nandus nandus* IN THE WETLAND (GAJNER *BEEL*, NORTH WESTERN BANGLADESH) ECOSYSTEM

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The Gangetic leaffish, *Nandus nandus* is a small indigenous fish species in Bangladesh. It is a freshwater fish species of the family Nandidae. The present study describes the population biology including length-frequency distribution (LFD), length-weight relationships (LWRs), length-length relationship (LLR), condition factors (Allometric, K_A; Fulton's, K_F; Relative condition, K_R; Relative weight, W_R) form factor ($a_{3.0}$) and size at first sexual maturity (L_m) of *N. nandus* in the Gajner *beel*, Pabna, northwestern (NW) Bangladesh. A total of 308 specimens ranging from 4.2 cm to 17.7 cm TL and 2.26 g to 99.86 g BW were analyzed in this study. Sampling was conducted using traditional fishing gears including *fash jal* (Gill net), *thela jal* (Push net) during July 2017 to June 2018. The lengths including total length (TL) and standard length (SL) were measured using digital slide calipers and total body weight (BW) was measured using an electronic balance to the nearest 0.1 cm and 0.01 g accuracy, respectively. The LWRs was calculated using the expression: $W= aL^b$, where the W is the body weight (BW in g), L the total length (TL in cm), a and b are the regression parameters. Fulton's condition factor (K_F) was calculated using the equation: $K_F =100\times (W/L^3)$, where W is the total body weight (BW, g) and L is the total length (TL, cm). The 8.00 to 11.00 cm in size group was numerically dominant, constituting 42.21% of the total population. On the basis of b values, the growth pattern of *N. nandus* was positive allometric (b>3.0) in all the LWRs. Also, all the LWRs were highly significant with all r^2 values > 0.960. Also, the results showed highly significant correlation between TL *vs.* SL (p<0.001). From four types of condition factor, the K_F showed highly significant relationship between TL *vs*. K_F and BW *vs.* K_F (p<0.001), therefore, K_F is the best for assessing the wellbeing of this species in the Gajner *beel*, NW Bangladesh. In addition, the calculated $a_{3.0}$ was 0.0214 which indicates the fish is short and deep in body size. Also, the L_m of *N. nandus*was10.29 cm TL in the Gajner *beel*. Therefore, the results of this study would be very effective for sustainable management and conservation of *N. nandus* in the Gajner *beel* and adjoining ecosystem.

MORPHOMETRIC AND MERISTIC CHARACTERISTICS OF *Trichogaster fasciata* IN GAJNER BEEL WETLAND ECOSYSTEM (NORTH WESTERN BANGLADESH)

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This study represents the morphometric and meristic characters of the least concern, *Trichogaster fasciata* including length-weight relationships (LWRs) and length-length relationships (LLRs) using a total of six linear dimensions and various meristic counts from the Gajner *beel*, a large wetland ecosystem of northwestern Bangladesh. A sum of 324 specimen of *T. fasciata* were occasionally collected from the Gajner *beel* during July 2017 to June 2018, using different traditional fishing gears like cast net (mesh size:1.0-2.0 cm), gill net (mesh size:1.5-2.5 cm), square lift net (~1.0 cm) etc. Fin rays were counted with the help of a magnifying glass. Moreover, a total of seven different lengths (TL, SL, PrDL etc.) were measured to the nearest 0.01 cm using digital slide calipers and total body weight (BW) was weighed by an electronic balance with 0.01 g accuracy for each individual, respectively. Minimum and maximum sizes were 3.1-8.8 cm (Mean ± SD = 5.78± 1.50) in total length (TL) and 0.81- 13.15 g (Mean ± SD = 4.90±3.30) body weight (BW). All LWRs were highly significant ($p< 0.001$) with r^2 values ≥ 0.960. Based on r^2 value, LWRs by BW *vs.* TL was the finest fitted model among seven equations. In addition, the LLRs had also significance with r^2 values ≥ 0.993. Based on r^2 values, LLRs by TL *vs.* SL was the best fitted model among six equations. The fin formula of *T. fasciata*is: dorsal fin is XV-XVII/10-14, pectoral fin 9-10, pelvic fin 1, anal fin XV-XVIII/ 15-19 and caudal fin 18-20. This study will contribute for species identification and stock assessment of *T. fasciata* in Gajner *beel* and adjacent ecosystems.

PRESENT STATUS OF USES OF AQUA-CHEMICALS IN HATCHERIES AND FISH FARMS IN RAJSHAHI DISTRICT

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Present study was conducted in fish hatcheries and fish farms to find out different chemicals used in freshwater aquaculture activities in Rajshahi District, Bangladesh. Data were collected through questionnaire interview, personal contact with fish hatchery owners and culture farmers. Fifty different chemicals were used for different purposes as pond preparation, water quality management and fish poisoning, insect killing, disinfectant and fish disease treatment in this region. Lime and Zeolite were used for pond preparation and water quality management. Rotenone, phostoxin tablet, ripcord were used as fish poison of which rotenone was widely used (65.9%). In addition, sumithion, bleaching powder, lime were used as medicine for disease treatment. 79.2% of the farmers used sumithion. Triple super phosphate and urea were the most widely used fertilizers in this region. Fish health management and disease treatment were the key areas where majority of different chemicals were used. Farmers use different chemicals in disease treatment namely lime, salt, potash, zeolite, zeotox where 57.3% farmers used potash. Renamycin was the most widely used (31.1% farmers) antibiotic besides farmers used tetracyclin, orgamycin 15% for disease treatment. The study also indicated some problems associated with the use of such chemicals due to lack of knowledge of farmers about the use of chemicals, appropriate dose, method of application and their indiscriminate use of chemicals. The study also highlighted the names and dose of aquaculture chemicals available with the fish farmers in Rajshahi district.

TEMPORAL VARIATIONS OF SEX RATIO, GROWTH PATTERN AND PHYSIOLOGICAL STATUS OF *Eutropiichthys vacha* IN THE PADMA RIVER, BANGALDESH

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The present study describe the first complete temporal variations of sex ratio (SR), length-frequency distributions (LFDs), growth pattern based on length-weight relation (LWR), length-length relationships (LLRs) and physiological status of *Eutropiichthys vacha* in the Padma River, Bangladesh. A total of 1386 specimens (male = 652, female = 734) were collected from the fishers catch during January to December, 2016. For each individual, total length (TL), fork length (FL), standard length (SL) and body weight (BW) were measured using digital slide calipers and electronic balance with 0.01 cm and 0.01 g precision. The overall SR differed statistically from the expected 1:1 ratio, although females were greater in percentage throughout the year, except in April. The TL of males and females ranged from 6.2–19.9 cm and 6.5–20.6 cm, respectively. The overall growth pattern was negative allometric for both sexes, though ANCOVA reveals significant difference in LWRs. All LLRs were highly significant with $r^2 > 0.962$. The highest percentage of fatty fish was found in April and March whereas the lowest was in August for both sexes. Finally, these findings will be useful for further studies and to suggest sound policy for the sustainable management of *E. vacha* in the Padma River ecosystem.

SEASONAL (DRY- AND WET-SEASON) VARIATIONS OF FISH DIVERSITY, WATER QUALITY AND PHYTOPLANKTON ABUNDANCE IN TWO WETLAND ECOSYSTEM, NW BANGLADESH

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Bangladesh is endowed with a vast expanse of inland and marine water resources characterized by rivers, canals, natural and man-made lakes, freshwater marshes, estuaries, brackish water impoundments, floodplains, coastal belt and vast sea waters. The study was conducted to make a comparison of Water quality parameters, fish diversity and plankton abundance between two *beels* namely *Beel* Kumari (Community managed) and Shutki *Beel* of Rajshahi district in dry (October to December)and wet (July to September) season for a period of six months from July 2015 to December 2015.The study was carried out by using traditional fishing gear like seine net and collecting water sample. Different indices of fish diversity were studied using software PAST. There was a slight variation in water quality parameters between two *beels.* Mean values of air temperature, water temperature, transparency, pH, DO,CO_2 and alkalinity of *Beel* Kumari and Shutki *Beel* were 31.416±2.479°C, 30.35±2.424°C, 20.266±9.291cm, 7.316± 0.293, 5.611± 0.179 mg/l, 20.373± 2.696 mg/l, 63.1± 8.927 mg/l and 29.916±2.772°C, 28.483±2.510 °C, 18.1±10.889 cm, 7.266± 0.234, 5.513± 0.188mg/l, 21.653± 1.851 mg/l, 63.1± 8.082 mg/l, respectively. A total of 30 species of fish were found from *Beel* Kumari belonging to 6 orders and 11 families. On the other hand, 22 species were observed belonging to 6 orders and 11 families. Cypriniformes was recorded as the most diversified fish group in term of both number of species and individual observed in both *beels*. Species were more diversified in dry season than wet season in both waterbodies. In both *beels* phytoplankton was relatively higher in dry season than wet season. The findings of the current study would be very effective for the conservation and management of two wetlands and adjoining ecosystems.

MORPHOMETRIC, MERISTIC AND LANDMARK BASED ANALYSIS OF FOUR VARIETY OF CLIMBING PERCH (*Anabas testudineus*) IN BANGLADESH

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The study was aimed to evaluate the morphological variations among the four variety (Indigenous, Thai, Vietnam and Thai-Vietnam cross) of climbing perch (*Anabas testudineus*) based on the morphometric, meristic and landmark analysis. Fish samples were collected from the South-west coastal region of Bangladesh during January to June, 2017. A total of 120 specimens (30 individuals of each variety) ranging from 8-15.20 cm in total length (TL) and 7.60-71.80 gm in body weight (BW) were collected. Seventeen morphometric characters and body weight of fishes were measured. Eight landmark points determining 12 distance outlines were analyzed by Klonk professional image measurement software version 3.2.1.2. Five meristic measurements were tested (ANOVA), among them DFR, PcFR and PvFR showed significant variation (Table 1). For both morphometric and landmark measurements, the first Discriminant function (DF1) accounted for 89.7% and65.7%, the second Discriminant function (DF2) accounted for 9.7% and 25.7% and the third Discriminant function (DF3) accounted for 0.6% and 8.7%, respectively; among group variability, explaining 100% of total among groups variability (Fig. 1). The Length-weight relationship was estimated by the liner regression analysis based on natural logarithm (Fig. 2). The calculated regression parameter 'b' based on relationships between TL and BW indicates negative allometric growth for Indigenous variety, positive allometric growth for Thai variety, isometric growth for Vietnam variety and Thai-Vietnam cross variety ($p<0.05$).

Table 1. Meristic measurement differences among samples from four variety of climbing perch

Meristic characters	Wilks' Lambda	F	P value
DFR	.846	7.042	.000***
PcFR	.729	14.371	.000***
PvFR	.438	49.522	.000***
CFR	.941	2.436	.068
AFR	.888	4.873	.003**

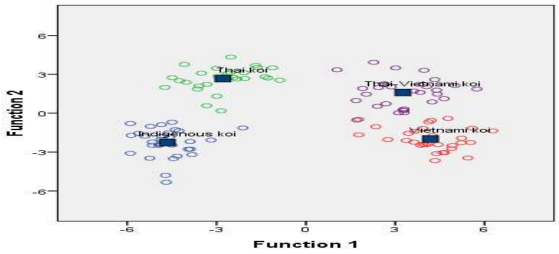

Fig. 1. Sample centroids of discriminant function scores based on landmark measurements of four variety of perch.

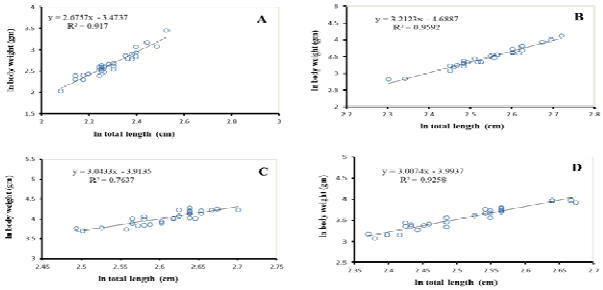

Fig. 2. Relationship between log-transformed total length and log-transformed body weight for Indigenous (A), Thai (B), Vietnam (C) and Thai-Vietnam cross variety (D) of climbing perch.

MORPHOMETRIC AND MERISTIC CHARACTERISTICS OF *Channa punctata* IN THE GAJNER BEEL WETLAND ECOSYSTEM

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The Spotted snakehead, *Channa punctata* is a freshwater, brackish, benthopelagic, and potamodromous fish belonging to the family Channidae. This species is listed as least concern due to lack of major threats of life *C. punctata* is renowned in Indian Subcontinent and surrounding areas ranging across Afghanistan, Pakistan, India, Sri Lanka, Nepal, Bangladesh, Myanmar and Tibet. Also this species are widely abundant in ponds, ditches, *beels*, and swamps. This research work affirms with the morphometric characters and meristic counts of *Channa punctata* in a wetland ecosystem (Gajner *beel)* from northwestern Bangladesh. A sum of 307 specimens of *C. punctata* were sampled intermittently from Gajner *beel* during July 2017 to June 2018, using different conventional fishing gears (e.g. cast, gill, and square lift net mesh size ranges: 1.5 - 2.5 cm, mesh size ranges: 1.5–2.0 cm, mesh size:~2 cm). Fin rays were counts by a magnifying glass. As well a total 7 diverse morphometric lengths were assessed to 0.1 cm and whole body weight (BW) was calculated to the nearest 0.1 g for each individual. The fin formula is: dorsal, D. 30–32; pectoral, P_1. 15-17; pelvic, P_2. 5; anal, A. 19-21; and caudal, C. (ii -iv/12-14). Minimum and maximum sizes were 5.80 to 23.00 cm in total length (TL) and also body weight (BW) were 1.96 to 126.90 g, respectively. All LWRs were highly significant ($p< 0.001$) with $r^2 \geq 0.986$. Based on r^2 value, $BW = 0.0112*(TL)^{2.98}$ was the best fitted model among 7 equations. Besides, based on r^2 values, LLRs by TL *vs.* SL was the best fitted model among 6 equations. These findings will help for species identification and further stock/ biomass estimation of *C. punctata* in the Gajner *beel* or connected ecosystems.

SEASONAL DYNAMICS OF STOMACH CONTENTS, TROPHIC LEVEL, LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR OF *Mystus bleekeri*

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The present study describes the stomach content, trophic level, length-weight relationship (LWR) and condition factors of *Mystus bleekeri* collected from Dekhar Haor, Sylhet, Bangladesh from July 2017 to June 2018. A total of 600 specimens ranging from 6.9–24.6 cm total length (TL) and 5.7–72.4 g body weight (BW) were analyzed in this study. Stomach content analysis revealed that fish fed mostly on molluscs (25.36%) and worms (21.68%) followed by plant matters (3.32%), cladocerans (1.18%), copepods (0.95%), and teleosts (0.36%). The significantly (p<0.05) highest mean trophic level (3.02±0.23) was observed in August while the lowest (2.35±0.13) was in December. The LWR analysis revealed that M. bleekeri indicated negative allometric growth (b<3) throughout the year. The results also indicated that LWR were highly correlated (r^2=0.569–0.906). The mean K values was significantly higher (p<0.05) in October indicating the heavier weight and good condition of fishes.

Table 1. Monthly percentage frequency of different prey types in the gastro-intestine of *M. bleekeri* during the study period

	Frequency of occurrence (%)/ Month											
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Plant matter	0	0	8	8	0	16	8	4	24	8	28	8
Insects	16	8	36	40	16	28	72	32	40	32	44	28
Mollusks	88	84	88	64	88	68	60	68	84	68	60	36
Teleosts	4	0	4	0	4	0	0	0	0	0	0	0
Worms	48	72	64	56	48	60	48	84	56	84	64	48
Cladocerans	12	0	4	4	12	0	4	0	0	0	4	0
Copepods	0	0	4	8	0	8	0	0	0	0	12	0
Other	100	100	100	100	100	100	100	100	100	100	100	100

Table 2. Monthly regression coefficients of length-weight relationships of *M. bleekeri* in the Dekhar Haor, Bangladesh from July 2017 to June 2018

Month	a ±S.E	*b* ±S.E	r^2	χ^2	Equation	GT	*K*	*K*n
July	0.302±0.110	1.474±0.152	0.692	1.652	$W = 0.302L^{1.474}$	A-	$0.8546±0.275^{B}$	$1.006±0.106^{G}$
August	0.040±0.088	2.323±0.184	0.761	3.645	$W = 0.040L^{2.32}$	A-	$0.706±0.099^{B}$	0.989±0.132
September	0.101±0.027	2.018±0.098	0.906	5.707	$W = 0.101L^{2.018}$	A-	$0.768±0.093^{B}$	$1.028±0.070^{G}$
October	0.067±0.042	2.140±0.231	0.656	21.931	$W = 0.067L^{2.140}$	A-	$0.743±0.200^{B}$	$1.216±0.306^{G}$
November	0.129±0.036	1.928±0.105	0.875	5.005	$W = 0.129L^{1.928}$	A-	$0.780±122^{B}$	0.989±110
December	0.077±0.030	2.089±0.149	0.820	4.155	$W = 0.077L^{2.089}$	A-	$0.746±139^{B}$	$1.030±141^{G}$
January	0.387±0.232	1.605±0.214	0.569	33.879	W = 0.3871.605	A-	$0.882±0.180^{B}$	$1.000±0.149^{G}$
February	0.339±0.172	1.674±0.172	0.652	40.074	$W = 0.339L^{1.674}$	A-	$0.859±0.243^{B}$	$1.009±0.182^{G}$
March	0.212±0.073	1.795±0.120	0.847	10.152	$W = 0.212L^{1.795}$	A-	$0.733±0.117^{B}$	$1.002±0.078^{G}$
April	0.140±0.051	2.01±0.121	0.868	23.523	$W = 0.140L^{2.010}$	A-	$0.856±0.135^{B}$	$1.002±0.117^{G}$
May	0.39±0.015	2.490±0.173	0.835	35.499	$W = 0.39L^{2.490}$	A-	$0.704±0.147^{B}$	$1.024±0.193^{G}$
June	0.07±0.024	2.14±0.103	0.900	21.238	$W = 0.07L^{2.14}$	A-	$0.677±0.109^{B}$	$1.03±0.122^{G}$

DETERMINATION OF HEAVY METAL CONCENTRATIONS IN CULTURED TILAPIA *Oreochromis niloticus* FROM NOAKHALI AND LAXMIPUR, BANGLADESH

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Pollution of aquatic environment with heavy metals has become a world-wide problem during recent years. The present study carried out to determine the heavy metals (Cu, Zn, Pb, Ni, Cd, Cr and Mn) in the muscle of *Oreochromis niloticus* fish species from aquaculture ponds in Noakhali and Laxmipur region were research during March, 2018. Fish samples were collected from twelve fish farms and heavy metals were measured by using ICE 3300; Thermo Scientific designed in UK made by China, Atomic Absorption Spectrophotometer. The results revealed that the metals followed the order of Zn (8.71mg/kg) > Mn (6.82mg/kg)>Cu (1.25mg/kg)>Cr (0.41mg/kg) in Noakhali region and Zn (9.22mg/kg) > Mn (5.40mg/kg) >Cu (0.97mg/kg) >Cr (0.34mg/kg) in Laxmipur region. Copper concentration in fish samples were composed from aquaculture ponds ranging from 0.74mg/Kg to 1.67mg/Kg, zinc concentration in fish samples ranges from 7.63 mg/Kg to 10.44 mg/Kg, manganese concentration in fish specimen ranges from 2.24 mg/Kg to 13.57 mg/Kg and the Cr concentration in fish samples ranges from 0.20 mg/Kg to 0.70 mg/Kg. The obtained value showed that the average value of Cu, Cr, and Zn and Mn concentration in fish of aquaculture ponds didn't exceed the limit of the WHOs standard regard. The estimated concentrations of all metals in the present study were lower than the limits permitted by FAO, WHO, EU, United States Food and Drug Administration (USFDA), US Environment Protection. Multivariate statistical analysis such as principle component analysis and correlation matrix showed significant anthropogenic intrusions of Zn, Cd, Pb, Cu, Ni, Mn, and Cr in fish muscle. The study suggested that the fish of these aquaculture farms are safe for human health.

MORPHOMETRIC RELATIONSHIPS OF *Salmostoma bacaila* (CYPRINIDAE) FROM THE GANGES RIVER USING MULTI-LINEAR DIMENSIONS

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The present study illustrates the first complete and inclusive information of morphometric relationships including length-weight relationships (LWRs) and length-length relationships (LLRs) using 9 linear dimensions and meristic characteristics covering various fin-rays of *Salmostoma bacaila* from the Ganges River in northwestern (NW) Bangladesh. A total of 236 individuals of *S. bacaila* were collected occasionally from the Ganges River from July 2015 to June 2016, using traditional fishing gears including a cast net (mesh size ranges: 1.5 - 2.5 cm), a gill net (mesh size ranges: 1.5–2.0 cm), and a square lift net (mesh size: ~2.0 cm). For each individual, a total of nine various lengths were measured nearest to 0.01 cm with digital slide calipers, and the body weight was measured to the nearest 0.01g accuracy by an electronic balance. The LWRs were calculated using the formula: $W = a \times L^b$, where W is the body weight (g), L is the length (cm), and *a* and *b* are LWRs parameters. Fin-ray numbers from all fins as well as scales were computed by a magnifying glass.

Total length (TL) varied from 5.9 -11.5 cm and the total body weight (BW) ranged from 1.31-8.8g. All LWRs were highly significant ($p < 0.001$) with r^2 values ≤ 0.959. Based on r^2 value, LWR by BW *vs.* TL ($W = a \times L^b$) was the best fitted model among nine equations. In addition, the LLRs were also significant with r^2 values ≤ 0.985. According to r^2 value, LLR by TL *vs.* FL ($TL = a + b \times FL$) was the best fitted model among eight equations. The fin formula of *S. bacaila* is: dorsal, D. 8-9 (2–3/6-7); pectoral, Pc. 12 (2-4/8-10); pelvic, Pv. 8-9 (2–4/8-10); anal, An. 13-16 (2-4/10-13); caudal, Ca. 20–24 (6–7/14–17), respectively. The present study would be very valuable for species recognition and stock assessment in the Ganges River of NW Bangladesh and the contiguous ecosystems.

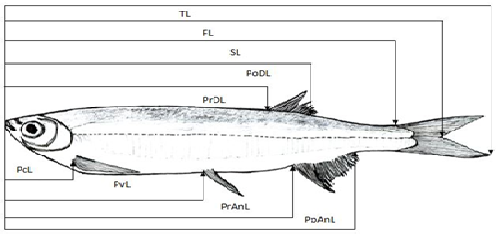

Fig. 1. Showing the morphometric measurement of *Salmostoma bacaila* from the Ganges River.

LIFE-HISTORY TRAITS OF THE BARED SPINY EEL *Macrognathus pancalus* IN A WETLAND ECOSYSTEM

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The Bared spiny eel, *Macrognathus pancalus,* is a freshwater fish species found in ponds, rivers and canals of Bangladesh, India and Pakistan. The present study describes the first complete description on life-history traits, i.e., length-frequency distributions (LFDs), length-weight relationships (LWRs), length-length relationship (LLR), condition factors (allometric, K_A; Fulton's, K_F;relative, K_R; relative weight, W_R), form factor ($a_{3.0}$), size at sexual maturity (L_m), and natural mortality (M_w) of *M. pancalus* in a wetland known as Gajner *beel*, Pabna, northwestern Bangladesh. Sampling was done using traditional fishing gears including cast net, square lift net from July 2017 to June 2018. The total length (*TL*) and standard length (*SL*) were measured to the nearest 0.01 cm using digital slide calipers and total body weight (*BW*) was measured using an electronic balance with 0.01 g accuracy. A total of 480 specimens were measured ranging from 6.00 cm–18.80 cm *TL* and 0.53 g–27.56 g *BW* during this study. The estimated *b* values indicated positive allometry growth pattern *(b*>3.00*)* in *M. pancalus*. The LWRs were highly significant (p<0.001) with all r^2 values is $\geq$ 0.950. The Fulton's condition factor (K_F) showedhighlysignificantvariationsforthispopulations(Pearson's correlation test, P< 0.0001 for BW *vs.* K_F), but the relative weight (W_R) showednosignificantvariations(P = 0.7414 for TL *vs.* W_R) during the study. Wilkoxon sign ranked test for W_R showed no significant dissimilarity from 100 signifying the balanced habitat for *M. pancalus*. Moreover, the size at sexual maturity of *M. pancalus* was estimated as 11.16 cm TL. The calculated formfactor ($a_{3.0}$) was 0.0055 in the Gajner *beel* for *M. pancalus* suggesting that, this fish can be classified as elongated which is characteristic of many riverine fishes. The M_w of *M. pancalus* was 1.44 year^{-1}. The results of this study would be useful for the sustainable conservation of this threatened fishery in Bangladesh and also neighboring countries.

EFFECTS OF CLIMATE CHANGE ON FISHERIES RESOURCES AND FISHERS' COMMUNITY IN THE MEGHNA, LAUKHATI AND GALACHIPA RIVERS

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Climate change is a contemporary global threat to the whole world especially in the coastal area like Bangladesh. Bangladesh is extremely vulnerable to climate change impacts because of its geographical location. The study was contemplated between July 2017 to June 2018 with a view to assessing the effects of climate change on fisheries resources and fishers' community in the Meghna, Laukhati and Galachipa rivers near Chandpur and Patuakhali districts. The data on fisheries resources and fishers' livelihood were collected by using a well-developed questionnaire from the rivers and selected areas. The water quality parameters and primary productivity were measured by using appropriate apparatus and plankton nets. The histology of fish organs were also performed to observe the changes of organs in tissue or cellular level. A total of 61 fish species belonging to 13 orders and 29 families were documented in the Meghna river and a total of 73 species belonging 11 orders and 33 families were documented simultaneously from the Laukhati and Galachipa rivers. Among them Cypriniformes (16%) and Siluriformes (29%) were found to be the most dominant order and very rare and threaten to disappear species as Elong (*Megarasbora elanga*), Kalibaus (*Labeo calbasu*), Shorpunti (*Puntius sarana*), Gozar (*Channa marulius*), Pangas (*Pangasius pangasius*), Muribacha (*Clupisoma garua*), Baghair (*Bagarius bagarius*), Gang tengra (*Gagata cenia*) and Baim (*Mastacembelus armatus*) were also found. The total number of identified genera of phytoplankton was 41, 14 and 34 and the total number of zooplankton genera was 24, 12 and 23, respectively in the Meghna, Laukhati and Galachipa rivers. The most dominant groups of phytoplankton were Bacillariophyceae (13) and Cholophyceae (12) whereas the dominant groups of zooplankton were Rotifera (9) and Cladocera (4). The average temperature was recorded 30.5 ± 0.90°C, 27.1 ± 1.05°C and 27.4 ± 0.60°C and the dissolved oxygen was 6.37 ± 1.11 mg/L, 5.63 ± 0.33 mg/L and 6.33 ± 0.51 mg/L in the Meghna, Laukhati and Galachipa rivers, respectively. The pH was 8.3 ± 0.59, 8.03 ± 0.50 and 7.8 ± 0.50 and the salinity was 0.10 ± 0.10 ppt., 0.23 ± 0.13 ppt. and 1.2 ± 0.15 ppt. in the Meghna, Galachipa and Laukhati rivers, respectively. Through the histological study, it was found that kidney, liver and gill were affected by climate change. This study also revealed that livelihoods of fishers were seriously affected by natural hazardous events. Among all hazards, flood, cyclone and storm surge were found to be affected 50%, 49%, 46% and 57%, 54%, 51% of fishers at Chandpur and Patuakhali districts, respectively. The Leopold matrix was used to clearly identify the effects of climate change on fishers' livelihood who was affected by sundry hazards. The highest annual income of fishers was found BDT 20,080 and 24,000 per year at Chandpur and Patuakhali districts, respectively. Therefore, Government and NGOs should take proper steps by taking various need based projects and providing some sorts of management policy to rescue the vulnerable communities from climate change impacts.

STOCK ASSESSMENT OF THE LONG WHISKER CAT FISH *Mystus gulio* IN THE COASTALWATER OF SOUTHERN BANGLADESH

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The present study illustrates the stock' status of *Mystus gulio* emphasizing on sex ratio, length-weight relationship (LWR), condition factors, form factor ($a_{3.0}$), pre-predator status (based on relative weight, W_R), growth parameters(asymptotic length, asymptotic weight, growth co-efficient, age at zero length), growth performance index, longevity, size at first sexual maturity, age at sexual maturity, length at maximum yield per recruit, and mortality parameter (fishing mortality, *F*; natural mortality, *M*; total mortality, *Z*), exploitation rate, and maximum sustainable yield (MSY) in the Maloncho River of southern Bangladesh. A sum of 1200 individuals of *M. gulio* was sampled during January to December 2017 using cast net (Jhakijal). For each individual, total length (TL) was measured to slide calipers/ measuring board and whole body weight (BW) was taken on an electric balance with 0.01 g accuracy. The LWR was calculated using the expression: $W = a*L^b$, where *W* is the total body weight (BW, g), *L* the total length (TL, cm), *a* and *b* are the parameters of regression analysis. The size at first sexual maturity (L_m) of this species in the Maloncho River was calculated using the equation, log (L_m) = -0.1189 + 0.9157* log (L_{max}). The regression line in the Wetherall plot was fitted through all data representing the fully exploited part of the sample, often from one length-interval to the right of the highest mode in the length-frequency data. Total length (TL) and body weight (BW) was ranged from 7.8 – 18.3 cm and 8.8g – 72.34gfor male; while 9.3 – 22.1 cm and 8.09g – 128.82g for female. The overall sex ratio differed statistically from the expected 1:1 (Male: Female= 1:1.86,p<0.05).The overall *b* value of LWR indicated negative allometric growth (b<3.0) in both males and females. The mean W_R was not significantly different from 100 for both males and females of *M. gulio* indicating the habitat was quite suitable for both sexes. The calculated values of $a_{3.0}$were 0.0105 and 0.0110 for male and female, respectively. The size at first sexual maturity was 10.90 cm in TL. Asymptotic TL and body weight was 19.34 cm, 87.10 g for male and 23.28 cm, 137.95 g for female. The longevity of males and females were calculated as 2.97 and 2.90 years. Length at first recruitment for males and females were 8 and 9.5 cm. The calculated *M* was 1.55 $year^{-1}$ for males and 1.59 $year^{-1}$ for females; and *F* was recorded as 2.75 $year^{-1}$ and 1.98 $year^{-1}$ for males and females, respectively. In addition, the *Z* was 4.30 and 3.57 $year^{-1}$ for male and female populations of *M. gulio.* The *E* was 64% and 56% while the maximum sustainable yield was 48% and 42%, indicating 16% and 14% fishing pressure should be reduced for males and females, respectively. Length at maximum yield per recruit for males and females were 12.88 and 15.37 cm. Therefore, these results of this study would be very effective for wild stock management of *M. gulio* in the coastal Maloncho River and adjoining ecosystems.

LIFE-HISTORYTRAITS OF LONG WHISKER CAT FISH *Mystus gulio* (SILURIFORMES: BAGRIDAE) IN THE COASTAL WATER OF SOUTHERN BANGLADESH

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The Long whiskers catfish, *Mystus gulio* is an economically important a delicious food fish in coastal areas of Bangladesh and it is also found in fresh and brackish water of south Asian countries. The current study illustrates the illustration on life history traits *M. gulio* including sex ratio, population structure through length-frequency distributions (LFDs), growth pattern (length-weight relationships, LWRs; length-length relationships, LLRs), condition factors (Allometric, K_A; Fulton's, K_F; relative condition, K_R), relative weight (W_R), form factor ($a_{3.0}$), size at first sexual maturity (L_m) and natural mortality (M_W) in the Maloncho River, southern Bangladesh. A total of 407 individuals of *M. gulio* were scarcely collected from January to December 2017. Different traditional gears (cast net, seine net, square lift net) were used for collecting samples. *M. gulio* were scarcely collected, where 56% were males and 44% were females. The overall sex ratio of this species did not differ significantly from the expected 1:1 ratio ($\chi 2 = 4.06$, $df=1$, $p>0.05$). The minimum and maximum total length were observed as 5.20 cm and 15.50 cm in males and 5.20 cm and 17.50 cm in females. The minimum and maximum body weights were observed as 2.11g and 33.60g in males and 1.25g and 57.12g in females. All LWRs were highly significant ($p<0.001$), with all r^2 values exceeding 0.967. The calculated allometric coefficient (b) indicated negative allometric growth in male ($b<3.00$, $p<0.001$), positive allometric growth in female and also in combined ($b<3.00$, $p<0.001$). All LLRs were highly significant ($p<0.001$) and most of the coefficients of determination (r^2) values >0.965. Among the condition factors, K_F is the best for wellbeing of this species in the Maloncho River. The W_R was not significantly different from 100 for males ($p = 0.552$) and females ($p = 0.249$) indicating the habitat was in suitable condition. The calculated $a_{3.0}$ were 0.0103, 0.0108 and 0.0106 for male-female and combined sexes, respectively. The L_m was 9.13 cm and 10.46 cm in total length for male and female *M. gulio*. Moreover, the M_W was estimated 1.16 $year^{-1}$ and 1.02 $year^{-1}$ for male and female *M. gulio* in the Maloncho River, southern Bangladesh. The findings of this study would be very effective for the sustainable conservation of this least concern catfish in (Maloncho River) Bangladesh and also neighboring countries.

DETECTION OF CROSSBREED MAGUR (*Claras batrachus* x *C. gariepinus*) IN BANGLADESH THROUGH GEOMETRIC MORPHOMETRIC AND MITOCHONDRIAL COI GENE ANALYSES

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Due to the high popularity, the seeds of indigenous Magur, *Clarias batrachus* have huge demands to the fish farmers. But production of seeds of indigenous magur sometimes shows difficulties due to the scarcity of male counterpart. In such situation crossing of indigenous *C. batrachus* with *C. gariepinus* are reported from fish farmers. Hence in this study, attempts were taken to detect the available magur population in Bangladesh by using simple morphometrics, geometric morphometrics and mitochondrial gene Cytochrome C Oxidase subunit 1(COI) analyses. Fishes were randomly collected from fish markets of Dinajpur districts and using the simple morphometrics the collected fishes were categorized into two groups; A) the native *C. batrachus* and B*)* the suspected cross as *C. batrachus*. As third group the *C. gariepinus* was included in the study. The result of geometric morphometric study showed 86.78% variance among them where in pair wise study, the highest variance (2940.58) was found between *C. gariepinus* and *C. batrachus*. The cluster analysis showed separate cluster formation of three populations. The COI gene was amplified by PCR and the sequences were submitted to the NCBI genebank database (accession number MG988399, MG988400, MG988401). The nucleotide sequences of COI gene of *C. batrachus* and *C. gariepinus* of other countries were also retrieved from the NCBI genebank database as the reference sequences. Finally the selected sequences were analyzed by using MEGA software (version 6.01). Nucleotide divergence showed the highest interspecific divergence (6.238) between the *C. gariepinus* (Indonesia) and *C. batrachus* (India), where the lowest interspecific divergence (0.295) found between the suspected cross (Bangladesh) and *C. gariepinus* (exotic to Bangladesh). Phylogenetic trees constructed showed that the *C. batrachus* of Bangladesh did not form cluster with *C. batrachus* of other countries, instead formed sister with exotic *C. gariepinus* of Bangladesh. The study indicated that suspected crossbreed of *C. batrachus* (B) is a cross of native and African magur that deteriorating the native stocks during escaping to the natural water bodies. Further studies are required to detect the hybrid magur in Bangladesh as well as the level of genetic deterioration is also need to identify.

EFFECT OF HARMFUL AGENT ON PRODUCTION INCOME AND BIODIVERSITY OF SHRIMP FARMING IN BANGLADESH

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Shrimp farming in Bangladesh is an important activity for the country's GDP and substantial especially in the coastal areas. Following the hypothesis that different shrimp farming practices effect on overall production, income and biodiversity considering to the use of chimerical fertilizer and harmful chemical (Harmful agent). Research was conducted in three Upazila (Kaliganj, Syam Nagar Asasuni) under Sathkira district the southwest reason of Bangladesh. Three different farming practices organic, traditional and control farmer were selected for the research. Shrimp is one of the leading exportable seafood products from where Bangladesh is earning about UD$ 500 million yearly contributing 3.78% to the GDP. Farmer follows the traditional and extensive farming practices and average production is 275 kg/ha which is the lowest compared to other countries producing shrimp around the world. Reasons of this low production are lack better technology, dearth of quality seed and feed and effect of shrimp disease. Small-scale organic shrimp farming practice introduced recently has shown better production and profitability under four coastal sub district (Upazila) of Sathkira district in the southwest part in the country. Three different farming practices were studied: (i) organic (ii) traditional and (iii) extensive or control farming where farmers were interviewed to collect data. Study found organic farmer producing is average 10.64% higher than the traditional farmers and 20.84% higher than extensive or control farming system. Cost-benefit analysis showed organic farming is more profitable compared to other practices because of low input cost and premium price received for organic shrimp. Percentage of gross sell of organic is 10% higher than traditional and 19.37% higher than control shrimp farming. Interview and PRA method were used for the collection of data. The main research question was what effect dose the overall production, income and biodiversity among the three different farming practices.

Effect were found that production kg/ha is organic and traditional the farming practice more or less same and organic production is little bit higher than the control and traditional farming practices traditional farming production cost is higher than the organic and control production . Considering to the biodiversity organic farming conserve more biodiversity than control and traditional farming practices.

- Compare to the Organic, Traditional and control farming organic is sustainable and environmentally friendly farming system
- Organic farming is less input cost and higher production and high product value
- Organic farming protects the environment and biodiversity
- Organic farming could be creating the international Image of Bangladesh product in the International Market

DO BIOTIC INTERACTIONS EXPLAIN ZOOPLANKTON DIVERSITY DIFFERENCES IN THE MEGHNA RIVER ESTUARY ECOSYSTEMS OF BANGLADESH

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Differences in species diversity in ecosystems have long and often been discussed and interrogated in ecological research. A two year study on zooplankton diversity in the Meghna River and its estuary of Bangladesh found that diversity is comparatively higher in the estuary than the river. This study examines whether the biotic interactions of species can explain the diversity difference between these two aquatic habitats. The study is based on several species diversity hypotheses related to biotic interactions (i.e. low interspecific interactions, comparatively higher disturbance, higher species recruitments and higher intransitivities cause higher species diversity). A first order Markov chain model was used to estimate the biotic interactions i.e. species displacement ability, disturbance, colonization and intransitivities. Monte Carlo Markov chain (MCMC) simulations were performed to estimate species interactions from the Markov chain model. Results suggest low inter-specific interactions, comparatively higher disturbance rate, higher species recruitment and intransitivies in the Meghna estuary have caused higher zooplankton than the Meghna riverine ecosystem. In addition, it is evident that the negative association of species colonization with species displacement ability and displacement risk also led to a comparatively higher diversity in the Meghna estuary than the Meghna River. It is apparent from the zooplankton abundance data, that biotic interactions can explain the zooplankton species diversity difference in the Meghna aquatic ecosystems of Bangladesh. With these findings the current study provides valuable insights into zooplankton diversity differences in tropical ecosystems.

STOCK ASSESSMENT OF RAZORBELLY MINNOW *Salmostoma bacaila* FROM THE MAHANANDA RIVERIN NORTHWESTERN BANGLADESH

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The razorbelly minnows, *Salmostoma bacaila* is a small indigenous fish species (SIFS), widely distributed in Asian countries including Bangladesh, India, Pakistan, and Nepal. This study was estimated the growth parameters (asymptotic length, L_∞; asymptotic weight, W_∞;growth co-efficient, K; age at zero length, t_0), growth pattern, growth performance index (φ), life-span(t_{max}), relative weight (W_R), form factor ($a_{3.0}$), size and age at sexual maturity (L_m), total-(Z), natural (M) and fishing (F) mortality and exploitation rate (E)of *S. bacaila* in the Mahananda River, northwestern (NW) Bangladesh. Sampling was carried out using a traditional fishing gear (Seine net) during August 2016 to July 2017 from the Mahananda River. For each individual, total length (TL)was measured to the slide calipers with0.01cm and total body weight (BW) was measured using an electronic balance with0.01 g. A total of 305 specimens, ranging from 5.5 to 11.9 cm TL and 1.05 to 9.20 g BW were analyzed. The growth pattern was estimated through LWR: $W= aL^b$.The L_m and L_∞ were estimated based on maximum observed total length. The φ was calculated by $Ø' = \log_{10}K + 2\log_{10}L_\infty$, while the t_{max} was estimated by $t_{max}=3/K$.In addition, the Z was estimated by the length converted catch curve, $\ln(N_t/\Delta_t) = a + b^*t$. The M was obtained by $M = -\ln[0.01]/t_{max}$. The F was estimated using the relationship: $F = Z - M$ and E was calculated using the formula: $E = F / (F + M)$. The allometric coefficient *'b'* of length-weight relationships (LWR) indicated negative allometric growth with $r^2 = 0.931$.Growth parameters were computed as $L_\infty = 12.66$ cm, $K = 0.97$ year^{-1}, $W_\infty = 11.358$ g,$t_m = 0.87$ year^{-1},$t_0 = 0.020$ and $t_{max}= 3.10$ year^{-1}with the growth performance index, φ' of 2.19. Additionally, the size at first sexual maturity (L_m) was 7.34 cm in TL. The W_R showed no significant dissimilarity from 100 signifying the balanced habitat for *S. bacaila.* The calculated form factor ($a_{3.0}$) 0.0052 suggesting that, this fish can be classified as elongated. Furthermore, the Z was estimated 2.55 year^{-1} using catch curve method. The M,F and E were obtained as 1.49, 1.06 and 0.42year^{-1}respectively.Thefindings of this study would be very effective for the sustainable management of this species in Bangladesh and also bordering countries.

EFFECTS OF SALT PLUG FORMATION ON WATER QUALITY IN THE PASUR RIVER ESTUARY

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The Pasur River Estuary (PRE) is the longest (>164 km) estuary in the south western part of Bangladesh. The PRE has a direct link with the Ganges, the principal freshwater source upstream. Due to constructing the Farakka barrage in the Ganges in 1975, the freshwater diversion at Farakka reduced the dry-season discharge in the PRE upstream from a pre-Farakka mean flow of 190 m^3 sec^{-1} in 1973to post-Farakka mean flows of 10 m^3 sec^{-1} in 2008. Consequently, salt water intrusion in the PRE has received substantial attention in recent years due to increases in the magnitude and frequency of salt water intrusion upstream due to climate change and decreases in river discharge levels resulting from an upstream barrage. However, earlier work typically omitted the details of vertical salinity distribution in the PRE. Here we investigated the influence of river discharge patterns on the formation of salt plug in the Pasur River estuary using longitudinal and time series vertical profile of salinity and density.The longitudinal vertical salinity and density were taken using a conductivity-temperature-depth (CTD) profiler along the Pasur River from Harbaria to Batiaghata over 40 kmin the dry and wet seasons in 2014 and 2018. The longitudinal vertical salinity of the PRE duringthe dry season shows salt plug, a salinity maximum zone within estuary, around Chalna in the PRE. An export of saline water from the Shibsa River estuary (SRE) to the PRE through Chunkhuri channel occurs in the dry season, resultant a salt plug is created and persisted for several months around Chalna in the dry season. This salt plug was essentially isolated the upper reaches of the estuary from bay water and prevented the seaward flushing of riverine waters and the landward intrusion of ocean waters. Therefore, the dissolved oxygen level dropped < 5.0 mg L^{-1} in the salt plug area in the PRE. Water pH ranged between 7.62 and 7.91 is suitable for biological productivity. pH value was highest in the salt plug region at Chalna. Ammonium concentration was higher at low tide than at high tide and ranged between 0.13 to 3.21 mgL^{-1}. Nitrate concentration was ranged between 0.01 and 0.07 mgL^{-1} whereas nitrite concentration ranged between 0.001 and 0.006 mgL^{-1}. The highest Chlorophyll-a was found at high tide in the salt plug area. The plankton concentration was less upstream and downstream of Pasur river, but was higher in the salt plug area. Thus, this work will provide an ecological baseline for the PRE and serves as a basis for an interdisciplinary approach linking the physical phenomena with chemical and biological properties.

BODY SHAPE VARIATION AND BIOCHEMICAL COMPOSITION ANALYSES OF HILSHA SHAD, *Tenualosa ilisha* FROM MARINE, ESTUARINE AND FRESHWATER ENVIRONMENT OF BANGLADESH

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The study aimed to find the body shape variation and biochemical composition variation of Hilsha shad from all three environments through landmark-based geometric morphometrics and analysis of biochemical composition. The Hilsa fish is anadromous, with a life cycle that follows the general breeding pattern upstream in freshwater of channel of the Padma, Meghna, Karnafully. A total of 100 samples of Hilsa consisted of 15 females and 10 male of each population were collected from four rivers that represented all three environment-the Padma (Freshwater river), Meghna (Estuarine river), Rupsa (Freshwater) and Karnaphuli (The landing center of marine Hilsa). After collection, images of each sample were taken for geometric morphometric analyses and muscle tissues for biochemical composition analysis. Sixteen landmarks points on the fish's body were digitized using TPS series software and analyses by using PAST software (version 3.0). The overall body shape variations were found in principal component one (PC1: 75.52%) among four populations indicates that there was significant body shape variation of *T. ilisha*. The results of scatter plot and UPGMA cluster analysis showed overlapping between two estuarine habitat (Meghna andRupsha river populations) and few overlapping between marine and estuarine habitat (Karnafully and Rupsha river populations), where the marine water dwelling Hilsa and freshwater dwelling (Padma population) was distinctly separated. The biochemical composition of crude protein, lipid and Ash contents were carried out following the methods of AOAC (1980). The highest protein content and fat content were found in estuarine habitat (15.27% and 16.43% respectively). The highest ash content was found in marine habitat population (0.98%). The findings of biochemical composition of Hilsa showed significant variation. These body shape variation and biochemical composition differentiation may be related to geographically isolated regions or habitat or feeding habits or other environmental conditions. This result will be helpful for the proper Hilsa stock management as well as for the consumers, fish processors and the researchers.

MIGRATORY HILSA SHAD CONSERVATION AND FISHING RIGHTS ACTIVISM IN THE BRAHMAPUTRA RIVER BASIN: HOW TO STRIKE A BALANCE

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Bangladeshi civil society has been spearheading campaigns for conserving its national fish Hilsa Shad which is also popular as Ilish. Their counterparts in the West Bengal region of India have also been running similar campaigns. This is claimed to have helped the respective Governments to take stricter measures, successfully reversing the trend of decline of the catch of Hilsa fish in the last decade. However, the issue of fishing rights of the fishermen and fisherwomen in the North Bengal region of Bangladesh and Assam state of India has never been highlighted in these movements. This study used a survey among a sample of 480 fisherfolks from upstream and downstream areas of Brahmaputra and Meghna rivers in Bangladesh along with key informant interviews, to reveal that the 22 day seasonal closure period to protect spawning Hilsa is the only time the fish gets to reach the upstream areas, due to overfishing downstream in the rest of the year. Also, the current compensation package offered by the Government of Bangladesh was found to cover only 17% of the expenditure needs of the fisher-families, which pushes the fisherfolks to continue fishing to cover their income needs. This is invoking resistance from fishers to the closure and potentially threatening the sustainability of the existing conservation initiatives. This study tells us why fishing rights agenda should be brought back in Hilsa Shad conservation discussions at policy and activism interface. The study suggests that the dialogue process needs to be opened to address the concerns of the upstream fisherfolks into account and to redesign the current management system.

SEASONAL VARIATION OF PLANKTON WITH REFERENCE TO WATER QUALITY PARAMETERS IN ANDHARMANIK RIVER OF SOUTHERN BANGLADESH

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Plankton is an important autochthonous energy source of riverine ecosystems which transferred energy to higher organisms through food chain. Considering importance of plankton, the present study was conducted to find out the monthly planktonic variation with physicochemical properties from Andharmanik River during January to December, 2017. Annual mean air temperature, water temperature, dissolve oxygen, pH, salinity, conductivity, transparency, alkalinity and hardness of the Andharmanik river were found 29.37±4.90˚C, 27.92±4.96˚C, 7.39±0.43 mg/L, 7.74±0.70, 13.82±2.74 ‰,23807.19± 6157.58 µS/cm, 35.68±6.86 cm, 127.42±3.12 mg/L and 138.17±3.47 mg/L respectively. A total of 54 plankton species belonging 41 genera, 38 families, 23 orders, 12 classes, 7 phyla were recorded from Andharmanik River. *Pseudo-nitzschiapseudodelicatissima* showed dominancy in February, March and November followed by *Chaetocerosmessanensis* in April and May; *Oscillatoria* in June and July; *Chaetoceros* in August and September; *Thalassionema* in October; *Proboscia* in December and January.Plankton showed positive correlation(r= 0.204) with water temperature and negative correlation (r= -0.879, p<0.01) with transparency (Table 1). The present study recorded plankton cells count of 10.740×10^3–32.374×10^3 cells/L from Andharmanik River. Several biodiversity parameters *viz.,* Shannon Weiner diversity index (H), Gibson's evenness (E), Simpson's dominance index (D), Simpson's index of diversity (1-D), Margalef's index (*d*), Berger-Parker Dominance (d), Menhinick's index (D_{mn}), Fisher's alpha (S), Brillouin index (HB), Equitability (Eq) (Table 2) were analyzed to observe the biodiversity condition of plankton. Calculated biodiversity parameters indicated higher planktonic diversity which denoted that Andharmanki river could support a wide range of fisheries resource.

Table 1. Correlation coefficient between physicochemical parameters and plankton of Andharmanik River.

Parameters	Air Tem.	Water Tem.	DO	pH	Salinity	Transparency	Conductivity	Alkalinity	Hardness	Plankton
Air Temperature	1									
Water Temperature	0.999**	1								
DO	0.512	0.488	1							
pH	0.837**	0.838**	0.390*	1						
Salinity	-0.130	-0.126	-0.026*	-0.451	1					
Transparency	-0.392	-0.369	-0.567*	-0.146	0.036	1				
Conductivity	0.103	0.126	-0.191*	-0.098	0.605*	0.357	1			
Alkalinity	0.630*	0.616*	0.372*	0.583*	-0.311	-0.565	0.616*	1		
Hardness	0.849**	0.856**	0.104*	0.784**	-0.366	-0.191	-0.018	0.652*	1	
Plankton	0.204	0.186	0.447	-0.048	0.187	-0.879**	-0.247	0.404	-0.066	1

Note: Significant correlations at p<0.01 are marked as ** and at p<0.05 are marked as *.

Table 2. Biodiversity parameter value with total number of species and individual of Andharmanik River.

Month	Species	Individuals	(H)	(E)	(D)	(1-D)	(*d*)	D	FA	D_{mn}	J	HB
January	17	20909	1.81	0.36	0.25	0.75	1.61	0.42	1.82	0.12	0.64	1.81
February	27	32374	2.31	0.37	0.18	0.83	2.50	0.35	2.90	0.15	0.70	2.31
March	26	25690	2.43	0.43	0.14	0.86	2.46	0.30	2.86	0.16	0.74	2.42
April	21	19069	2.07	0.38	0.19	0.81	2.03	0.34	2.33	0.15	0.68	2.07
May	17	13002	1.86	0.38	0.25	0.75	1.69	0.42	1.93	0.15	0.66	1.86
June	16	12218	1.76	0.36	0.31	0.69	1.59	0.53	1.82	0.14	0.63	1.75
July	18	10740	1.94	0.38	0.24	0.76	1.83	0.40	2.11	0.17	0.67	1.93
August	26	27177	2.35	0.40	0.16	0.84	2.45	0.32	2.84	0.16	0.72	2.35
September	22	20064	2.25	0.43	0.16	0.84	2.12	0.33	2.44	0.16	0.73	2.25
October	17	11674	1.69	0.31	0.34	0.66	1.71	0.56	1.96	0.16	0.59	1.65
November	15	12060	1.84	0.42	0.24	0.76	1.49	0.40	1.69	0.14	0.68	1.84
December	14	14933	1.78	0.42	0.25	0.75	1.35	0.44	1.52	0.11	0.67	1.78

FISHING GEARS AND CRAFTS USED IN PAYRA RIVER, BANGLADESH

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The aim of the present study was to identify the traditional fishing gears and crafts used by the fishermen of Payra River at Amtaliupazila under Barguna district for a period of 12 months from September 2015 to October 2016. Questionnaire Interview (QI) and Key Informant Interview (KII) were done to obtain information about fishing gears and crafts. The investigation showed that a wide variety of fishing gears and crafts were operated throughout the year in the study area for commercial fishing. Fishermen were found to follow 4 fishing techniques i.e. netting, angling, trapping and spearing. Among them 18 types of the fishing gear was recorded to be used by the fishermen of which 5 gill, 1 seine, 2 fixed purse, 1 lift, 1 cast, 2 push/drag nets, 2 traps, 2 hooks and lines and 2 wounding gears were recorded.

Table 1. Different types of net used for fishing in the Payra River

Gear type	Local name	Construction cost (BDT/net)	Mesh size (cm**)	CPUE*** (Kg/efrt)	Major species caught	Fisherman needed for operation	Fishing effort/day	Season	Dura-bility (yrs)
Gill net	Chandijal *	30000-50000	2.75-4.5	5-15	Hilsha, Poa, Taposhi	3-6	2	All	1-2
	Poajal	20000-30000	1.75-3.5	5-10	Poa, Taposhi, Hilsha, Faisha	3-5	4	September-February	1-3
	Ramsosjal	20000-30000	1.75-3.5	6-15	Taposhi, Poa, Cheua	3-5	2	December-May	1-3
	Ayrejal	40000-50000	6-8	2-5	Ayre	3-4	4	September-February	2-4
	Coral jal	50000-100000	5-7	4-7	Coral, Ayre, Pangus	4-8	4-5	February-May	3-5
Seine net	Berjal	40000-60000	0.0	10-20	All	7-10	2	All	1-2
Fixed purse net	Behundijal	40000-50000	0.0-0.5	8-15	All	3-5	2	All	1-2
	Chargorajal	20000-30000	0.0-0.5	6-12	All	3-5	2	All	1-2
Lift net	Dharmajal	4000-5000	0.5-1	0.5-1	Taki, shol, Tengra, Prawn,	1	4	May-September	1
					Baila, Baim				
Cast net	Jhaki/jhaijal	3000-4000	0.5-1	1-2	Prawn, Koi, Poa, Boal,	1	10-15	All	3-4
					Taposhi, Bata, Baim, Baila				
Drag/ Push net	Moiajal	1000-1500	0.25-0.75	1-2	Prawn	2-3	7-8	All	1-2
	Thelajal	400-500	0.25-1	0.5-1.5	Prawn, Poa, Chewa, Koi, Gulsha	1	5-6	All	2-4

Three types of fishing crafts were recorded from the present study *viz.* Kosha, Dinghi and Trawler. Some of the gears were selective for a particular species like chandi jal, poa jal, ramsos jal, ayre and coral jal. But ber jal, behundi jal and chargora jal were found to catch fish irrespective of their size or species and destroy the habitat of the wild species.

VARIABILITY OF HEAVY METAL IN SHRIMP(*Paneaus monodon*) COLLECTED FROM DIFFERENT ECOSYSTEM OF SOUTHERN PART OF BANGLADESH

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Shrimp (*Penaeus monodon*) is one of the most commercially important fisheries resources in Bangladesh. Therefore, the present study focused to determine the variability of concentrations (µg/g dry Wt) of heavy metals in Shrimp (post larvae, muscle tissues and carapace) collected from different ecosystem (wild, local gher and hatchery) of Cox'sBazar region in May 2016 using the Atomic Absorption Spectrometry (AAS) following standard method. Five heavy metals [copper (Cu), zinc (Zn), cadmium (Cd),lead (Pb), and chromium (Cr)] were examined. The highest mean concentration was observed in local Gher for Cu (22.52±0.485), Zn (95.36±1.045) and Cd (0.017±0.001) compared to other sources (wild and hatchery). The highest concentration for Pb (0.019±0.002) found in wild and the post larvae of shrimp collected from local hatchery exhibited the highest mean concentration for Cr (3.02±0.311). No significant correlation was observed except between Cu and Zn within the studying heavy metals (p>0.05).

Table 1. Concentration (µg/g dry weight) of heavy metals observed in shrimp collected from different ecosystem of southern part of Bangladesh

Sample	Cu	Zn	Pb	Cd	Cr
PH	15.32±14.425	45.42±33.517	0.017±0.002	0.016±0.002	3.02±0.311
MG	20.28±0.778	71.64±0.627	0.015±0.002	0.017±0.001	0.12±0.005
CG	22.52±0.485	95.36±1.045	0.012±0.001	0.016±0.001	2.52±0.173
MN	22.16±0.278	74.97±0.193	0.019±0.002	0.013±0.001	0.16±0.019
CN	20.96±0.920	92.8±0.588	0.013±0.001	0.014±0.002	2.44±0.184

Note: PH= Shrimp post larvae collected from hatchery; MG= Shrimp muscle collected from gher; CG= Shrimp carapace collected from gher ; MN= Shrimp muscle collected from wild; CN= Shrimp carapace collected from wild. Parentheses showed the sources of collection.

The study revealed that the heavy metals found in the samples are within or below the recommended levels fixed by various international legislation and may not constitute a health hazards for consumers.

HEAVY METAL CONTAMINATION IN SHRIMP PL NURSERIES OF KHULNA REGIONOF BANGLADESH

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Heavy metal contamination in aqueous environment and aquatic animals is now a serious problem in developing countries like ours. The south-west region of Bangladesh is considered as the potential area for shrimp nursing and farming. This study was designed to determine the heavy metals contamination in shrimp PL nurseries of Khulnaregion and associated human health risks. Water samples (inlet and outlet)and shrimp PL were collected from five nurseries of Dakope upazila of Khulna district and three nurseries of Satkhira Sadar upazila. Heavy metals (Zn, Cr, Mn, Cu, Pb and Ni) concentrations were determined by using Atomic Absorption Spectrometer (Model AA-7000, Shimadzu). Among all the metals Zn concentration was higher than other metals in all the nurseries and in PL samples this concentration was highest. Mn concentrations were below detection label (BDL). Except Nursery 2, Pb concentrations were below detection label in PL samples (Table 1).The mean concentrations of all the metals were highest in PL samples except Mn.

Table 1. Range of heavy metals (ppm) in inlet, outlet water and shrimp PL collected from five different nurseries of Khulna region

Heavy metals	Range of heavy metals (ppm)				
	Nursery 1	Nursery 2	Nursery 3	Nursery 4	Nursery 5
Zn	0.07 - 40.51	0.05 – 45.84	0.06 - 41.21	0.04 – 41.59	0.05 – 35.46
Cr	0.01 - 3.07	0.01 – 9.11	0.003 – 1.91	0 – 0.67	BDL
Mn	BDL	BDL	BDL	BDL	BDL
Cu	0.02 - 0.64	0.02 – 11.59	0.02 – 25.58	0.03 – 30.48	0.02 – 23.44
Pb	0 - 0.53	0.55 – 17.39	0 – 0.6	0 – 0.53	0 – 0.88
Ni	0 - 3.54	0 – 0.01	0.003 – 0.71	0.01 – 4.15	0.003 – 0.16

ASSESSMENT OF ORGANOCHLORINE PESTICIDE RESIDUES IN MUSCLES OF *Channa punctata* COLLECTED FROM BHAIRAB RIVER OF JESSORE REGION, BANGLADESH

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In Bangladesh Organochlorine pesticides (OCPs) were banned a long time ago. Though it was banned but still the residues of OCPs have been detected in a wide range of food materials. With this view, the present study was conducted to find out the different level of OCPs residues in *Channa punctata* fish muscle collected from Bhairab river of Jessore region, Bangladesh for a period of four months from February to May 2017. The samples were analyzed by Gas Chromatography (GC) with an Electron Capture Detector (ECD) for identification and quantification of OCPs. Five OCPs were detected such as Alpha-Benzene Hexachloride (α-BHC), Dieldrin, Endrin, Ortho-permethrin (O-Permethrin) and 2, 4-Dichloro-Diphenyl-Trichloroethane (2, 4-DDT). Residues of α-BHC, Dieldrin and 2, 4-DDT were detected in all the samples of fish muscle. Total OCPs Residue in the month of February, March, April and May was 0.094, 0.427, 0.059 and 0.208 mg kg^{-1}, respectively. The residues of 2, 4-DDT was found higher than the Maximum Residues Limits (MRLs) in case of most of the sample except April. Residues of endrin and o-permethrin were detected in the month of March only and the concentrations were 0.056 and 0.127 mg kg^{-1}, respectively. Both endrin and o-permethrin concentrations were significantly higher than the MRLs value. Estimated Average Daily Intake (EADI) were estimated for impact assessment of α-BHC, Dieldrin, Endrin, 2, 4-DDT and O-Permithrin and found that most of the intake of these OCPs by the people of standard body weight (40kg adult is 60 g day^{-1}) were below the guideline that estimated by Enzyme at al. (2015), except O-permethrin. Therefore, the experimented fish muscles were safe for human consumption except these which content O-permethrin.

IDENTIFICATION AND QUANTIFICATION OF BENTHOS IN DIFFERENT FEED TREATED TILAPIA PONDS

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The present study was designed to identify and quantify macro-benthic organisms those were developed in tilapia culture ponds at Shahas village, Dumuria, Khulna during the period of April 2017 to September 2017. There were six experimental groups on the basis of types of feed and number of doses with six replication of each. Two different control groups were assigned considering the fact of two diets where no feed was applied. Two separate experiments were conducted consecutively with four different diets in each experiment. Treatments was assigned as single feeding (T_1) and double feeding (T_2) of diet-1, and single feeding (T_3) and double feeding (T_4) of diet-2. Four samples were collected from experiment-1 and three samples were collected from experiment-2. Firstly, a total of 9 species under 3 classes (Oligochaeta: *Nais simplex*; Bivalvea: *Neritina reclivata*, *Mercenaria campechiensis*, *Anodonta californiensis*; and Gastropoda: *Melanoides tuberculata*, *Bellamya chinensis*, *Pila globosa*, *Indoplanorbis exustus*, and *Septaria porcellana*) were identified from all the ponds. Afterwards, the results demonstrated that in experiment-1 T_4 showed presence of higher *Melanoid tuberculata*, whereas, it was higher in C_1 and T_4 (p<0.05) compared to other treatment groups. Higher number of *Melanoides tuberculata* in T_4 indicated their preference on nutrient enriched aquatic environment. In addition, *Bellamya chinensis* was found to be higher in C_2 than that of T_1, T_3 and T_4; in contrast, it was lower in C_1 and T_2. However, this species was fond higher in T_3, followed by T_4 and T_1, and C_1, T_2, and C_2. Hence, it was a complex realization that whether the feed and/ or the bottom condition of ponds are responsible for abundance of this group of macro-benthos. Finally, significant effects of different diets were also observed on the abundance of *Indoplanorbis exustus* and *Mercenaria chiensis* species. In conclusion, different diets and its different doses might have effect on abundance of several macro-benthos in tilapia cultured pond. Therefore, further studies should be conducted to understand more exclusively the exact phenomenon of different feed effect on the macro-benthos community.

Table 1. Quantifications of macro-benthos from experiment 1

Treat-ment	*Melanoides*	*Bellamya*	*Neritina*	*Indoplanorbis*	*Mercenaria*	*Pila*	*Septaria*	Anodonta	*Nais*
C1	40.33±31.8^{a}	12.29±17.4^{a}	3±1.63^{c}	3.66±3.5^{a}	2.71±1.5^{a}	1.5±0.5^{a}	3.5±2.8^{a}	0	4.5±3.5^{a}
T1	35.58±33.1^{a}	8.14±5.7^{a}	6.6±4.8^{a}	9±9.3^{b}	2.4±1.4^{a}	2.5±0.5^{a}	1±0^{b}	0	0
T2	41.87±36.6^{a}	20.75±28.3^{a}	3.4±2.9^{c}	6.28±4.8^{a}	1.66±.7^{a}	2±1^{a}	3±2^{a}	0	6±2^{a}
C2	30±27.3$_{a}$	15.16±14.9$_{a}$	14.83±17^{b}	5.62±5.5$_{a}$	1.83±1.2$_{a}$	1.33±.5$_{a}$	3.6±2.7$_{a}$	2±0$_{a}$	4.5±3.5^{a}
T3	34.13±32.7^{a}	22.4±22.0^{a}	8.42±5.8^{a}	4.7±5.3^{a}	1.57±.7^{a}	8±0^{b}	1.75±.8^{a}	3±2^{a}	1±0^{b}
T4	69.5±9^{b}	30±30.1^{b}	4.88±4.1^{a}	3.77±2.0^{a}	2±.9^{b}	2±0^{a}	11.75±15.8^{a}	1±0^{a}	8±0^{a}

STUDY ON PLANKTON DIVERSITY OF PANGAS (*Pangasius hypophthalmus*) AND TILAPIA (*Oreochromis niloticus*) CULTURE PONDS IN BOGRA, BANGLADESH

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Plankton act as primary food source and indicates the productivity of water body. To determine the plankton diversity the study was conducted in pangas (*Pangasius hypophthalmus*) and tilapia (*Oreochromis niloticus*) culture ponds at Adamdighi, Bogra. Air temperature, water temperature, transparency, dissolve oxygen, pH, nitrate, phosphate and ammonia in Pangas and Tilapia fish ponds were found to vary from 21.36 to 35.83 ºC, 23.3 to 34.36 ºC, 15.54 to 53.72 cm, 3.7 to 5.73 mg/l, 7.53 to 8.63, 5.75 to 8.26 mg/l, 0.28 to 1.25 mg/l and 0.08 to 0.85 mg/l, respectively. A total of 61 and 59 plankton species were recorded. Phytoplankton composed of 6 groups (Bacillariophyceae-14, Chlorophyceae-19, Chrysophyceae-1, Dinophyceae-1, Cyanophyceae-9 and Euglenophyceae-4) in pangas pond and 5 groups in tilapia pond. Both pangas and tilapia pond recorded 4 groups of zooplankton; Copepoda (2), Cladocera (5), Rotifera (5) and Crustacean larvae (1). Chlorophyceae showed dominancy in both pangas (31.16%) and tilapia pond (32.20 %). Pangas pond showed highest abundance (117.045×10^3 cells/L) recorded in September and lowest (15.434×10^3 cells/L) in January. On the other hand, tilapia pond also showed highest abundance (116.236×10^3 cells/L) in September but lowest (17.241×103 cells/L) in December. Pearson correlation matrix in pangas and tilapia (Table 1) pond showed negative correlation(r= -.963, r= -.798) with transparency and pH. Table 2 showed the plankton diversity of culture ponds. Study showed tilapia pond was dominant by plankton. It can be summarized that the supplementary feed added to each pond had influence on nutrient content which enhanced algal biomass and productivity of the ponds.

Table 1. Pearson Correlation matrix for plankton abundance and water quality parameters in pangas (a) and tilapia (b) ponds

a

Parameters	Plankton	Air Temp.	Water Temp.	Trans-prency	DO	pH	NO_3	PO_4	NH_3
Plankton	1								
Air Temp.	.735*	1							
Water Temp.	.708*	.975**	1						
Transparency	-.963**	-.854**	-.817**	1					
DO	.187	-.358	-.422	.005	1				
pH	-.798**	-.694*	-.694*	.873**	-.200	1			
NO_3	.455	.488	.461	-.492	-.669*	-.142	1		
PO_4	-.562	-.777**	-.828**	.631	-.158	.533	-.415	1	
NH_3	.052	.012	-.016	-.068	-.719*	.087	.542	.309	1

b

Parameters	Plankton	Air Temp.	Water Temp.	Trans-parency	DO	pH	NO_3	PO_4	NH_3
Plankton	1								
Air Temp.	.624	1							
Water Temp	.584	.983**	1						
Transparency	-.974**	-.734*	-.694*	1					
DO	-.003	-.550	-.644*	.086	1				
pH	-.586	-.736*	-.678*	.725*	-.360	1			
NO_3	-.140	-.006	.010	.182	-.412	.308	1		
PO_4	-.167	-.346	-.311	.287	-.610	.588	.427	1	
NH_3	-.095	-.172	-.164	.140	-.550	.266	.380	.845**	1

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

Table 2. Plankton diversity in Bogra region during the study period

Diversity Indices	Pangas pond										
	2016					2017					
	J	A	S	O	N	D	J	F	M	A	Mean±SD
Margalef index	3.23	3.65	3.77	2.78	2.47	2.03	1.45	2.73	4.03	4.17	3.03±0.85
Menhinick's diversity	0.16	0.15	0.13	0.12	0.16	0.15	0.12	0.15	0.17	0.15	0.14±0.01
Evenness	0.54	0.54	0.55	0.65	0.56	0.59	0.43	0.70	0.72	0.64	0.59±0.08
Shannon-Wiener	2.97	3.13	3.21	3.03	2.69	2.53	1.87	3.04	3.50	3.46	2.94±0.45
Simpson's dominance	0.07	0.06	0.06	0.06	0.11	0.12	0.22	0.06	0.04	0.04	0.08±0.05
Simpson's index	0.92	0.93	0.93	0.93	0.88	0.87	0.77	0.93	0.95	0.95	0.90±0.05
	Tilapia pond										
Margalef index	2.89	3.78	3.60	2.72	2.413	1.84	1.22	2.82	3.95	4.15	2.93±0.90
Menhinick's diversity	0.15	0.16	0.12	0.12	0.17	0.14	0.09	0.15	0.17	0.15	0.14±0.02
Evenness	0.59	0.64	0.58	0.67	0.67	0.69	0.43	0.65	0.69	0.65	0.62±0.07
Shannon-Wiener	2.95	3.32	3.22	3.04	2.827	2.58	1.73	3.01	3.44	3.46	2.95±0.48
Simpson's dominance	0.07	0.04	0.05	0.06	0.08	0.09	0.24	0.07	0.04	0.04	0.07±0.05
Simpson's index	0.92	0.95	0.94	0.93	0.91	0.90	0.75	0.93	0.95	0.95	0.91±0.05

STUDY ON PLANKTON DIVERSITY OF PANGAS (*Pangasius hypophthalmus*) AND TILAPIA (*Oreochromis niloticus*) PONDS IN MYMENSINGH, BANGLADESH

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Production of fish is directly dependent on the productivity of the entire pond water ecosystem, specially on the plankton diversity as it provides natural food for fish. To determine the plankton diversity the study was conducted in pangas (*Pangasius hypophthalmus*) and tilapia (*Oreochromis niloticus*) culture ponds of Agro 3 fish farm at Trishal Upazila, Mymensingh. Air temperature, water temperature, transparency, dissolve oxygen, pH, nitrate, phosphate and ammonia in Pangas and Tilapia fish ponds were found to vary from 20.43 to 36.53 ºC, 22.36 to 34.65 ºC, 17.63 to 55.21 cm, 3.46 to 6.43 mg/l, 7.6 to 8.63, 5.31 to 7.97 mg/l, 0.15 to 0.47 mg/l and 0.08 to 0.54 mg/l, respectively. A total of 59 and 57 plankton species belonging 5 groups; Bacillariophyceae (13), Chlorophyceae (20), Cryptophyceae (1), Cyanophyceae (9) and Euglenophyceae (3) were recorded from pangas and tilapia ponds. In pangas pond, zooplankton composed of 13 species belonging 4 groups including Copepoda (2), Cladocera (4), Rotifera (6) and Crustacean larvae (1). In tilapia pond, zooplankton also composed of 4 groups but only difference was in number of rotifera (4). Chlorophyceae showed dominancy in both pangas (33.89%) and tilapia pond (35.09%). Pangas pond showed highest abundance (104.077×103 cells/L) recorded in September and lowest (13.712×103 cells/L) in January. On the other hand, tilapia pond also showed highest abundance (99.383×103 cells/L) in September but lowest (14.094×103 cells/L) in December. Pearson correlation matrix in pangas and tilapia (Table 1) pond showed positive correlation with air temperature (r=.666, r=.737) and water temperature (r=.660, r=.740). Table 2 showed the plankton diversity of culture ponds. Study showed tilapia pond was dominant by plankton. It can be summarized that the supplementary feed added to each pond had influence on nutrient content which enhanced algal biomass and productivity of the ponds.

Table 1. Pearson Correlation matrix for plankton abundance and water quality parameters in pangas (A) and tilapia (B) ponds

A

Parameters	Plankton	Air Temp.	Water Temp.	Trans-parency	DO	pH	NO_3	PO_4	NH_3
Plankton	1								
Air Temp.	.666*	1							
Water Temp.	.660*	.982**	1						
Transparency	-.972*	-.766**	-.754*	1					
DO	.798	.601	.555	-.841**	1				
pH	-.798**	-.776**	-.684*	.854**	.188	1			
NO_3	.162	.315	.268	-.333	-.319	-.399	1		
PO_4	.121	-.271	-.302	-.092	.039	-.184	.355	1	
NH_3	.578	-.169	-.183	-.436	-.640*	-.344	-.087	.195	1

B

Parameters	Plankton	Air Temp.	Water Temp.	Trans-parency	DO	pH	NO_3	PO_4	NH_3
Plankton	1								
Air Temp.	.737*	1							
Water Temp.	.740*	.988**	1						
Transparency	-.973*	-.834**	-.814*	1					
DO	.722*	.427	.394	-.726*	1				
pH	-.610	-.739*	-.691*	.717*	.069	1			
NO_3	.266	-.075	-.098	-.232	.423	-.484	1		
PO_4	.100	-.533	-.516	.038	.283	.245	.429	1	
NH_3	.312	-.010	-.071	-.331	.108	.010	.029	.485	1

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

Table 2. Plankton diversity in Mymensingh region during the study period

Diversity Indices	Pangas pond										
	2016						2017				
	J	A	S	O	N	D	J	F	M	A	Mean±SD
Margalef index	3.24	3.04	3.46	3.31	2.10	1.77	1.88	3.01	3.75	3.70	2.92±0.70
Menhinick's diversity	0.16	0.13	0.12	0.14	0.15	0.14	0.16	0.16	0.16	0.14	0.14±0.01
Evenness	0.67	0.62	0.67	0.63	0.65	0.68	0.39	0.64	0.62	0.64	0.62±0.07
Shannon-Wiener	3.18	3.07	3.31	3.18	2.66	2.50	2.02	3.05	3.29	3.31	2.95±0.40
Simpson's dominance	0.06	0.06	0.04	0.05	0.09	0.10	0.19	0.06	0.06	0.05	0.07±0.04
Simpson's index	0.93	0.93	0.95	0.94	0.90	0.89	0.80	0.93	0.93	0.94	0.91±0.04
	Tilapia pond										
Margalef index	3.43	3.14	3.38	3.05	2.23	1.87	1.94	3.13	3.8	3.75	2.97±0.67
Menhinick's diversity	0.17	0.13	0.12	0.13	0.14	0.15	0.14	0.17	0.17	0.16	0.14±0.01
Evenness	0.67	0.63	0.6	0.67	0.62	0.71	0.38	0.7	0.71	0.65	0.63±0.09
Shannon-Wiener	3.23	3.13	3.18	3.15	2.7	2.61	2.03	3.17	3.42	3.34	2.99±0.40
Simpson's dominance	0.05	0.06	0.05	0.05	0.1	0.09	0.2	0.05	0.04	0.05	0.07±0.04
Simpson's index	0.94	0.93	0.94	0.94	0.89	0.9	0.79	0.94	0.95	0.94	0.91±0.04

OVERWINTERING PERFORMANCE OF MONOSEX TILAPIA FRY IN *HAPA* CUM CAGE AQUACULTURE

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The use of hapas allows the possibility of commercially viable fry nursing in closed and open waters system. The uninterrupted and early supply of uniform sized fingerling for tilapia cage aquaculture in Bangladesh is a major problem. The present research was to assess the technical and socio-economic feasibility study of overwintering monosex tilapia in terms growth performance and profit index. For the technical feasibility study - hapa size of 18×9×3.5 ft^3 mesh size 0.2 cm. while the cage size was 20×10×6 ft^3 mesh size 1 cm. Nine hapas was set and stocked with T1(200), T2(250) and T3(300) fish per m^{-3} for 120 days. The omnibus F-test ANOVA results exhibited for technical performance in terms of average final body weight gain (AFBWG) (58.86±7.23g) was higher in the lowest stocking density (T1) however desirable highest biomass gain (222 kg $cage^{-1}$) obtained from the medium stocking density (T2) that was also higher than the highest stocking density (T3). Further culture of T2 for second and third culture also showed significantly higher production than T1. At the same time biomass gain in T2 was not significant with T3. The survival rates were not significant in the T1 and T2 which were significantly higher than T3. Linear regression also showed there were negative correlation coefficient found in terms of SR (%),FABWG (g), GR(g $week^{-1}$) and SGR (%gd^{-1}) and positive correlation coefficient found in only FCR. According to the result presented in the further culture; all crop showed most effective survival rate (85 - 90%) and those were not significant ($p>0.05$) among themselves. In economic viability observation – the average overwintered fingerling production for first time was (US$ 576) and the gross margin was166 that indicates 20% profitability was achieved. The next two crops also showed 26% and 30 % profitability over the investment regarding total cost. Taken together, data presented herein suggests that the overwintering of tilapia fry in hapa cum cage nursery at the stocking density of 250 m^{-3} is more profitable than other treatments.

TILAPIA FRY NURSING PERFORMANCE IN *HAPA* CUM CAGE SYSTEM IN HAOR WATERS IN BANGLADESH

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Production of fingerling through nursing of fry is a key factor for aquaculture. Community fishers (*viz.* Sutarpara and Channoagaon) operated trial was performed to assess production performance of monosex tilapia (*Oreochromis niloticus*) fry in floating cage aquaculture system in haor areas, Bangladesh. Four treatments, namely T1(126), T2(177), T3(227) and T4 (278) ind. m^{-3} in haor waters were used each with 3 replicates and fish were fed floating feed twice daily and significantly higher ($p < 0.05$) final average body weight gain (31.84 ± 4.1g). It was not viable technique to stock fry, size of 0.25g rather than 1.25g (rearing for about 2 weeks in nursery condition) in hapa cum cage system due to massacre mortality about 80%. The production (87.55 ± 9.31 kg $hapa^{-1}$) for tilapia fry were found in T2 was significantly higher than among all other treatments. InT2, the SGR, survival rate and growth rate were significantly ($p<0.01$) higher than the treatment having higher stocking density but this was not significantly different ($p > 0.05$) than T1. Significantly higher ($p > 0.05$) feed conversion rate was observed in T4, while four subset were observed and a positive correlation was reported in the two month long hapa cum tilapia fry nursing system. Two successive trials with the best results in the first crop ascertained that the stocking density with 177 ind.m^{-3}would be the best. While females participated more actively in research in the haor condition with the management of fry rearing activities and earned more BCR than the female in Channoagaon but not different ($p > 0.05$). The revenue/cost ratio of different treatments was >1, indicating that the innovative hapa cum cage nursery was technically and financially efficient.

STOCKING DENSITY AND GROWTH PERFORMANCE OF *MONOSEX* TILAPIA (*Oreochromis niloticus*) IN HAOR- CAGES

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Stocking density is one of the important factors that affect the fish growth and feed utilization. This experiment was conducted from May to August 2015 to optimize the stocking density of monosex tilapia (*Oreochromis niloticus*) in the haor-cages at Karimganj, Kishoreganj district. Twelve cages were used for this experiment having submerged volume 29.5 m^3. The experiment was designed into four treatments each with three replications assigned into a completely randomized design with various stocking density. The stocking density of different treatments T1, T2, T3 and T4 were 25, 35, 45 and 55 fry m^{-3}, respectively. Fish were fed daily twice in the morning and evening with commercial floating crumbled feed at a declining rate of 10% down to 3% of estimated average body weight. The survival rate ranged from 92.14-86.03 % in different stocking densities. Biomass gain was increased gradually from T1-T4 with increasing stocking density and a decrease in trend of FABW, ABWG and MDBWG with increasing stocking density. FB and BG were positively correlated with the stocking density from T1 to T4. FCR was positively correlated with the stocking density in all treatments. Final average body weight gain (FABWG), mean daily body weight gain (MDBWG) and specific growth rate (SGR) was negatively correlated with the stocking density. The SGR of fish decreased with increasing stocking density. Conversely, the feed conversion ratio (FCR) increased with increasing stocking density. Significantly ($p<0.05$) higher fish production in terms of BG (kg $cage^{-1}$) was found in T4 (472 kg) but the FB obtained from T2 had also significantly higher FABWG that results in higher profit index compared to other treatments. The output from the subsequent culture of the best treatment of the first crop further proved its justification to all of its' output growth performances and profit index. Therefore, results showed that the cage with 35 fish m^{-3}(T2) showed promising growth, yield and survival rate which could be recommended to adopt in the cage aquaculture system in haor water.

ASSESSING THE IMPACT OF DIFFERENT COMMERCIAL PROBIOTICS ON THE GROWTH OF POND CULTURED *Macrobrachium rosenbergii*.

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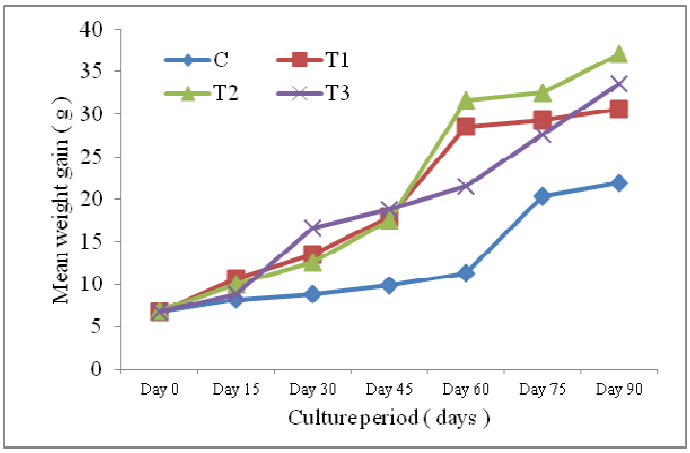
The current research was conducted to evaluate the effect of commercial probiotics on growth and production performance of fresh water prawn (*Macrobrachium rosenbergii*). After pond preparation, PL (average weight of each 9.32±6.74 g) was stocked at the rate of 2 per m^2. There were four experimental groups *viz* (a) control or without probiotics treated prawn (C), (b) feed probiotics (T_1) treated prawn, (c) Environmental probiotics (T_2) treated prawn and (d) Both feed and environmental (T_3) treated prawn and all treatments were duplicated. After, the prawn supplemented with the probiotic showed significantly better final weight, weight gain (DWG) daily weight gain (DWG) and daily growth rate (DGR) than those fed the basal diet (Control) ($P< 0.05$). There was no remarkable difference ($P > 0.05$) in specific growth rate (SGR) and relative growth rate (RGR) between the treated and control groups. After 90 days the weight gain(g) of prawn were 13.443±11.03, 21.362±13.95, 27.006±18.15, 25.456 ±17.93 g in C, T1, T2 and T3, respectively where T2 showed highest growth.

The SGR was found to be 1.547 ± 1.08, 1.656 ± 1.15, 1.589 ± 0.93 1.971 ± 1.21 % BW/day in C, T1, T2 and T3, respectively where T3 showed highest response. In terms of DGR it showed output as 14.937±12.26, 23.735 ± 15.50, 28.282 ± 20.17, 28.284 ± 19.93 % g/day where T3 has highest response to growth. In terms of relative growth rate (RGR) it yielded as 503.301±603.14, 603.343 ± 450.21, 453.296 ± 287.71, 892.655 ± 639.43 % in C, T1, T2 and T3, respectively where T3 showed highest yield response. The length weight relationship curve shows that their slope is higher in probiotics treated ponds than the control one. The production of probiotics treated ponds was always higher than without probiotics treated ponds but highest growth and production were found in (T3 as SGR is high) where feed and environmental probiotics were used combinedly. Farmers can try a formula of combining feed and environmental probiotics is their farm to find a better growth and high production output.



A JOURNEY TO CLIMATE RESILIENT SMART AQUACULTURE IN BANGLADESH: KEY DRIVERS, CHALLENGES AND ADVANCEMENTS

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Aquaculture in Bangladesh is mainly with selective freshwater fin fish and shellfish species including Indian and Chinese major carps, barbs, cichlids, catfishes, mud eels, shrimps and crabs, and dates back with ponds in the early fifties of the last century and it got its momentum in late seventies when intense aquaculture initiatives came forward with induced breeding of fish for production of sufficient fry and fingerlings for stocking in ponds, lakes, *beels* (natural depressions) and floodplains on a commercial scale overcoming natural hazards and disasters. It brought a drastic change in overall management which include timely stocking of HYV fry/ fingerling of selective species with proper ratio in consideration of their trophic levels and trophic niches, water quality maintenance, inclusion of vitamins and minerals, treatment of diseases, floods, droughts and other natural hazards, market demand, supply and value chain. With the introduction of such smart aquaculture interventions, within a decade, aquaculture in Bangladesh graduated itself from traditional extensive and improved extensive to semi-intensive and intensive aquaculture and now it is on a global stand with world recognition being 5th in the world ranking (FAO, 2015). The keys to success of aquaculture in Bangladesh are people's stride and struggle towards success. The credit goes to the Govt. of Bangladesh, international development agencies, inter-government organizations, non-government development organizations and community-based peoples' cooperatives. Some entrepreneurs' challenging initiatives and government support for research, extension and innovative technologies through the respective government agencies notably the Department of Fisheries and Bangladesh Fisheries Research Institute are worth mentioned. Introduction of climate resilient innovative agro-aquaculture (IAA) through rational utilization of common resources like land, water, labour, capital and organization with due emphasis on resource allocation, water recycling, environmental compatibility, food safety, value addition and quality development boosted primary production in multi-dimensional ways. Planned sharing of common resources- the number one challenge boosting biological production in Bangladesh. With 30 agro-ecological zones in Bangladesh (BBS, 2014), aquaculture finds its way through ten major climate resilient smart aquaculture and agro-aquaculture initiatives; i. Pond and lake aquaculture; ii. Aquaculture in rice fields; iii. Sorjan- aquaculture in fruit garden; iv. Aquaponic- aquaculture with vegetables; v. Recirculation aquaculture system (RAS); vi. Aquaculture in floodplains; vii. Floating net cage aquaculture in floodplains and open waters; viii. Floodplain aquaculture nursery; ix. Daudkandi model agro-aquaculture; and x. Vabadaha model agro-aquaculture.

IMPROVEMENT OF PRODUCTIVITY OF SEASONAL PONDS USING COMPOST UNDER CLIMATE CHANGE SCENARIO IN NORTHWESTERN BANGLADESH

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This experiment was conducted with the assessment of seasonal pond productivity at Kahoola area of Bogura Sadar Upazilia, Bangladesh with a view to increasing the water retention capacity under climate change scenario by using compost in carp polyculture ponds for a period of one year from January to December, 2018. This experiment was involved with three different treatments of varying water depth (T_1 = 7 feet, T_2 = 6 feet, and T_3 = 5 feet) and fixed stocking density (80 fingerlings per decimal; 20 *Hypophthalmichthys molitrix,* 25 *Labeo rohita,* 25 *Cirrhinus cirrhosus,* 5 *Barbonemus gonionotus* and 5 *Oreochromis niloticus*), each with three replications. In addition, there were five 'control' ponds. The water quality parameters were estimated fortnightly by Hack kit box (Model DR 2010, USA). The highest mean water depth was 7.29 feet for T_1 and the lowest was 4.01 feet for T_3. Mean water depth for all the treatments was above 5.38 feet round the year. Whereas, water lasted for 3 to 5 months only in control ponds which indicates that compost treated ponds were three times better than control ponds. The highest net fish production was 18.20 kg/decimal in T_1 and the lowest was 17.87 kg/decimal in T_3. However, the average fish production in compost treated ponds was 18 kg/decimal which was 3.5 times better than control ponds. However, both water depth and fish production varied significantly among treatments (all $P < 0.05$). The water quality parameters were in suitable ranges in all research ponds. The study concludes that both the water retention and fish production can be increased if seasonal ponds are treated with compost.

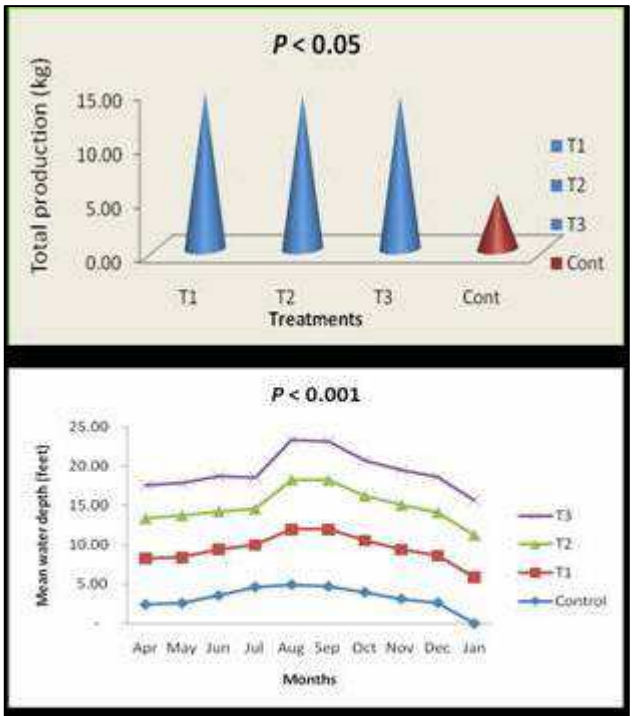

Fig. 1. Total fish production in different treatments (upper) and monthly variations of water quality parameters.

CULTURE POTENTIALITY OF LONG WHISKERS CATFISH, *Mystus gulio* IN SALINITY INTRUSION PRONE AREAS OF CENTRAL COAST, BANGLADESH

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The present experiment was conducted to evaluate the growth performance of *Mystus gulio* (Hamilton, 1822) in different culture systems in earthen ponds (40m^2) of the Noakhali Integrated Agro Industries Limited, Noakhali. The experimental fishes with initial weight of (mean±Std) (1.12±0.01g *Mystus gulio*, 1.21±0.01g *Oreochromis niloticus* and 1.13±0.01g, *Rhinomugil corsula* (Hamilton, 1822)) were reared for 120 days. Triplicate experimental treatment (stocking density 350) was employed explicitly T_1 mono culture of *M. gulio* (350), T_2 (polyculture of *M. gulio* (250) with *O. niloticus* (60) and *R. corsula* (40) and T_3 polyculture of *M. gulio* (250) with *O. niloticus* (40) and *R. corsula* (60). Fishes were hand-fed up to 20% body weight at the start and 6% at the end. Over the study period, majority of the water quality parameters were found within the acceptable range considered suitable for fish culture. The highest weight gain of *M. gulio* was observed in (24.24±0.71g) in T_1 than T_2 and T_3. Significantly higher (%) weight gain (2158.69±51.3) and final weight (25.36±0.72g) was recorded in T_1 followed by T_3 and T_2. Better SGR (% day^{-1}) were observed in T_1 (2.60±0.02) followed by T_3 (2.42±0.01) and T_2 (2.23±0.01). Average survival varied from 77.90 to 82.24% and the highest survival rate was observed in T_3. Gross production (kg ha^{-1}) were observed in T_2 (3866.37±69.66) followed by the T_3 and T_1. However, considering the survival, net profit and Benefit cost ratio (BCR) were found to be more efficient in T_3 followed by T_1 and T_2. The present findings revealed that poly culture of *M. gulio* in T_3 i.e. *M. gulio* (250) with *O. niloticus* (40) and *R. corsula* (60) may be suggested to the fish farmer as a potential climate change adaption option to utilize the vast salinity intrusion prone areas of coastal Bangladesh.

OBSERVATIONS OF FISH PRODUCTION AND AVAILIBILITY OF AQUATIC INHABITANTS UNDER PEN CULTURE IN CHATOL BEEL FLOODPLAIN

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Present study concerned about the growth and production of fishes and availability of aquatic inhabitants in Chatol beel floodplain under pen culture technology for a period of 135 days. The pen enclosure was made by bamboo-split fence which covering an area about 2.43 ha. A combination of seven fish species– *Labeo rohita, Catla catla, Cirrhinus cirrhosus*, *Ctenopharyngodon idella*, *Puntius gonionotus*, *Aristichthys nobilis and Labeo gonius* were stocked in the pen at the ratio of 30:20:25:5:10:5:5 with the stocking density of 6250 fingerings/ha. The gross fish production of pen was 5282.9 kg, which included 4684.9 kg from stocked fish and 598 kg from non-stocked fish. The small indigenous species of fish (SIS) was dominant in the catches of non-stocked fish and total 20 different SIS species belonged to 12 families were found with varying abundance. A total of 9 species of phytoplankton, 5 species of zooplankton, 21 aquatic weeds and 9 taxa of benthic fauna were observed during study period. The net profit was US $3532 and cost- benefit ratio was 1:1.8, which delineate that composite fish culture through pen culture technology in floodplain area has immense possibilities for increasing fish production and financial gains.

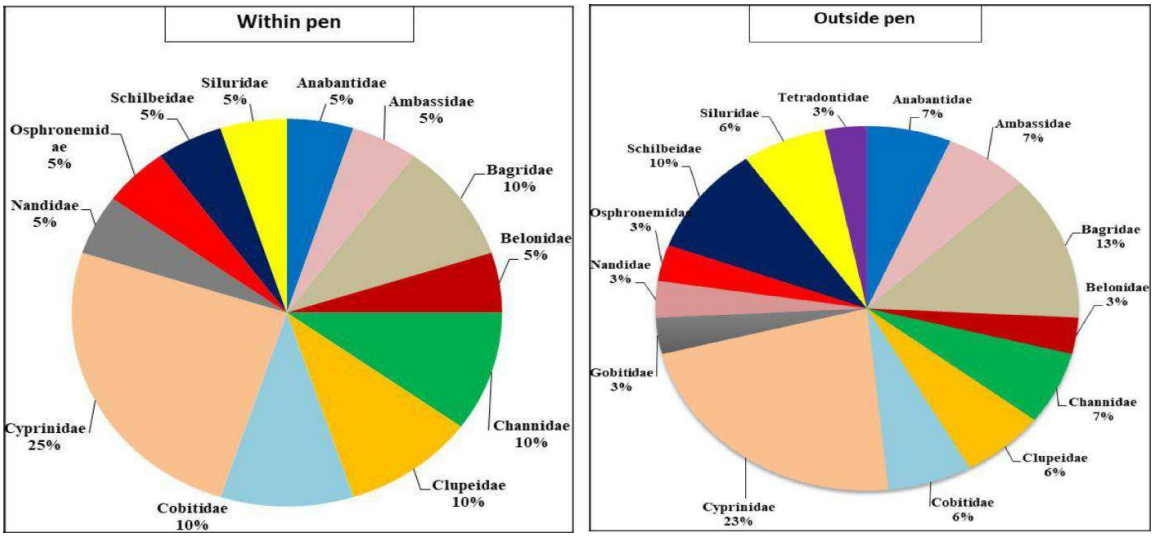

Fig. 1. Contribution of different families (%) in composition of Small Indigenous Species (SIS) within pen and outside pen

DETERMINATION OF DIFFERENT PHYSICO-CHEMICAL PARAMETERS IN CUCHIA CULTURE POND

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The present study was carried out on the physico-chemical conditions of nine cuchia culture ponds under the Department of Fisheries, University of Rajshahi. The duration of study period was from September, 2016 to December, 2016. Samples were collected at weekly intervals. During the study period (September, 2016 to December 2016), with four months duration under different three treatments, water quality parameters of nine experimental ponds were determined. Water quality parameters were monitored weekly in a whole four times per month. There were about three different treatments carried out in the whole experimental design where T_1 was the low density pond, T_2 was the moderately density pond and T_3 was the high density pond carrying T_1=40 per decimal or 9880 per hectare, T_2=60 per decimal or 14820 per hectare and T_3= 80 per decimal or 19760 per hectare. Mean values of water temperature, water transparency, DO, p^H, total alkalinity and ammonia nitrogen (NH_3-N) were varied from 22.92±0.13 to 23.37±0.06, 58.04±0.14 to 59.17±0.13, 6.34±0.04 to 6.54±0.08, 7.50±0.021 to 7.68±0.021, 125.90±0.41 to 126.40±0.48 and 0.05±0.003 to 0.08±0.02.

Table 1. Mean Variation of water quality parameters of sixteenth weeks under different treatments during the whole study period in nine Experimental ponds

Parameters	Treatment -1	Treatment-2	Treatment-3
Temperature	23.37±0.06	22.98±0.02	22.92±0.13
Transparency(cm)	58.21±0.64	58.04±0.14	59.17±0.13
DO(mg/l)	6.44±0.04	6.34±0.04	6.54±0.08
pH	7.53±0.032	7.50±0.021	7.68±0.021
Alkalinity(mg/l)	126.40±0.48	125.90±0.41	126.38±0.08
NH3(mg/l)	0.08±0.02	0.05±0.003	0.06±0.003

GROWTH AND PRODUCTION PERFORMANCES OF INDIGENOUS WALKING CAT FISH MAGUR (*Clarias batrachus*) IN CAGE SYSTEM IN THE RIVER BRAHMAPUTRA, MYMENSINGH

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Culture of fish in cages is comparatively a new method of aquaculture, which has gained much popularity in Bangladesh due to a number of advantages over the conventional methods of fish farming. For cage culture or any other intensive culture system, selection of species is also important since not all species are suitable for all culture system. Among the various culturable species Magur (*Clarias batrachus*) is particularly important for their growth, lucrative size, good taste, and high market demand in Bangladesh. A preliminary study of growth and production performance of Magur in cage in the river Brahmaputra was carried out for a period of six months during November 2016 to April 2017. Four treatments depending on the density of fish per cubic meter viz. 100, 150, 200 and 250 were tested with the cage size of 3.0 m^3. Fish were fed with pelleted supplementary feed (containing 30% crude protein) at the rate of 5-15% of body weight. On the basis of final growth attained, it was observed that the highest average weight was found in treatment-1. At harvest, the average weights attained by Magur were 148 ± 4.21, 136± 3.95, 125 ± 4.68 and 106± 3.96g, in treatments-1, 2, 3 and 4, respectively. The harvesting weight of treatment-1 was significantly higher ($P<0.05$) than treatment-2, 3 and 4, respectively. The survival rate of fish varied between 55 to 74%. In treatment-1, the highest survival rate was observed. The productions obtained in cages were 10.95, 13.26, 15.50 and 14.58 kg/m^3 from treatments-1, 2, 3 and 4, respectively. The highest and lowest production was obtained from treatment-3 and 1, respectively. Economic returns analysis showed that T_3 generated the highest return over a period of six months of Tk. 9620/cage (3m^3). The growth performances as well as economic return of Magur are very encouraging.

EFFECT OF DIFFERENT FOOD SOURCES ON REPRODUCTIVE PERFORMANCE OF EARTHWORM *Perionyx excavatus*

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To understand the growth and reproduction of a commercial earthworm *Perionyx excavatus*an experiment was conducted under laboratory conditions using various organic wastes. Cow dung (T_1) was used as control. Other five different organic wastes such as water hyacinth (T_2), banana tree (T_3), vegetable scrape (T_4), paddy straw (T_5) and sugarcane (T_6) were used and mixed with cow dung at 3: 1 ratio. The growth and reproductive performance of *P. excavatus* was measured by studying parameters, such as, gain in body weight, number of cocoons produced and number of hatchlings emerged. This experiment was conducted in triplicates by using cylindrical plastic containers for 10 weeks. 40 adult non-clitelated worms were inoculated in each container. The net weight gain/worm in different organic wastes was in the order of: vegetable scrape> banana tree> sugarcane> cow dung> water hyacinth> paddy straw. The number of cocoons produced per worm in different organic wastes was in the order of: banana tree> sugarcane> vegetable scrape> paddy straw> water hyacinth> cow dung. The number of hatchlings emerged/ cocoon in all the organic wastes was in the order of: banana tree> sugarcane> water hyacinth> paddy straw> vegetable scrape> cow dung.

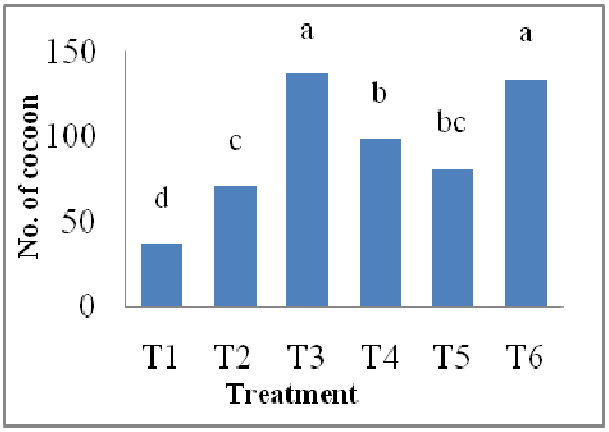

Fig. 1. Cocoon production by *Perionyx excavatus* in different organic waste.

Table 1. Hatching performance of cocoons of *P. excavatus*

Parameter	T_1	T_2	T_3	T_4	T_5	T_6
Total no. of hatched cocoons	5	8	10	6	7	8
Hatching success (%)	50	80	100	60	70	80
Total no. of hatchlings emerged	5.00^{c} ±0.4	9.67^{b} ±0.58	12.33^{a}±0.51	6.67^{c}±0.52	7.00^{c} ±0.13	9.67^{b}±0.54
Hatchlings/cocoon	0.50± 0.10	0.97±0.06	1.23±0.15	0.67±0.15	0.7±0.10	0.97±0.15

Significant difference was recorded among all the parameters of *P. exacavatus* in all the 6 different treatments. The overall result of this study showed that better weight gain observed in vegetable scrape but higher number of cocoon produced and hatching emerged in banana tree.

SODIUM BICARBONATE AS AN INORGANIC CARBON SOURCE FOR *Chlorella ellipsoidea* CULTURE

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Chlorella ellipsoidea is a freshwater microalgae, which served as an important food for larvi culture of aquatic organisms. In culture medium an adequate supply of inorganic carbon source like sodium bicarbonate ($NaHCO_3$) can potentially be utilized for photosynthetic activity of *C. ellipsoidea*. Therefore, an experiment was conducted for 18 days by using Bold's basal medium (BBM) (T_1 = Control) and different concentrations of $NaHCO_3$ supplemented to BBM (T_2 = 0.25 g/L, T_3 = 0.5 g/L, T_4 = 1.0 g/L, T_5 = 1.5 g/L and T_6 = 2.0 g/L) to assess growth performance of *C. ellipsoidea*.

In the experiment, physico-chemical characteristics of the culture media such as light intensity, temperature, dissolved oxygen (DO) and pH were at suitable ranges for *C. ellipsoidea* culture. The initial cell density of *C. ellipsoidea* was 11.32×10^5 cells/ml which increased up to 19.08 (T_1), 21.08 (T_2), 24.39 (T_3), 31.20 (T_4), 41.17 (T_5) and 31.11 (T_6) ($x10^5$ cells/ml), respectively. The result showed that maximum cell density was attained in T_5 at the 15th day of culture (Figure 1). The highest cell dry weight (24.55 ± 0.85 mg/L) was found also in T_5 at 15th day of culture (Figure 2). Similar trend was observed in case of chlorophyll a content where highest value (4.65 ± 0.07 mg/L) was found in T_5. On the basis of cell number and chlorophyll *a*, the maximum specific growth rate (SGR) was recorded 0.16 µ/dayin T_5.

The study showed that, growth performances of *C. ellipsoidea* was significantly ($P<0.05$) higher in T_5 where 1.5 g/L $NaHCO_3$ was supplemented to BBM than other different media; which indicated the potentiality of $NaHCO_3$ as an inorganic carbon source for microalgae production.

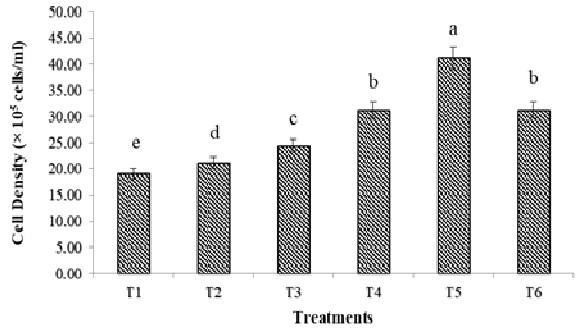

Fig. 1. Cell density ($\times10^5$ cells/ml) of *C. ellipsoidea* at 15th day of culture

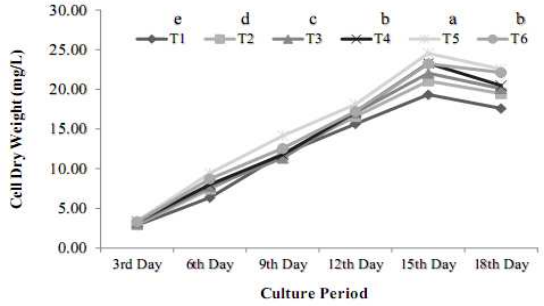

Fig. 2. Cell dry weight (mg/L) of *C. ellipsoidea* under different treatments during the experimental period

EFFECT OF DIETARY AND ENVIRONMENTAL PROBIOTICS ON GROWTH PERFORMANCE OF *Macrobrachium rosenbergii*

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This experiment had been conducted to investigate the effect of environmental and feed probiotics on growth performance of freshwater prawn *Macrobrachium rosenbergii*. The experiment had three treatments *viz.* environmental probiotics (T_1), feed probiotic (T_2), and combination of both feed and environmental probiotics as T_3 with a control group with no probiotics. Over wintering large size PL of average weight 6.82±3.66g was stocked at 2/m^2. Available commercial feed was given according to the prawn's body weight. After 90 days of probiotic treatment, the average weight gain was 31.67±1.34, 36.03±1.33 and 28.97±1.17 g, respectively at T_1, T_2 and T_3 the lowest values was observed in control group (21.93±0.33 g) (Table 1). The growth parameters like final weight, weight gain, daily weight gain, daily growth rate were significantly ($P<0.05$) higher in probiotic incorporated diet fed juvenile. However, insignificant differences were recorded in SGR and RGR between control and experimental groups but higher values of these parameters were found in probiotic supplementation diet fed prawn. On the other hand, positive allometric growth (b= 3.105) and strong length-weight relationship (R^2= 0.901) were found in feed probiotics treated prawn. So, probiotic supplementation diet fed juvenile resulted in better growth performance and strong length-weight relationship. This was only because of presence of beneficial bacteria in the probiotics. Therefore, incorporation of feed and environmental probiotics in aquaculture is stressed for promoting sustainable culture of *Macrobrachium rosenbergii.*

Table 1. Growth (mean ± standard error) of *M. rosenbergii* under different probiotic treatments. Different superscript letters indicate significant differences among the treatments (Kruskal Wallis, $p<0.05$).

Treatment	Initial Weight (g)	Final Weight (g)	SGR	WG (g)	DWG (g)	DGR	RGR
C	6.82±3.66	21.93±0.33^{a}	1.51±.167^{a}	14.19±1.54^{a}	.157±.017^{a}	15.77±1.71^{a}	5.02±92.02^{a}
T_1	6.82±3.66	31.67±1.34^{b}	1.17±.20^{a}	17.88±3.35^{a}	.198±.037^{a}	19.87±3.72^{a}	4.448±1.17^{a}
T_2	6.82±3.66	36.03±1.33^{c}	1.81±.208^{a}	24.49±2.45^{b}	.272±.027^{b}	27.22±2.71^{b}	8.52±1.898^{a}
T_3	6.82±3.66	28.97±1.17^{ab}	1.62±.23^{a}	18.23±3.79^{ab}	.20±.04^{ab}	20.26±4.21^{ab}	8.277±1.64^{a}

AQUAMIMICRY: A SUSTAINABLE NATURAL SHRIMP FARMING

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Disease has become a main constraint and great challenge for successful aquaculture. Recently, farmers are facing the early mortality syndrome (EMS) or acute hepatopancreatic necrosis disease (AHPND), white spot syndrome virus disease, vibriosis and many other diseases during shrimp culture due to high density and use of more feed. These diseases are highly responsible for the reduced total production which ultimately causes great loss for the farmer. To prevent shrimp diseases and increasing the production, farmers are using different aqua-drugs, chemicals, and antibiotics. These drugs are not safe for human, as farmers are using overdose of these drugs again the chemicals are altering the natural environment and leads to loss of biodiversity. In this regard, new culture technique ensuring natural biosecurity, environment friendly and economically profitable is an urgently required to get sustainable shrimp production. Therefore, aquamimicry could be best alternative for establishing natural disease management strategy in existing shrimp culture practices. Aquamimicry is the intersection of aquatic biology and technology (symbiotics) mimicking the nature of aquatic eco-systems to create living organisms for the well-being development of aquatic animals." It is the way to prevent the diseases in intensive aquaculture without using any drugs or chemicals and provides natural live diets "Copepod" for post larvae prior to stocking, pond water stability, enhances good survival rate, fastest growth rate, high profitable, totally and sustainable shrimp production without any destructive to our mother nature. If the aquamimicry system could be applied in combination with our traditional culture technique the occurrence of diseases will be minimized and the cost of the production will be lowered. So this study has been designed to optimize and adapt aquamimicry system in the existing culture practices in brackishwater environment. This experiment was carried out in the pond/ghers situated shyamnagar, satkhira with three treatments (Control: 100% commercial feed; T_1: 70 %CF+30%LFRB, and T_2: 90%CF+10%LFRB with HDPE liner, respectively) with two replications. The water quality parameters were at optimum level in the treatment pond treated with HDPE linear + LFRB compared to control. The transparency was low (35cm) in the T_1 which was treated with 30% LFRB and the growth of that treatment was better comparatively control. The microbiological analysis was carried out in laboratory and analysis at species specific level will be done.

CHARACTERIZATION OF COMMERCIAL PROBIOTICS USING FOR FISH AND SHRIMP CULTURE IN BANGLADESH

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Probiotics are feed supplement which beneficially affects the host animal by improving its intestinal microbial balance. Almost all of probiotics used in Bangladesh are import based and labelling of those products is not well written. But the efficacy and the other viability of properties of the probiotic is in questionable still now. So, with this veiw this research was carried out to isolate and characterize the bacteria from commercial probiotics. In this study, commercial probiotics were collected from five companies including Pond care, ACP prop, Nutri grow, Biotics and Navio plus. Firstly, pure bacteria were isolated from commercial probiotics using different specific media including MRS, NB, LB, PDA, ASP, BHI and TS. Then, pure isolates were pureed by subsequent isolation. Biochemical characterization including gram staining, catalase test, oxidase test and probiotic properties including acid tolerance, bile salt tolerance, auto-aggregation capacity were determined from pure isolates. A total of 32 isolates were isolated from five companies' commercial probiotics using selective media. Regarding this biochemical characterization 28/32 isolates were shown gram (+) and 4/32 gram (-), 11/32 oxidase (+) and 21/32 oxidase (-), 32 catalase (+). Most of the tested isolates showed moderate tolerance in acidic condition whereas highly resistant in bile salt and about 26/32 bacterial isolates were shown low, 2/32 medium and 4/32 absent in auto-aggregation capacity. Further, antibiotic susceptibilities were completed by using five antibiotics including ciprofloxacin, cephalexin, amoxicillin, tetracycline and doxycycline. Most of the isolates showed diverse range of susceptibilities in this type of antibiotics. About 16/17 isolates were resistant to cephalexin and amoxicillin and 1/17 intermediate to amoxicillin, 2/17were intermediate and 15/17 susceptible to ciprofloxacin, 9/17were resistant, 6/17 intermediate and 2/17 susceptible to tetracycline, 9/17 were resistant, 1/17 intermediate and 7/17 susceptible to doxycycline antibiotics. Hemolytic activity test profiles were determined by using blood agar plate that contains 0.5% sheep blood. About 12/43 isolates were shown alpha hemolysis, 14/43 beta hemolysis and 17/43 gamma hemolysis. Finally, DNA extraction procedure were performed by using 16s rRNA sequencing method. Approval procedures of probiotic products must be strengthened through scientific-based efficacy trials and product labels should allow identification of individual bacterial strains and inform the farmer on specific purpose, dosage and correct application measures. Therefore, the present study will be carried out to develop comprehensive microbial database of probiotics using for fish and shrimp culture in Bangladesh for ensuring food safety and quality.

COMPARATIVE STUDY OF NUTRITIONAL QUALITY OF CUCHIA (*Monopterus cuchia*) AND CARPS AND POTENTIALS OF CUCHIA CULTURE IN BANGLADESH

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Freshwater mud eel (*Monopterus cuchia*) known as Cuchia is nutritionally rich and medicinally valuable compare to other fishes especially carps. Cuchia plays important role to improve socio-economic condition of the rural people of Bangladesh especially the poor tribal people. The present experiment was conducted to know the nutritional comparison of Cuchia *(Monopterus cuchia)* and three indian major carps explicitly Rui *(Labeo rohita),* Catla *(Catla catla)* and Mrigal *(Cirrhinus cirrhosus).* The moisture content of Cuchia was 78.05% whereas Rui, Catla and Mrigal was 78.18, 79.25 and 78.84%, respectively. Protein content of Cuchia was 18.45% whereas Rui, Catla and Mrigal was17.02, 16.75 and 17.10%, respectively. Cuchia contain 2.25% lipid whereas Rui, Catla and Mrigal contain 3.10, 2.16 and 2.11% lipid, respectively. The ash content of Cuchia was 1.25 % whereas Rui, Catla and Mrigal contain 1.70, 1.84 and 1.95%, respectively. This illustrates the nutrient content of Cuchia particularly rich which should guide policy and programmes to improve food and nutrition security in Bangladesh.

NANOTECHNOLOGY: A NOVEL APPROACH IN FISHERIES AND AQUACULTURE

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Nanotechnology has a tremendous potential to revolutionize agriculture and allied fields including aquaculture and fisheries. It can provide new tools for aquaculture, fish biotechnology, fish genetics, fish reproduction and aquatic health etc. Nanotechnology tools like nanomaterials, nanosensors, DNA nanovaccines, Gene delivery and smart drug delivery etc. have the potential to solve many puzzles related to animal health, production, reproduction, prevention and treatment of diseases. It is sensible to presume that in the upcoming years, nanotechnology research will reform the science and technology and will help boost livestock production. Nanotechnology applications in the fish processing industry can be utilized to detect bacteria in packaging, produce stronger flavors, colour quality, and safety by increasing the barrier properties. This paper presents the review of nanotechnology and its applications in aquaculture and fisheries. Nanoparticles have found their way into many applications in the field of medicine, including diagnostics, vaccination, drug and gene delivery. In this review, we focused on the antimicrobial effects of nanoparticles, with particular emphasis on the problem of antibiotic resistant bacteria in fisheries. The use of nanoparticle-based vaccines against many viral pathogens is a developing field in fish medicine research. Nanoparticles have gained much interest as a specific and sensitive tool for diagnosis of bacterial, fungal and viral diseases in aquaculture. Nevertheless our review also highlights the many applications of nanotechnology that are still to be explored in fish medicine.

GROWTH PERFORMANCE AND PRODUCTION OF THREATENED RIVERINE MENODA CATFISH, *Hemibagrus menoda* IN POND BASED ON STOCKING DENSITY

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An experiment was conducted to study the effect of stocking density on growth performance of fingerlings production of riverine menoda catfish*, Hemibagrus menoda* in pond condition under three treatments each with three replications for a period of three months. The first experiment was tested with three different stocking density under the treatment of menoda catfish with average weight of 2.5±.02g at a rate of 250 fish/dec (61750 fish/ha), 300 fish/dec (74100 fish/ha) and 350 fish/dec (86450 fish/ha) in T_1, T_2 and T_3, respectively. The diets and feeding rates were same for all treatments. Physico-chemicals parameters of the pond water were within the suitable level for fish culture. The highest mean weight gain were observed in T_1 (40.2±0.30) and lowest in T_3 (25.9±0.19). The significantly lowest SGR 2.69±0.004 was obtained in treatment (T_3) where highest SGR value 3.15±0.007 was recorded in treatment (T_1). The average daily gain was found highest in (T_1) 0.44±0.07 and followed by in (T_2) 0.36±0.004 and in (T_3) 0.28±0.004.The survival rate was significantly higher in T_1 (85.00±0.57) and lower in T_3 (75.33±0.33) treatments to treatments variation was significant. The yield of fish in T_1, T_2 and T_3 were 2274.5±57.73, 2066.4±100.00 and 1847.9±100.00 kg/ha/90 days. The significantly ($P<0.05$) highest net profit 555112 (Tk/ha) was obtained in treatment T_1, in treatment T_2 net profit 478246 (Tk/ha) was found and the lowest net profit in treatment T_3 379535 (Tk/ha) were obtained. Correlation matrix among stocking density, weight gain (g), survival rate (%), SGR (%) and production of *H. menoda* and gave a clear indications among the growth parameters that stocking density inversely correlated with weight gain (g), survival rate(%), SGR(%) and production. The highest cost and benefit ratio (CBR) was calculated 1:1.62±0.005 in T_1 than that of the 1:1.37±0.005 and 1:1.06±0.001 for T_2 and T_3, respectively.

EFFECT OF PHOSPHORUS SUPPLEMENTATION ON THE GROWTH AND COMPOSITION OF *Azolla pinnata*

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Azolla pinnata appears as a good source of protein, minerals, vitamins, probiotics and biopolymers. It proliferates at a high rate in natural ponds or rice field and if necessary, for large supply, can be grown with simple management practice and low cost. However, phosphorus (in the form of phosphate) is the major limiting nutrient for *A. pinnata* production. The optimum requirement level of phosphorus for the mass production of *A. pinnata* in the tropical environment is not yet clearly identified. Therefore, the present study was undertaken to investigate the effect of different concentration of supplemental phosphorus on growth, yield and proximate composition of *A. pinnata*.

A. pinnata were grown in four treatments, labelled T_1 to T_4, by supplying 0, 10, 20 and 30 ppm phosphorus (Triple Super Phosphate), respectively for 15 days at the beginning of winter (Trial 1) and 21 days at the end of the winter (Trail 2). 1.5m x 1.5m x 0.3m culture pits covered with silpauline sheets was prepared by spreading sieved fertile soil and 2-3 days old cow dung. The water quality parameters such as temperature, pH, NH_3, PO_4-P, NO_3-N and NO_2-N were monitored at every day. The growth performance was measured at every 3 days interval while gross biomass production and proximate compositions were measured at the end of the experiment to examine the effect of different levels of phosphorus. At the end of the experiment in both trials, *A. pinnata* supplemented with 10 ppm phosphorus (T_2) had significantly (p< 0.05) higher final weight gain, percentage weight gain and gross biomass production (Figure 1) compared to *A. pinnata* grown in all other treatments. Similarly, average crude protein and lipid contents of *A. pinnata* were significantly (p< 0.05) higher with 10 ppm phosphorus supplementation (Table 1). The results indicate that phosphorus is a necessary component for the *A. pinnata* and 10 ppm phosphorus appears to be sufficient for the optimum mass production and proximate composition of *A. pinnata*.

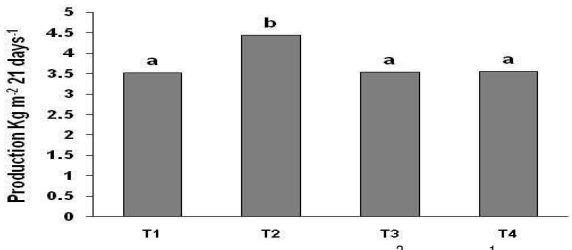

Fig. 1. Gross biomass production (Kg m^{-2} 21 $days^{-1}$) of *A. pinnata* in Trial 2. Mean bearing different letters are significantly different p< 0.05.

Table 1. Proximate composition (% in dry weight) of *A. pinnata* in different treatments

Composition %	T_1	T_2	T_3	T_4
Moisture	84.11^{a}	78.25^{b}	79.20^{b}	81.17^{ab}
Protein	28.84^{ab}	30.52^{a}	28.02^{b}	28.23^{b}
Lipid	5.55^{b}	7.77^{a}	4.15^{bc}	2.65^{c}
Ash	18.37^{b}	21.36^{a}	17.37^{b}	14.65^{c}

NUTRIENT COMPOSITIONS OF PABDA *Ompok bimaculatus* GROWN IN RECIRCULATING AND CLOSED AQUACULTURE SYSTEMS

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Pond aquaculture accounting the highest percentage of fish production, but average pond production is still low (lower than 5 tonnes/ha). Other countries have been producing in excess of thousand tonnes/ha by adopting intensive culture technique such as recirculating aquaculture system (RAS). Aquaculture production of Bangladesh can be increased many folds through RAS and other vertical expansion, for example, closed aquaculture system (CAS). As pabda is now an endangered species, it may be saved from extinction as well as increase production by culturing in these two systems. In both systems, fish were fed same commercial feed (Tongwei) at same rate according to body weight (BW) (Table 1). Water quality parameters were maintained in optimum level in RAS and monitored at every 7 days interval in CAS.

The moisture (RAS: 78.68 ± 1.23%; CAS: 79.78 ± 0.37%) and crude protein (RAS: 16.41 ± 1.35%; CAS: 15.47 ± 0.47%) content of pabda did not differ between systems. The fish had higher ash and lipid content rose in RAS (ash: 1.46 ± 0.17%; Lipid: 3.77 ± 0.75%) than in CAS (ash: 0.76 ± 0.12%; Lipid: 1.55 ± 0.09%) (Table 2). Of 8 essential amino acids, lysine, leucine and arginine were the major EAAs in the fish in both systems. Of NEAAs, glutamic acid was found in highest percentage in both systems (RAS: 18.38 ± 0.18**;** CAS**:** 16.31 ± 0.21) followed by aspartic acid (RAS: 11.26 ± 0.21; CAS: 11.93 ± 0.39). The total percentage of PUFA in pabda was found to be nearly 33% in RAS which was significantly lower than that of CAS (41%). Similarly, MUFA was found to be significantly higher in CAS (32%) than did the RAS (20%). The ratio between omega-3 and omega-6 fatty acids in RAS and CAS were 0.73 and 0.69, respectively. Of six minerals, only potassium (K) was significantly higher in RAS than that of CAS.

Table 1. Proximate compositions (% dry basis) of feed

Ingredients	Proximate compositions (% dry basis)
Moisture	12 (max)
Ash	20 (max)
Protein	30 (min)
Lipid	7 (min)

Table 2. Proximate compositions (% wet basis) of muscle of *Ompok bimaculatus* sampled from two culture systems, RAS and CAS

Proximate composition (% wet basis)	Culture systems	
	RAS	CAS
Moisture	$78.68 \pm 1.23_a$	$79.78 \pm 0.37_a$
Protein	$16.41 \pm 1.35_a$	$15.47 \pm 0.47_a$
Ash	$6.85 \pm 0.59_a$	$3.74 \pm 0.57_b$
Lipid	$3.77 \pm 0.75_a$	$1.55 \pm 0.10_b$

CONTINUOUS PRESENCE OF AHPND POSITIVE *Vibrio parahaemolyticus* STRAINS ISOLATED FROM SHRIMP *Penaeus monodon* IN BANGLADESH

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Acute hepatopancreatic necrosis disease (AHPND) is an emerging shrimp disease that causes massive die-offs in farmed shrimps within the first 30 days after stocking in grow-out ponds. The causative agent is *Vibrio parahaemolyticus*, which is typically known to cause food-borne gastroenteritis in humans; but those strains carrying the *pir*A and *pir*B like toxin genes known to cause AHPND in shrimp. Detection of *V. parahaemolyticus* isolates is typically based on molecular techniques through species-specific gene *ldh* (lecithin dependent hemolysin); AHPND positive strains are commonly identified using AP3 and AP4 primers. The overall objective of this study was to check the continuous presence of AHPND positive *V. parahaemolyticus* strains in 2018; as it was reported the presence of this pathogen in 2016 and 2017 that were isolated from shrimp (*Peneaus monodon*) of south west region of Bangladesh.

The sampling covered 37 different '*Gher'* of three sampling districts of south-west shrimp farming region of Bangladesh *viz*., Rampal of Bagerhat, Sadar of Satkhira, Dumuria and Paikgacha of Khulna districts. The processed samples were inoculated in TCBS media and further re-streaked in CHRO Magar *Vibrio* media. The colony which shows large violet color was cultured in TSA+2% salt media for DNA extraction. Detection of the AHPND positive *V. parahaemolyticus* strains were performed by *ldh*, AP3and AP4 PCR.

Among 49 primary isolates, 15 were selected for strain specific (*ldh*, AP3, AP4) PCR, along with MSR 16 as positive control. 14 showed positive result with *ldh*, 3 isolates (SVp 1, SVp 15, SVp 43)were positive for AP3, whereas 5 isolates (same 3 of AP3 and another 2 SVp 23, SVp 48) showed positive results with AP4 method. In summary, out of 15 isolates, 5 isolates were confirmed as AHPND positive *V. parahaemolyticus*.

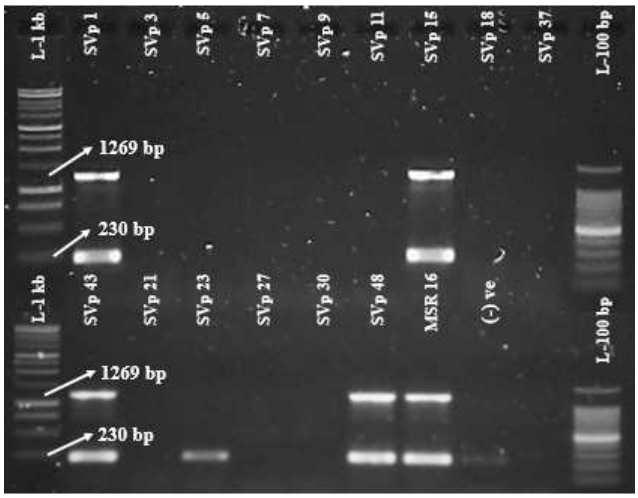

Fig. 1. AP4 (1st and 2nd step) nested PCR amplicons obtained from representative *V. parahaemolyticus* isolates obtained from shrimp samples of south-west regions.

EFFECTS OF DIETARY POLYUNSATURATED FATTY ACID AND BETA-GLUCAN ON INCREMENT OF MATURITY, IMMUNITY AND FRY QUALITY OF GANGETIC MYSTUS (*Mystus cavasius*)

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The present study was undertaken to determine the effects of polyunsaturated fatty acids (PUFAs) on enhanced maturation and reproduction, and dietary beta glucan in enhancing immunity of endangered Gangetic Mystus *(Mystus cavasius*). Fishes were collected from the Brahmaputra River, Mymensingh, Bangladesh and stocked in the cisterns and ponds. Treated group was provided supplemental diet enriched with 1% squid extracted lipids as a source of PUFAs and 10% barley powder as a source of beta glucan, and finely chopped squid meal for four months whereas controlled group will be fed the same diet except PUFAs and beta glucan. Histomorphology of liver and serum calcium ion concentration indices will be used to clarify gonadal maturation and a spawning trial will be conducted to spell out the reproductive performances. Acetylcholinesterase (AChE) activity, lysozyme activity and cell count of erythrocytes ($\times 10^3/mm^3$) and leucocytes ($\times 10^6/mm^3$) will be measured using standard methodology to explain the immunomodulatory effects of beta glucan in association with PUFAs enriched diet on (*Mystus cavasius).*This study proposes that treated group will attain higher weight increment compared to the control group. We are expecting that treated group will exhibit an advanced gonadal maturation and higher reproductive performances in spawning trial. Higher fertilization rate, hatching rate and survival rate of offspring is also expected in treated group compared to control. Higher serum Ca^{2+} level, AChE activity, lysozyme enzyme activity in treated fishes are also expected. WBC of the blood acts as defensive element against the external and unwanted intrusive element and results of WBCs count cell ($\times 10^6/mm^3$) in blood which will be fed with beta glucan in associated with PUFAs is expected increased in number as compared with the control. Therefore, the present studywill focus the enhanced spawning performances and immune status of (*Mystus cavasius)*owing to PUFAs and beta glucan supplementation in diet.

EFFECT OF PARTIAL REPLACEMENT OF FISH MEAL BY MUSTARD OIL CAKE IN AQUAFEED ON GROWTH PERFORMANCE, FEED UTILIZATION, PROXIMATE COMPOSITION AND ECONOMIC ANALYSIS OF RUI, *Labeo rohita* CULTURED IN CAGE

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The study was conducted to investigate the effect of partial replacement of fish meal with mustard oil cake (MOC) meal as dietary protein source for cage culture of *Labeo rohita* for 90 days in 9 cages. The fishes were fed with three iso-nitrogenous (30% protein) and iso-caloric experimental diets *viz.*MOC 0% (fish meal based diet), MOC 50% (50% fishmeal and 50% mustard oil) and MOC 75% (25% fish meal and 75% mustard oil cake) diet. The fishes with an initial average weight of 52.97g were stocked in each cage. The fishes were fed twice in a day near saturation. The water quality parameters were monitored with slandered method. The feed conversion ratio (FCR)of MOC 50% fish group was also showed best performance than other feed types. The gross and net yield were obtained significantly (p<0.05) higher in MOC 50% fish group. Although the cost for the formulation of experimental diets was highest in MOC 0% fish group (44 BDT/kg) followed by MOC 50% fish group (35 BDT/kg) and MOC 75% fish group (31 BDT/kg), however the net return and benefit-cost ratio (BCR) was obtained significantly ($P < 0.05$) higher from MOC 50% fish group than other groups. Hence, it can be concluded that mustard oil cake (up to 50%) can be partially replaced with fish meal as the alternative protein source without changing the nutritional quality of feed for cage culture of *L. rohita*.

COMPARATIVE STUDY OF VIRULENCE GENES CONSERVED IN FISH PATHOGENIC *Streptococcus* sp. ISOLATES

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Streptococcosisis an important disease in aquaculture that causes severe losses throughout the world. *Streptococcus iniae*, *S. agalactiae*, and *S. parauberis* have been reported as the pathogens of this disease. The present study was conducted to identify and compare the virulence genes among the different species of *Streptococcus* sp. published in different articles and construct gene library of 58 virulence genes and to compare them. Whole genome sequence of nine fish pathogenic *Streptococcus* sp. strains including *S. iniae* (ISET0901, 89353, SF1 & ISNO), *S. agalactiae* (GD201008-001, S25, SA20-06 & SA623) and *S. parauberis* KCTC3651) were obtained from NCBI. The genome size of the strains isolated from streptococcosis diseased were found to vary between 1.84 to 2.15 Mb. Antimicrobial resistance genes were identified for 15 antibiotics in the whole genome sequences of these strains. All strains of *S. agalactiae* harbor the antimicrobial resistance gene *mreA* (MLS - Macrolide, Lincosamide, and Streptogramin B). Among the *S. iniae* strains, 22 virulence genes (*cpsD, cpdB, ligA, cfi, tnpA, mgx, pdi, pgmA, satA, ScpI, simA, sag* (*A-I*)*, soda, and telX*) were identified. *S. agalactiae* strains conserve *adhE, cps* (*A-F*)*, clp* (*C,E & L*)*, copA,cpdB, cyl* (*A, B, E &F*)*, fmtC, gshA, hylB, kup,pbp2A, relA, scpA, soda, uvrA, uvrB, vacB*, and *yhg E*virulence gene. *S. parauberis* KCTC3651 conserves 6 virulence genes including *clpC, clpL, copA, htrA, pbp2A* and *relA*. Furthermore, only 41 to 46% predicted coding sequence (CDSs) could be functionally categorized into 520 to 557 subsystems. Among the functional genes in subsystem, carbohydrates, amino acids and derivatives and protein had greatest numbers of functional genes in all studied bacteria. The phylogenetic tree analysis based on single nucleotide polymorphisms (SNPs) on the core genome sequence of the strains clearly categorized them according to species and origin. Findings of this study would be useful to find out virulence genes in *Streptococcus* spp. and selection of suitable strains for vaccine development.

PRESENT STATUS OF FISH DISEASE AND AQUA DRUGS IN DIFFERENT AQUACULTURAL FARMS IN SYLHET DIVISION, BANGLADESH

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A study on present diseases and aqua drug status in small to large scale aquacultural farms in Sylhet division was conducted in January 2018 to June 2018, in co-operation with the Department of Fisheries. Total 120 farms of four districts were surveyed by questionnaire. Maximum farms were selected from respondents to the information of the department of fisheries. Maximum (90%) of the farmers follow polyculture system whereas few (9%) were continuing single species culture i.e., tilapia, pungus and catfishes. Among the 18 different cultured species, Indian major carps were largely susceptible to different diseases in different seasons i.e., Rui (23%) followed by the Tilapia (21%), Catla (18%) and Mrigal (16%). The most prevalent disease was an external parasite (85%) followed by the Epizootic Ulcerative Syndrom (53.33%), red spot (47.5%), fin and gill rot (48.33%). The average prevalence of fish diseases was highest (34%) in Moulavibazar followed by the Habiganj (32%), Sunamganj (20%) and Sylhet (14%). The diseases occurred mainly in the winter season. Overall, the knowledge of the farmers on basic fish health management was found very poor. There are 10 companies' aqua drugs are available throughout the Sylhet division and among them, ACI (30%), Eon (19%), SK-F (17%) and Fishtech (13%) are more dominant. Most commonly used chemicals are gas remover and mineral supplier (Megazeo Plus, Zeopel and Zeolite Gold), disinfectant (Timsen, Polgard and Virex), oxygen supplier (Bio-Ox and Oxigold), antibiotic (Micronid, Renaflox and Renamycin), vitamin (Acevit-C, Ossi-C and EskaVit-C traditional lime, bleach and salt. Among the 16 fish feed companies, Megafeed (26%), ACI (22%), Narish (15%), Quality feed (12%) and Aftab (7%) are dominant in the whole division. The average production cost of farms was 610,433 taka and average profit was 281,375 taka. For disease treatment, 4.92% cost spend behind different traditional and packaged chemicals and drugs. This study identified common diseases, drugs used against them throughout the Sylhet division.

ISOLATION AND IDENTIFICATION OF PATHOGENIC BACTERIA IN INDIGENOUS AND EXOTIC CLIMBING PERCH, *Anabas testudineus* FROM NORTH EASTERN PART OF BANGLADESH

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The present study was aimed to evaluate the pathogenic bacteria in indigenous and exotic climbing perch (*Anabas testudineus*) from North Eastern Part of Bangladesh during December, 2014 to May, 2015. To carry out this study 30 climbing perch fish samples were collected from ten (10) fish markets. The study concentrated on the bacteriological parameters such as Total Coliform Count (TCC), Total Fecal Coliform Count (TFC) and variety of pathogenic bacteria. The highest mean TCC and TFC of indigenous and exotic Koi were 161.67 and 111.17 MPN/g, 59.37 and 36.81MPN/g respectively. The isolated pathogenic bacteria were *Escherichia coli*, *Pseudomonas* spp., *Aeromonas* sp., *Staphylococcus aureus, Salmonella* spp. and *Vibrio* spp. Findings of this study indicated that both varieties of studied *A. testudineus* were more or less contaminated but comparatively higher TCC, TFC and pathogenic bacteria were recorded in indigenous climbing perch than exotic variety of *A. testudineus*.

STUDY OF PARASITIC INFESTATION OF *Clarias batrachus* IN DINAJPUR REGION OF BANGLADESH

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An experiment was carried out for a period of six months during August 2018 to January 2019 to investigate the parasitic infestations on *Clarias batrachus*. The present experiment was aimed to investigate the infestation of parasites and their effects, prevalence of different parasites with respect to sex, different seasons of walking catfish, *Clarias batrachus* from Dinajpur region, Bangladesh. A total of 120 *C. batrachus* fish were collected from market, Dinajpur region where 76 fish were males and 44 fish were females. Sex, total length, weight, and no. of parasites were recorded. Total 1723 parasites were collected. Most of the parasites were observed in the stomach of host fish. Prevalence, intensity, abundance and index of infestation with parasites were varied to different sex groups and season. In case of sex, the male fishes were more infested than the female and in case of season parasites were more infested summer than winter. Most of those parasites were cestodes. The prevalence was (100%) in November and the lowest September. The maximum mean intensity (41.27) was found in October and the minimum (4.25) in November. The highest abundance 37.15 was observed in October and the lowest 4.25 was in November. The highest Index of infestation 668.7 was observed in October and the lowest 72 was in November.

Month	Fish no.	sex		Total no. of parasites	Infected fish	Mean intensity	Prevalence (%)	Abundance	Index of infestation
		male	female						
Aug	20	13	7	108	17	6.35	85	5.4	91.8
Sep	20	11	9	90	16	5.62	80	4.5	72
Oct	20	11	9	743	18	41.27	90	37.15	668.7
Nov	20	14	6	85	20	4.25	100	4.25	85
Dec	20	13	7	244	18	13.55	90	12.2	219.6
Jan	20	14	6	453	19	23.84	95	22.65	430.35
Total	120	76	44	1723	108	Mean=15.81	Mean=90	Mean=14.35	Mean=261.24

MOLECULAR IDENTIFICATION AND ANTIBIOGRAM OF GUT BACTERIA ISOLATED FROM STRIPED CATFISH, *Pangasianodon hypophthalmus* CULTURED IN BANGLADESH

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Striped catfish (*Pangasianodon hypophthalmus*) also known as Pangasius or locally as Pangas or Thai Pangas, is a commercially important and fast-growing aquaculture commodity in Bangladesh as well as in the Asian region. Fish gut is a major route of bacterial infection because it is a nutrient rich habitat suitable for bacterial growth. The study was carried out to isolate and identify the gut bacteria of pangasius using 16S rRNA gene sequencing.

In this study, total bacterial count (TBC) in the gut of Pangas from farm and market samples were found $5.07\pm1.70\times10^6$ cfu/g and $1.40\pm0.47\times10^6$ cfu/g, respectively. The gut microbiota of Pangasius was found to be dominated by members of the Gram-negative genera. Only three isolates (MyF1/1, MyF1/4 and GaW1/2) were found to be Gram-positive among 16. Using 16S rRNA gene sequencing; *Bacillus, Macrococcus, Citrobacter, Aeromonas, Proteus, Klebsiella, Enterobacter, Escherichia and Edwardsiella* were found to be associated with the gut of this fish. Among the identified genera, *Aeromonas* was the most dominant (5 out of 16). Results of antibiogram reflected that all the isolates were sensitive to Gentamycin. Multiple antibiotics resistance pattern (MAR) were also observed on the isolates and MyF3/13 (identified as *Citrobacter amalonaticus)* was found resistant against seven tested antibiotics.

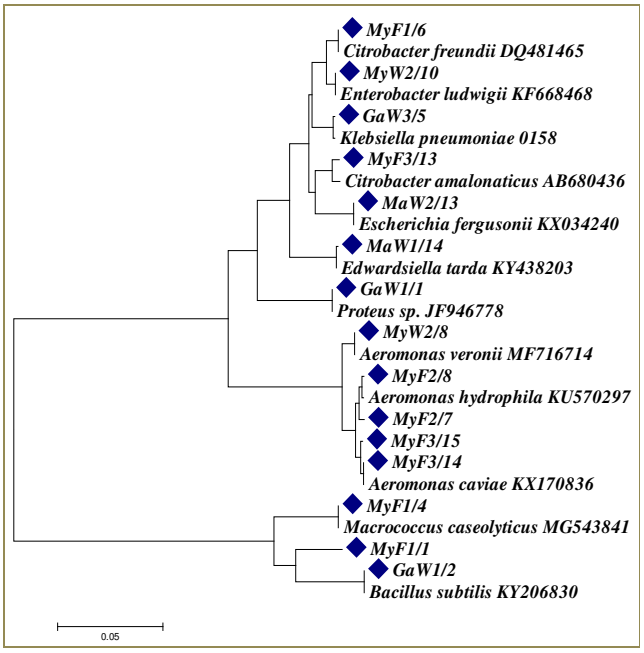

Fig. 1. The neighbor-joining (NJ) phylogenetic tree of the representative 15 bacterial isolates from present study based on partial 16S rRNA gene sequences. Blue diamond shape indicates position of the studied strains.

The existence of pathogenic bacteria in fish gut revealed improper or poor handling practices in fish market and unhygienic condition in the culture sites which might be a reason of fish-borne disease outbreaks.

PATHOGENIC BACTERIA IN SHRIMP PL NURSERIES OF SOUTH-WEST REGION OF BANGLADESH

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Black Tiger Shrimp *Penaeus monodon* is a valuable aquatic food resource high in protein and commands good export markets worldwide. With increasing demand for shrimp, supply of wild larvae or post larvae (PL) for the increasing number of shrimp farms has become insufficient and inconsistent. The excellent growth performance of hatchery-bred PL in grow-out ponds strongly shows that the shrimp hatchery can satisfy the industry needs for adequate supply of healthy shrimp PL for farming. The major constraints for shrimp growth are diseases caused by infectious pathogens. So, this study was aimed to identify the pathogenic bacteria of inlet, outlet water and shrimp PL of rearing nurseries in south west region of Bangladesh.

Raw, treated and outlet water and PL samples were collected from eight different nurseries of Khulna and Satkhira districts. Processed samples were inoculated on different selective agar media to isolate the bacterial colony and 26 representative isolates were then identified using16S rRNA gene sequencing.

The isolates were identified as *Vibrio alginolyticus*, *V. brasiliensis, V. nitrigiens, V. shilonii*, *Bacillus paralicheniformes, B. safensis, Acinetobacter venetianus, A. junii*, *Shewanella algae, Aeromanshydrophila, Zobellella denitrificans* and *Pseudomonas putida*. Except the genera *Bacillus,* rest of the bacterial genera are gram-negative. The phylogenetic tree confirmed the relationship of the identified isolates with the 16S rRNA gene sequences of reference bacterial strains downloaded from NCBI GenBank. The results revealed that the water samples (raw, treated and outlet water) and shrimp PL samples were contaminated with different groups of pathogenic bacteria. The presence of pathogenic bacteria in aquatic environment and PL might be the consequence of poor health management practices in the studied nurseries. The reasons behind this type of contamination might be improper inlet water treatment, larvae from infected mother shrimp and contaminated feed as well.

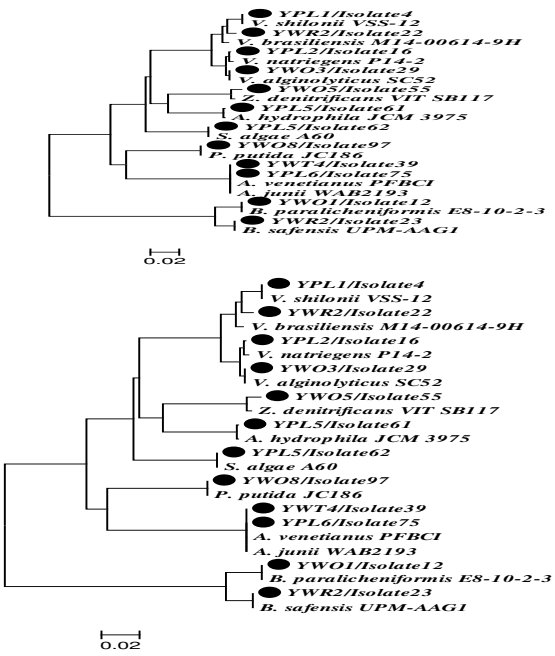

Fig. 1. The neighbor-joining phylogenetic tree of representative bacterial isolates based on 16S rRNA gene sequences. Black circles shows position of

MOLECULAR IDENTIFICATION, PUTATIVE VIRULENCE GENE DETECTION AND ANTIBIOGRAM PROFILE OF THE PATHOGENS CAUSING STREPTOCOCCOSIS IN *Barbodes gonionotus*

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Streptooccosis disease is one of the most important disease that causes severe economic losses in freshwater and marine fishes all over the world. The disease is also suspected to be present in other fishes specifically in *Barbodes gonionotus*. Bacteria belong to the genera *Streptococcus*, *Enterococcus*, *Lactcoccus* etc. are reported as the causative agents of the disease. The present study was conducted to identify the pathogens causing streptococcosis in *B. gonionotus*, confirm the pathogens through artificial infection challenge test, to find out the virulence associated genes and to find out the antibiogram profile of the pathogens. Bacteria were isolated from the diseased fish on KF media. A total of 47 isolates were randomly selected for initial phenotypic identification, where 17 isolates were identified as *Enterococcus* sp. To confirm the pathogenic potential of the isolates, three randomly selected isolates (PS-1, PS-3, PS-6) and three laboratory isolates (S-20, S-22, S-38) of *Enterococcus* sp. were used for artificial infection challenge test in *B. gonionotus* and *Oreochromis niloticus* where, all but one isolates exhibited moderate to high virulence in fish. Based on 16S rRNA gene sequence analysis five out of six isolates exhibited 99~100% sequence homology with *Enterococcus faecalis*. The other isolate was identified as *E. hirae*. PCR amplification was done by using specific primers for detection of five virulence genes *viz., esp*, *cyl*, *agg*, *hyl* and *gel*, where only *esp* gene was found in all of *E. faecalis* isolates. Eleven commercial antibiotic discs were used to determine the antibiogram profile of *E. faecalis* by disk diffusion assay where all of *E. faecalis* isolates were found resistant to multiple antibiotics specifically, amoxycillin, ampicillin, cefradine, cefuroxime, erythromycin and penicillin-G.

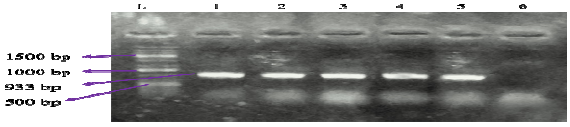

Fig. 1. PCR amplification of *esp* gene of (1) PS-1, (2) PS-3, (3) PS-6,(4) S-20, (5) S-22, (6) S-38 isolates.

Table 1. Antibiogram profile of *Enterococcus* sp. isolates

Antibiotic	Conc. µg/disc	Inhibition zone ratio					
		PS-1	PS-3	PS-6	S-20	S-22	S-38
Amoxycillin	30	R	R	R	R	R	R
Ampicillin	25	R	R	R	R	R	R
Azithromycin	30	R	2.05	2.38	2.77	1.77	1.44
Cefradine	25	R	R	R	R	R	R
Cefuroxime	30	R	R	R	R	R	R
Erythromycin	15	R	R	R	R	R	R
Gentamicin	10	R	3.16	2.83	4.2	4.05	2.27
Levofloxacin	5	R	2.23	2.61	4.5	4.83	2.11
Nitrofurantoin	300	R	4.05	3.61	1.88	4.05	2.5
Penicillin-G	10	R	R	R	R	R	R
Vancomycin	30	2.33	3.38	3.38	2.44	4.38	2.77

EXOGENOUS DIETARY SUPPLEMENTATION OF PEPSIN: EFFECTS ON GROWTH, FEED UTILIZATION AND HEALTH STATUS IN FISH (PANGAS, *Pangasius hypophthalmus*)

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Complementary incorporation of enzymes to feed advances in the nutritional influences by eliminating antinutritional factors and improves the utilization of dietary energy. The effects of exogenous protease enzyme (pepsin) on the growth performance, feed utilization and hematology parameters was evaluated using 90 days feeding trials in juvenile Thai pangus (*Pangasius hypophthalmus*). The 35% crude protein diet was prepared by adding different feed ingredients along with 0, 0.25, 0.50, 0.75, and 1.0 g of pepsin kg^{-1} feed in a dose dependent manner. Experimental results showed significant differences ($p<0.05$) in weight gain, specific growth rate (SGR), feed conversion ratio (FCR), feed conversion efficiency (FCE) and protein efficiency ratio (PER) in fish fed with 0.5g pepsin kg^{-1} feed compared to control. In case of hematological parameters, higher values($p<0.05$) of red blood cells (RBCs), white blood cells (WBCs), blood glucose, hemoglobin (Hgb) and mean corpuscular volume (MCV) revealed in fishes fed with 0.5g pepsin kg^{-1}feed compared to control, while in other blood parameters [hematocrit (HCT), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC)] showed no significant differences ($P > 0.05$) which indicates a better health conditions in fish. Low levels of ammonia, nitrate and nitrite was also measured in the pepsin added group compared to control. Our results suggest that, pepsin supplementation with formulated feed can improve the growth, feed utilization blood parameters and overall culture environment in fish.

TOWARDS A SUSTAINABLE AQUACULTURE GROWTH THROUGH RESPONSIBLE USE OF FEED AND FEED INGREDIENTS IN BANGLADESH

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Bangladesh, with a total area of 147,570 sq. km is largely an agrarian country with agriculture, aquaculture, livestock, forest and fisheries. Aquaculture in Bangladesh is next to agriculture with a production of 2.33 million metric ton (MT),contributing 56.44% to total (4.134 million MT), 24.41% to agriculture and 3.61% to GDP in 2016-17. Bangladesh is an UN signatory country and follows the Code of Conduct for Responsible Fisheries (FAO, 1995).Accordingly, as per Article 9, the government of Bangladesh took initiatives for responsible development of its aquaculture through compliance and development of appropriate legal and administrative frameworks. Notable ones are i. The Protection and Conservation of Fish Act 1950; ii. Fish and Fish Products (inspection and quality control) Ordinance 1983; iii. Fish and Fish Products (inspection and quality control) Rules1997 with subsequent amendments up to 2008); iv. National Fisheries Policy 1998; v. National Water Policy 1999; vi. Coastal Zone Policy 2005; vii. National Fisheries Strategy 2006; viii. Fish Hatchery Act 2010; ix. Fish Hatchery Rules 2011; x. Fish Food Act 2010; xii. Fish Food Rules 2011; xii. Country Investment Plan 2011; xiii. National Shrimp Policy 2014; xiv. Five Year Plans (I-VII); xv. Vision 2021; xvi. SDGs 2030; xvii. Delta Plan 2100 and xvii. Fisheries Master Plan 2018 including Aquaculture. Besides these, National Aquaculture Policy 2019 is under way. National Residue Control Plan (NRCP) monitors use of unauthorized and unhygienic ingredients in aquaculture through collection and chemical analyses in three accredited chemical laboratories of Department of Fisheries (DoF) at Dhaka, Chattogram and Khulna and other certified laboratories home and abroad for compliance with national and international human quality standards. For quality assurance, DoF officials collect samples at regular intervals from aquaculture farms at random and implement legal tools as control measures whenever necessary. Use of aqua-medicines in aquaculture throughout Bangladesh needs prescription from competent authority. Research and extension on development of appropriate technologies on production, management, value addition and overall value chain, development of genetically sound HYV of seeds, and cost-effective eco-friendly feed and other aquaculture ingredients support enormously for sustainable aquaculture growth in Bangladesh.

USE *OF Spirulina platensis* AS A DIETARY PROTEIN SOURCEFOR BETTER GROWTH AND SURVIVABILITY OF BUTTER CATFISH *Ompok pabda* AT ADVANCE FRY STAGE

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Eight weeks feeding experiment was conducted in earthen pits to find out the effect of dietary *S. platensis* on growth and survivability of butter catfish *Ompok pabda* at advance fry stage. Five isonitrogenous diets (35% protein) were made by combining fish meal, dried *S. platensis,* soybean meal, mustard oil cake, rice bran,wheat bran and ata, where the main protein source was replaced with *S. platensis* protein.

Treatment S_0 was control diet without *S. platensis* and treatments $S_{10,}$ $S_{15,}$ S_{20} andS_{25} were prepared by replacing fish meal protein with *S. platensis* at 10%, 15%, 20% and 25%, respectively. *O. pabda* with an average weight0.51±.016 g were stocked at 40 fish per pit. Fish were fed with experimental diets twice a day near satiation. Experiment was conducted with three replication. Significant difference (p<0.05) were observed in final mean weight gain (g), percentage weight gain (%) and specific growth rate (SGR % day^{-1}). However higher value of all parameters were observed in *S. platensis* supplemented diets compared to control diet (Table 1).While among the *S. platensis* supplemented diets the highest value for all the parameters were recorded in S_{15} where 15% fish meal protein was replaced with dried *S. platensis* followed by S_{20}, $S_{25,}$ and $S_{10,}$ respectively. Significant level of different (p<0.05) was also recorded in food conversion ratio (FCR) where lowest value of FCR was founded in S_{15} and highest in $S_{0.}$

Figure 1. Survivability rate of *O. pabda* under different treatments. Values are mean ± standard deviation (SD) (n=3). Different letters at the end of trend line represent significant differences among the treatments.

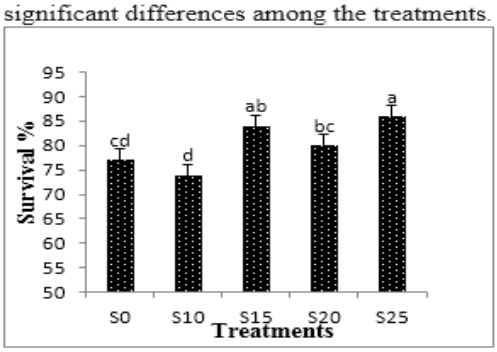

Table 1. Growth parameters of *O. pabda* at different treatments.

Parameters	S_0	S_{10}	S_{15}	S_{20}	S_{25}
Mean Weight Gain (g)	5.07 ± 0.18^{d}	5.27 ± 0.24^{cd}	5.92 ± 0.18^{a}	$5.60\pm.08^{b}$	5.53 ± 0.27^{ab}
Percentage Weight Gain (%)	990.01^{c}	1014.05^{bc}	1130.07^{a}	111.94^{a}	1057.96^{b}
Specific growth rate (% day^{-1})	1.83 ± 0.05^{c}	1.87 ± 0.03^{bc}	1.94 ± 0.01^{a}	1.91 ± 0.02^{ab}	1.92 ± 0.02^{ab}
Food Conversion Ratio (FCR)	2.30 ± 0.03^{a}	2.18 ± 0.04^{bc}	2.07 ± 0.10^{c}	2.25 ± 0.07^{ab}	2.24 ± 0.03^{ab}

Values are expressed as mean ± SD, n = 3. Values with same superscript letters are not significantly (P > 0.05) different.

Substantial difference (p<0.05) were also recorded in survival rate (%) among the treatments, where maximum survivability occurred in S_{25} (86%)and minimum in S_{10} (74%). Though S_{25} showed highest survivability rate there is no significant difference (p>0.05) among S_{25} and S_{15} (Fig. 1). Thus it can be concluded that 15% fish meal protein in diet can be replaced with *S. platensis* for better growth, survivability and feed utilization of *O. pabda.*

EFFECTS OF AFLATOXIN CONTAMINATED FEED ON THE FINGERLINGS OF TILAPIA *Oreochromis niloticus*

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The effects of aflatoxin related to the country's export through food safety program of EU/USFDA. However, presence of aflatoxin in cultured fish and their impact are still underestimated in Bangladesh. Present research aimed to know the effects of aflatoxin on the growth and overall residue in tilapia fingerlings. For this purposes non-contaminated feed (T_0), and aflatoxin contaminated feeds at different levels such as contaminated feed with aflatoxin 25 ppb (T_1), 50 ppb (T_2) and 100 ppb (T_3) were used. The results showed that the average body length (cm) and weight (gm) gained in treatment T_0 (1.68 and 4.98), T_1 (1.60 and 5.48), T_2 (1.31 and 4.06)and T_3 (1.20 and 3.10) respectively. The Specific Growth rate (SGR) was almost same in treatment T_0 (52%), T_1 (51%) and T_2 (52%) but significant lower in treatment T_3 (39%). The survival rate of tilapia fingerling significantly decrease in treatment T_2 (60%) and T_3 (40%), on the other hand pure diet and low dose aflatoxin contaminated diet remain higher survival rate as 90% in treatment T_0 and T_1. In HPLC (High Performance Liquid Chromatography) method aflatoxin not detected in treatment T_0 and treatment T_1,on the other hand aflatoxin was detected on treatment T_2 and T_3 after feeding of 14 and 21 days and found absence of aflatoxin on treatment T_2 and T_3 after 7 days feeding of tilapia fingerling. The finding of this study indicated the growth and survival of tilapia fingerlings severely affected if the feeds contaminated with aflatoxin. So it's crying need for more research to safeguard the aquaculture production as well as healthy food for human consumption.

EFFECTS OF SOYBEAN MEAL ON GUT HISTOLOGY AND DIGESTIVE ENZYMES ACTIVITIES OF SILVER BARB, *Barbonymus gonionotus*

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The aim of this study was to evaluate the effects of substituting fish meal (FM) with soybean meal (SM) on growth performance, gut histology and digestive enzymes activities of silver barb, *Barbonymus gonionotus*. Five diets were prepared with SM 0 (FM 100), SM 25 (FM 75), SM 50 (FM50), SM 75 (FM25) and SM 100% (FM 0%) by replacing FM with SM. Each diet was fed to *B. gonionotus* having initial weight of 8.80 ± 3.11 g to apparent satiation twice a day for six months. Stomach and intestine of fish were collected for histomorphic analysis and digestive enzymes (protease, amylase and lipase) activities were also determined. During the 120th days, the growth were significantly (P< 0.05) higher in fish fed with SM50 diets compared to SM0 diets. But in 150th days, growth were significantly (P<0.01) higher in fish fed with SM25 diets compared to SM0 diets. Finally during 180th days, growth were significantly (P<0.1) higher in fish fed with SM50 and SM25 diets compared to SM0 diets. Fish fed the diet SM25 was displayed significantly (P< 0.05) higher hepato somatic index (HSI) and digestive somatic index (DSI) compared to SM0 diet. Fish showed in significant (P<0.01) enlargement of villus height and diameter of gut by offering SM75, SM50 and SM25 diets. In stomach, protease enzyme was significantly (P< 0.05) higher in SM75 diet but there is no significant difference of lipase enzyme activities in stomach. Amylase enzyme was significantly higher in SM25 diets compared to SM0 diet. In anterior intestine, protease enzyme activity was significantly (P<0.01) higher in SM75 and SM25 diets. In posterior intestine, protease enzyme activities was significantly (P<0.05) higher in SM25 diet. Considering the result of present study, we recommend to replace 50% SM as a source of protein with 50% FM for better growth of *B. gonionotus.*

Table 1. Intestinal morphometric measurements of *Barbonymus gonionotus* fed with experimental diets for 6 months

Parameter	100 % SM	75 %SM	50 %SM	25 %SM	0 %SM
Villus height (mm)	214.33±5.13	474.33±6.6**	359.33±30.1**	325±4.08**	235.66±4.04
Intestine diameter (µm)	1242±47.30	1700±26.45	1431±25.16	1173±41.6	1296±50.30
Id/Vh	5.83	3.48	3.64	3.5	5.51

***p*<0.01 vs 100 SM

HEAVY METALS AND ESSENTIAL ELEMENTS IN POULTRY FEEDS AVAILABLE IN CHITTAGONG, BANGLADESH

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Excessive high concentration of metal intake can have an adverse effect upon the human and animals either it essential or toxic in nature. The study was conducted to determine the concentration of toxic metals and essential metals in the different types of poultry feeds (starter, grower and finisher) collected from the local market of Chittagong, Bangladesh. The samples were prepared for analysis according to standard method and the heavy metals were determined by Atomic Absorption Spectrophotometry (AAS). The concentration of toxic metals varied for Chromium (Cr): 5.05 ppm - 1.45 ppm; Nickel (Ni): 4.40 ppm - 23.00 ppm; Lead (Pb): 0.01 ppm - 0.15 ppm; Cadmium (Cd): 0.05 ppm - 0.50 ppm and Arsenic (As): 0.01 ppm - 0.10 ppm. While the amount of essential metals ranged for Calcium (Ca): 14210 ppm -2990 ppm; Magnesium (Mg): 1120 ppm - 2543 ppm; Manganese (Mn): 72.8 ppm - 147.5 ppm; Zinc (Zn): 57.9 ppm - 232.7 ppm; Iron (Fe): 435.8 ppm - 135.9 ppm and Copper (Cu): 72.4 ppm - 251.5 ppm. Some metals are essential for the growth of poultry but they may become toxic if the concentrations exceeded the permissible limit. In the present study the amount of essential metal is too high compared to international standard and other findings. In terms of toxic metals, Chromium surpassed the allowable limit whereas other metals are within the standard limit. Excess amount of metals uptake by animals find their way to human body, very harmful for human health.

REPLACEMENT OF SODIUM BICARBONATEAND MICRONUTRIENTS IN KOSARIC MEDIUM WITH BANANA LEAF ASH EXTRACT FOR THE CULTURE OF *Spirulina platensis*

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Spirulina platensis is one of the most promising microalgae for culture due to its high nutritional values. The main constraint to its production is the high cost of culture media. Therefore, an experiment was conducted for 28 days to evaluate the growth performance of *S. platensis* with the aim of replacing sodium bicarbonate ($NaHCO_3$) and mineral nutrients in Kosaric medium (KM) with banana leaf ash extract. KM was used as control medium in treatment T_1. In treatments T_2 to T_5, 50% of $NaHCO_3$ in KM was replaced with banana leaf ash extract (BLAE). In addition, micronutrients in KM were reduced to 75%, 50% and 25% in treatments T_3 to T_5, respectively.

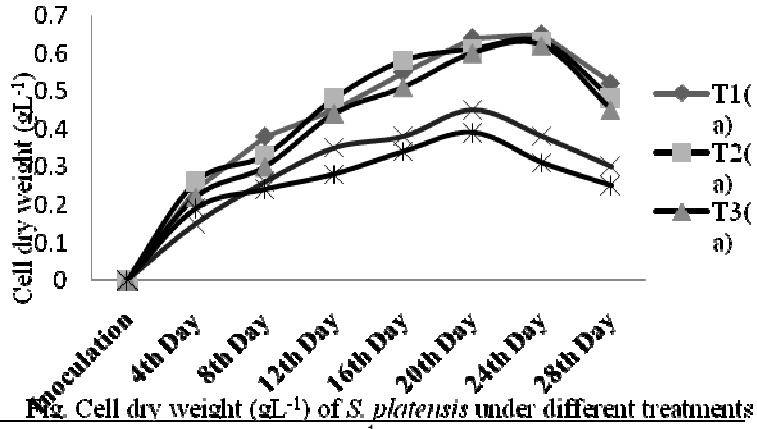

Fig. Cell dry weight (gL^{-1}) of *S. platensis* under different treatments

Table: Cost of nutrient media for *S. platensis* culture

Medium	Ingredients	Amount (gL^{-1})	Price (Tk)	Total (Tk)
T_1	$NaHCO_3$	9.00	22.5	30.00
	Other ingredients	-	7.5	
T_2,T_3,T_4 and T_5	$NaHCO_3$	4.50	11.25	18.75
	BLAE	4.50	0	
	Other ingredients	-	7.50	

The values of different physical and chemical parameters (temperature, pH, dissolved oxygen and light intensity) of the culture media were within the suitable range for *S. platensis* culture. Optical density in T_2 and T_3 were similar to that was in T_1. Maximum cell dry weight (0.65 gL^{-1}) was observed in T_1 and it was insignificant ($P>0.05$) to T_2 and T_3 where 50% of $NaHCO_3$ in KM was replaced with banana leaf ash extract with 100% and 75% micronutrients supply, respectively. The similar trend was found in chlorophyll *a* content. It was evident that 50% of $NaHCO_3$ in KM can be replaced with BLAE for the culture of *S. platensis,* in addition micronutrients in KM can be reduced to 75%.

DIETARY ZINC REQUIREMENT OF STINGING CATFISH *Heteropneustes fossilis*

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Stinging catfish *Heteropneustes fossilis* is an important aquaculture and food fish in Bangladesh because of its highly nutritive value, recuperative and possessing of medicinal properties. Its flesh is rich in protein, iron and fairly high content of calcium and lower fat content compared to many other freshwater fishes. It has ability to adapt to fresh and brackish waters with very low oxygen content and to high stocking densities to grow under generally poor environmental conditions. For its culture, development of appropriate feed is necessary. For development of feed, information of different nutrient requirements is necessary. Zinc (Zn) is an essential trace nutrient for fish. The requirements of dietary Zn for many fishes, mostly freshwater fishes, have been reported. However, information on Zn requirement of *H. fossilis* is less available. The present study was conducted to investigate the dietary requirement of *H. fossilis* for Zn. Fingerlings *H. fossilis*were fed with 5 experimental diets supplemented with zinc sulfateat 0, 10, 20, 30 and 40 mg Znkg^{-1}diet. Water temperature, dissolved oxygen and pH were within suitable range for *H. fossilis* culture.

After a 10 weeks experimental period, growth was significantly increased in fish fed diet with 30mg Znkg^{-1} diet. Specific growth rate was also higher in fish fed diet with 30mg Zn kg^{-1}. Supplementation of dietary Zn also lowered the FCR value. Dietary Zn supplementation up to 30 mg Zn kg^{-1} proportionally increased bone Zn content in *H. fossilis*. Further increase in dietary zinc level did not increase the bone Zn content. On the other hand, muscle Zn content was not affected by dietary supplementation of Zn. Blood parameters were independent of dietary Zn supplementation except for serum alkaline phosphate, which increased with dietary Zn supplementation. It was concluded that a dietary supplementation of 30 mg Zn kg^{-1}is suitable for growth, feed utilization and maintaining bone Zn level in *H. fossilis*.

Table 1. Growth performances of *H. fossilis* fed diets with graded levels of Zn for 10 weeks

Parameters	Dietary Zn level (mg kg^{-1})				
	0	10	20	30	40
Initial weight (g)	1.40	1.40	1.40	1.40	1.40
Final weight (g)	4.42±0.30^{c}	4.78±0.32^{b}	4.81±0.42^{b}	5.02±0.37^{a}	4.98±0.28^{ab}
% Weight gain	215.7±3.7^{c}	241.4±2.8^{b}	243.6±3.2^{b}	258.6±3.1^{a}	255.7±2.7^{ab}
SGR (%)	0.71±0.12^{c}	0.86±0.21^{b}	0.88±0.15^{b}	0.96±0.16^{a}	0.89±0.13^{ab}
FCR	1.59±0.30^{a}	1.42±0.28^{b}	1.38±0.22^{c}	1.35±0.18^{c}	1.45±0.21^{b}
Survival rate (%)	99.2	100	100	99.2	98.3

*Data in the same row bearing different superscript letters are significantly different.

ISOLATION AND IDENTIFICATION *Aphanomyces invadans* CAUSING EPIZOOTIC ULCERATIVE SYNDROME (EUS) FROM KARNATAKA ESTUARINE FISHES

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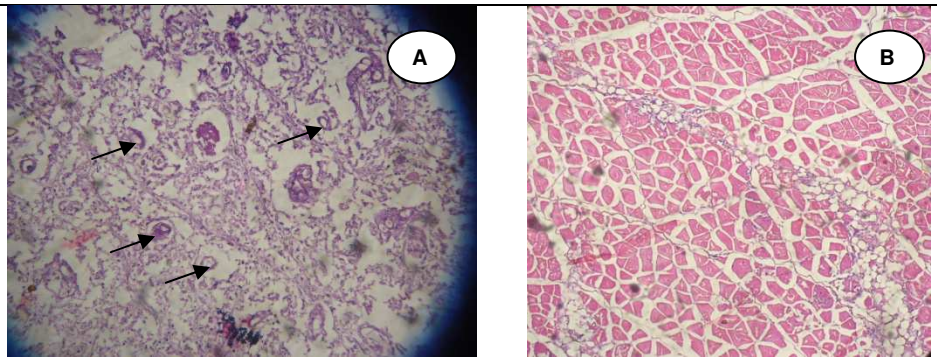
Epizootic ulcerative syndrome (EUS), a disease listed by World Organization for Animal Health (OIE) has been reported in 26 countries across 4 continents. This study was conducted to isolate and identify *A. invadans* from naturally infected mullet (*Mugil cephalus*), *Platycephalus* sp. and *Sillago* sp. from two estuaries, Mulky and Kodi, Karnataka. A total number of 110 fishes from Mulky estuary (Prevalence 71%) and 108 fishes from Kodi estuary (Prevalence 65%) are showed clear ulcer and skin inflammation have been observed on caught fishes during August and September 2018. Result revealed that fungus-oomycetes *A. invadans* grow on Glucose Peptone (GP) broth and agar. In agar, opaque uneven white transparent velvet colonies at room temperature were observed.We examined, microscopically, lactophenol cotton blue stained fungal growth appeared as non-septate thin long branched hyphae are shown with cluster of encyst and histopathologically, it shown deeply penetrating fungal hyphae surrounded by chronic, granulomatous inflammation.PCR performed on ulcerated muscle tissues was positive for *A. invadans* DNA (234 bp PCR product specific to *A. invadans*).In a word, the results of the present work showed that EUS is still prevailing Karnataka estuaries.



Histopathology of EUS-affected fishes. **A**, Mycotic granulomas (arrows) replacing most of the host tissue in *M. cephalus*(400x).**B**, Note that the dermis and musculature are intact in non-infected Mullet.

INCORPORATION OF WATER HYACINTH, *EICHHORNIA CRASSIPES* MEAL IN AQUA-FEED AND ITS EFFICACY ON GROWTH AND PRODUCTION OF RUI, *Labeo rohita* REARED IN CAGE

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This study was conducted to develop low cost eco-friendly feed incorporation with water hyacinth, *Eichhornia crassipes* meal, and to evaluate the effects on growth performance and production economy of Rui, *Labeo rohita* (Ham.) aquaculture. Rui at average weight of 200 g were fed with three different experimental diets with 0% water hyacinth meal (WH0 diet), 15% (WH15 diet) and 25% (WH25 diet) for 12 weeks in six different experimental cages. Fish were fed two times daily at a rate of 4% of their body weight during the entire experimental period. The water quality parameters of the experimental ponds were monitored every 3 weeks interval. The water quality parameters were found at acceptable limit. The result indicated that growth performance tended to decrease with increase in inclusion level of water hyacinth meal. The weight gain and specific growth rate (SGR) were significantly higher ($P<0.05$) in fish groups fed WH0 and WH15 diets than WH25 fish group. Also, the feed conversion ratio (FCR) was significantly lower in fish groups fed WH0 and WH15 diets than fish group fed WH25 diet. The fish groups fed WH0 and WH15 diets showed no significant difference in weight gain (WG), SGR and FCR. The cost benefit ratio (CBR) was found significantly higher in WH15 (15% water hyacinths meal based diet) fish group than other groups. The cost of feed production decreased as the incorporation level of water hyacinth increased. Result indicated that incorporation of 15% water hyacinth meal in a diet was the best as a practical diet of Rui for reducing feed cost and increasing profit.

MOLECULAR IDENTIFICATION OF FISH PATHOGENIC OOMYCETES IN DIFFERENT FISH FARMS OF MYMENSINGH, BANGLADESH DURING WINTER SEASON

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Water molds (oomycetes) of the order Saprolegniales, such as *Saprolegnia* and *Aphanomyces* species, can cause destructive infection of fish at low temperatures. The objective of this current research was to identify fish pathogenic oomycetes causing mycotic infections during winter season. Water and infected fish samples were collected from different fish farms in three districts (Mymensingh Sadar, Sherpur and Netrokona) of Mymensingh division from 15th November, 2015 to 9th February, 2016. A total number of 248 samples (217 water samples and 31 fish samples) were collected and the fish species were koi (*Anabas testudineus*), gulsha (*Mystus cavasius*), rui (*Labeo rohita*), mrigal (*Cirrhinus cirrhosus*), bata (*Labeo bata*), shol (*Channa striatus*), shing (*Heteropneustes fossilis*), and tilapia (*Oreochromis niloticus*). Samples were placed both in Potato Dextrose Agar (PDA) and Glucose Peptone Yeast Agar (GPYA) culture plates. Seven samples showed mycelia growth in culture plates. DNA of mycelia was extracted by and DNA extraction from the mycelium of each isolate was done using Phenol: Chloroform: Isoamyl alcohol (25:24:1). PCR amplification was done by using the primers ITS 5 and ITS 4 alt. PCR products were sequenced for identification of oomycetes species. On the basis on ITS region, analysis revealed that one isolate was recognized as *Saprolegnia parasitica* and gave 100% similarity with the retrieved GenBank sequence of KM061638. Rest of the isolates were identified to be *Aphanomyces invadans* (GenBank sequence AY283642, KC137250, KC137250, AY28364 and KC137251). In Mymensingh district, three fish pathogenic oomycetes (one *S. parasitica* and two *A. invadans*) were found. In Netrokona district, three *A. invadans* were found. The highest temperature (23.8°C) was recorded from Muktagacha and the lowest temperature (14.6°C) was recorded from Natrokona during this study. The highest pH (9.47) was recorded from Muktagacha and lowest (7.0) pH was recorded from (Dapunia) Mymensingh. This study indicates that farmed fishes in Mymensingh are susceptible to pathogenic oomycetes in winter season. Identification techniques of this study will be helpful for molecular identification of oomycetes species in other regions in Bangladesh in future.

MOLECULAR CHARACTERIZATION REVEALS THE PRESENCE OF PLANT PATHOGENIC *Pythium* spp. AROUND BANGLADESH AGRICULTURAL UNIVERSITY CAMPUS, MYMENSINGH, BANGLADESH

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Oomycetes (water molds) are ubiquitous organism thriving in moist or aquatic environment. They can cause devastating infections to animals and plants. Farmers, both crop and fish, count huge losses every year due to outbreak of oomycete infections. However, the lack of study in Bangladesh makes it harder to address the problem in the country. This study was conducted to investigate the diversity of oomycetes in the surrounding crop fields and water bodies of Bangladesh Agricultural University campus, Mymensingh, Bangladesh. The sampling took place during the winter season. A total of 356 water samples were collected out of which only seven came positive with oomycete growth. The seven isolates were grown in potato dextrose agar (PDA) plates. The isolates were identified using molecular methods that included DNA extraction, PCR amplification and subsequent sequencing of the internal transcribed spacer (ITS) region of the genomic DNA of the samples. The BLAST analysis of the retrieved sequences to GenBank revealed that four of the isolates were *Pythium catenulatum*, two were *Pythium rhizo-oryzae* and the remaining isolate was *Pythium torulosum* strain. *Pythium* spp. are known to be plant pathogens of both crops and vegetable. The results suggest the evidence of plant pathogenic oomycetes around the study area that were causing damage to the crops and extend understanding of the diversity of the genus *Pythium*.

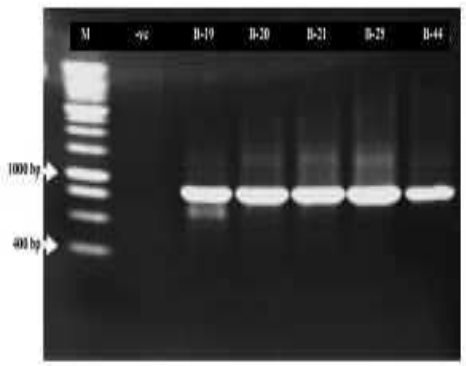

Fig. 1. Agarose gel (1%) run of the PCR products of isolates produce an approximate band size of 800 bp that was visualized under UV. M: 1 kbp molecular marker, -v: Negative control (DNAse/RNAse free water), lane B-19 to B44 represents the positive amplicons of the isolates in PCR reaction.

ASSESSING THE GROWTH, NEW MUSCLE GENERATION, DIGESTIVE ENZYMES ACTIVITIES AND GUT HISTOLOGY OF TILAPIA (*Oreochromis niloticus)* REPLACING FISHMEAL WITH SOYBEAN MEAL IN DIETS

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This study was designed to determine the effect of fish meal (FM) replacement with soybean meal (SBM) in diet on the growth, new muscle generation, digestive enzymes activities and gut histology of Tilapia (*Oreocromis niloticus*). Five diets were formulated where D_1 contained fishmeal as the primary protein source (SBM 0), FM substituted with graded levels of a mix of SBM to replace 25% (SBM 25), 50% (SBM 50), 75% (SBM 75) and 100% (SBM 100) of fishmeal naming as D_2, D_3, D_4, and D_5. Juvenile tilapia having weight and length of 6.60±0.13 g and 5.42±0.17 cm were randomly divided into five treatment groups having 40 individual each and fed to visual satiation for 180 days. Diets with SBM *i.e.* D_2, D_3, D_4, and D_5 resulted statistically significant increase in final body weight, and length, weight gain and specific growth rate in fish compared to the ones fed with FM meal. Hepatosomatic index and viscerosomatic index were not affected by the experimental diets. There was a significantly increased number of muscle fiber at lower level (D_1, and D_2 diets) of FM substitution with SBM. Fish having the similar weight (34±1.41 g) fed the diets D_3, D_4, and D_5 containing higher level of SBM showed significantly longer intestine compared to D_1. Villus height of stomach and intestine were significantly greater in the fish fed with the diets D_1, D_2 and D_3 compared to D_5. Muscular thickness was inversely changed with the increasing villus height. Protease activity significantly increased in stomach of fish fed with D_2 compared to D_5. In anterior segment of intestine, significantly higher amylase activity was observed in fish fed with the diets D_1 and D_2 compared to diet D_5. In posterior segment of intestine, protease activity was significantly greater in D_1 compared to D_5. Lipase activity was not affected by the diets in all portion of the gut. These results suggest that the replacement of FM should be 50% with SBM (D_3), considering the growth performances, gut health and digestive enzymes activities. This substitution can lead better growth as well as reduce cost and pressure on fish stock for fish meal.

Table: Growth performances of *O. niloticus* fed with test diets having different soybean meal replacement levels for 180 days

	Diets				
	D_1	D_2	D_3	D_4	D_5
Initial weight (g)	6.52±0.69	6.58±0.45	6.5±0.96	6.6±0.85	6.62±0.66
Final weight (g)	89±13.99	94±7.04	91.2±11.99	88±9.97	48.8±3.27
Weight gain (g)	83.3±14.51	87.42±6.72	84.7±12.47	81.4±10.75	41.98±3.06
SGR (% d⁻¹)	1.06±0.04	1.08±0.02	1.07±0.03	1.05±0.03	0.46±0.02
HIS (%)	1.5±0.11	1.3±0.04	1.8±0.17	1.3±0.01	1.9±0.60
VIS (%)	3.2±0.23	3.8±1.24	3.7±0.64	5.1±2.26	3.8±0.64

Values are presented as mean ± SE of triplicate samples. Values with different letters in each row are significantly different (*P < 0.05 vs D_5). D_1, D_2, D_3, D_4, and D_5 indicates diets containing 0%, 25%, 50%, 75%, and 100% of SBM, respectively.

ASSESSING THE GROWTH, NEW MUSCLE GENERATION, DIGESTIVE ENZYMES ACTIVITIES AND GUT HISTOLOGY OF TILAPIA (*Oreochromis niloticus)* REPLACING FISHMEAL WITH SOYBEAN MEAL IN DIETS

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This study was designed to determine the effect of fishmeal (FM) replacement with soybean meal(SBM)in diet on the growth, new muscle generation, digestive enzymes activities and gut histology of Tilapia (*Oreocromis niloticus*).Five diets were formulated where D_1contained fishmeal as the primary protein source (SBM 0), FM substituted with graded levels of a mix of SBM to replace 25% (SBM 25), 50% (SBM 50), 75% (SBM 75) and 100% (SBM 100) of fishmeal naming as D_2, D_3, D_4, and D_5. Juvenile tilapia having weight and length of 6.60±0.13 g and 5.42±0.17 cm were randomly divided into five treatment groups having 40 individual each and fed to visual satiation for 180 days. Diets with SBM *i.e.* D_2, D_3, D_4, and D_5 resulted statistically significant increase in final body weight, and length, weight gain and specific growth rate in fish compared to the ones fed with FM meal. Hepatosomatic index and viscerosomatic index were not affected by the experimental diets. There was a significantly increased number of muscle fiber at lower level (D_1, and D_2 diets) of FM substitution with SBM. Fish having the similar weight (34±1.41 g)fed the diets D_3, D_4, and D_5 containing higher level of SBM showed significantly longer intestine compared to D_1.Villus height of stomach and intestine were significantly greater in the fish fed with the diets D_1, D_2 and D_3 compared to D_5. Muscular thickness was inversely changed with the increasing villus height. Protease activity significantly increased in stomach of fish fed with D_2 compared to D_5. In anterior segment of intestine, significantly higher amylase activity was observed in fish fed with the diets D_1 and D_2 compared to diet D_5. In posterior segment of intestine, protease activity was significantly greater in D_1compared to D_5. Lipase activity was not affected by the diets in all portion of the gut. These results suggest that the replacement of FM should be 50% with SBM (D_3), considering the growth performances, gut health and digestive enzymes activities. This substitution can lead better growth as well as reduce cost and pressure on fish stock for fish meal.

DEVELOPMENT OF SILVER ENHANCED FLOW THROUGH IMMUNOGOLD ASSAY FOR DETECTION OF WSSV

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A Silver enhanced flow-through immunoassay (SFTA), an improved version of immunodot, was developed using a nitrocellulose membrane baked onto adsorbent pads enclosed in a plastic cassette to detect white spot syndrome virus (WSSV) in shrimp. Sharp black dots developed with WSSV against the white background of the nitrocellulose membrane. The detection limits of WSSV by the SFTA and immunodot were 0.078 and 1.2 µg/ml crude WSSV protein, respectively. The SFTA could be completed in 2-3 min compared with 90 min for immunodot. The SFTA was more sensitive than 1-step polymerase chain reaction (PCR) and in between that of the 1-step and 2-step PCR protocol recommended by the Office of International Epizootics (OIE). The SFTA was more sensitive (25/27) than one-step PCR (23/27) and immunodot (20/27) for the detection of WSSV from white spot disease outbreak ponds. The reagent components of the SFTA were stable giving expected results for 6 months at 4-8 °C.

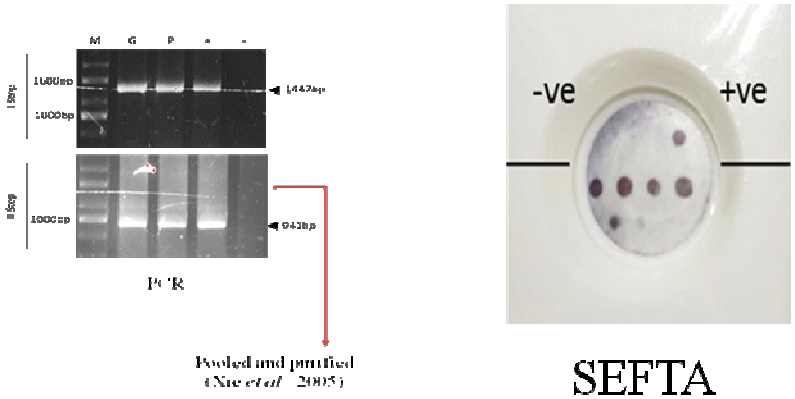

Fig. 1. Comparison of the sensitivity of detection of WSSV by Silver enhanced flow through immunogold assay with 1st and 2nd step PCR

EPIDEMIOLOGCAL STUDY OF WHITE SPOT SYNDROME VIRUS (WSSV) DISEASE IN CULTURED SHRIMP OF SOUTH-WEST REGION OF BANGLADESH

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Epidemiological study of a viral disease remarks the transmission, distribution, virulence, recovery rates and also highlights the risk factors behind the extreme infections. The cultured shrimp production of Bangladesh has markedly decreased because of serious viral disease outbreaks; especially the increased severity of widespread white spot syndrome virus (WSSV) infection became the most serious threat to our ongoing aquaculture production. The current research was, therefore, accomplished to determine the epidemiology (classical and molecular) of white spot syndrome virus in cultured shrimp of south-west region of Bangladesh.

For this purpose, forty-nine WSSV infected shrimp samples were collected from three different shrimp rearing areas of Bangladesh during April to August 2018. During that period, a questionnaire survey was also performed to expose the risk factors influencing the incidence of white spot disease (WSD). Infection due to WSSV confirmed through conventional and real-time PCR, where real-time PCR exclusively helped out to quantify the viral load as well. Finally, PCR confirmed eight isolates were sequenced through the use of VP28 gene.

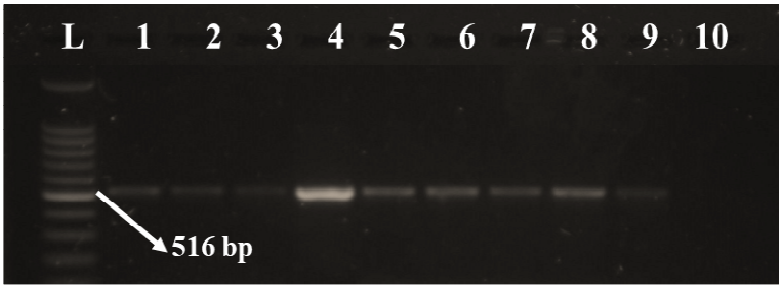

Fig. 1. Conventional PCR amplified products of eight representative WSSV isolates with characteristic 516 bp amplicon for VP28 gene; where 'L' represents 100bp ladder, no. 1-8 denotes PCR amplified products and no. 9, 10 shows positive and negative control, respectively.

This experiment will establish the number of factors influencing the incidence of WSD through statistical analysis and bring out the applied preventive measures of WSD. Viral load of suspected isolate will calculate through real-time PCR. After completion of the sequencing of eight WSSV positive isolates, we will construct the phylogenetic tree comprising the studied and downloaded reference sequences of NCBI GenBank database of other countries.

NANOSELENIUM : A NEW APPROACH TO ENHANCE AQUACULTURE PRODUCTION

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This is the time to change the trend of fisheries and aquaculture in terms of production and sustainability. Nano selenium is fulfilled it in most of the circumstances with improved immune and antioxidant properties. The fisheries and livestock sectors capture the highest share of protein-rich animal food and demonstrate accelerated growth as an agriculture subsidiary. Environmental pollution, climate change, as well as pathogenic invasions exert increasing stress impacts that lead the productivity momentum at a crossroads. Oxidative stress is the most common form of stress phenomenon responsible for the retardation of productivity in fisheries and livestock. Essential micronutrients play a determinant role in combating oxidative stress. Selenium, one of the essential micronutrients, appears as a potent antioxidant with reduced toxicity in its nanoscale form. In the present review, different methods of synthesis and characterization of nanoscale selenium have been discussed. The functional characterization of nano-selenium in terms of its effect on growth patterns, feed digestibility, and reproductive system has been discussed to elucidate the mechanism of action. Moreover, its anti-carcinogenic and antioxidant potentiality, antimicrobial and immunomodulatory efficacy, and fatty acid reduction in liver have been deciphered as the new phenomena of nano-selenium application. Biologically synthesized nano-selenium raises hope for pharmacologically enriched, naturally stable nanoscale selenium with high ecological viability. Hence, nano-selenium can be administered with commercial feeds for improvising stress resilience and productivity of fish and livestock.

NANO ZINC: AN ESSENTIAL PART OF ANIMAL NUTRITION

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The uniqueness of Zn is that, it is the second most abundant trace element in the animal body but can't be stored in the body, thus regular dietary intake is required. Zinc oxide (ZnO) nanoparticles (NP) particles are being extensively used in paints, skin lotions pigments, food, electronics appliances, biological and pharmaceutical applications and many more. Zinc oxide nanoparticles are the specially prepared mineral salt having particle size of 1 to 100 nm. It promotes growth can act as antibacterial agent, modulates the immunity and reproduction of the animals. Both in lower and higher doses of specifications it has exhibited a variety of effects on animal performances. Apart from being highly bioavailable, reports have already pointed out the growth promoting, antibacterial, immuno-modulatory and many more effects of nano zinc (nZn). These can be used at lower doses and can provide better result than the conventional Zn sources and indirectly prevents environmental contamination also. The toxicological studies provide mixed results in animal models. Studies been undertaken in diversified animal species and encouraging effects have been reported with nZn supplementation. However, there is a need to optimize the dose and duration of ZnO NP supplementation for human and livestock, depending on its biological effects. Actual bioavailability of ZnO NP in livestock is still to be worked out. In this review we have attempted to summarize, conclude the beneficial effects of nZnO and its possible usage as mineral supplement to different categories of human and livestock.

EFFECT OF DIFFERENT TILAPIA FEEDS ON THE SPECIES DIVERSITY, RICHNESS AND EVENNESS OF MACRO-BENTHOS COMMUNITY

Nipa Rani Roy, Shikder Saiful Islam*, Most. Sabina Akter, Kazi Ahmed Kabir, Md. Shamim Hossain, Alokesh Kumar Ghosh, Joyanta Bir and Khandaker Anisul Huq
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This study was conducted to assess the effect of different experimental diets on the species diversity, richness and evenness of benthos community in tilapia ponds. This study was conducted in total 36 ponds where two different feed experiments (two diets for experiment-1 and two other diets for experiment-2) (feed-1, feed-2) with two doses (single dose and double doses) were applied in tilapia culture to assess its effects on the macro-benthos community structure in culture system. There were two control groups (C_1, C_2) and four treatments (T_1, T_2, T_3, T_4) on the type of feed and number of doses with 6 replications for each. Benthos species diversity, richness and evenness were determined by seven sampling in which 4 samples were taken under experiment-1 and 3 samples were taken under experiment-2 in the tilapia culture period using Ekman dredger. The study revealed the presence of three major groups of macro-benthos; gastropods, Oligochaeta and Bivalvia comprising 9 species under 2 phylum. Gastropoda included 5 species (*Pila globosa*, *Septaria porcallana*, *Indoplanorbis exustus*, *Melanoides tuberculata* and *Bellamya chinensis*), Bivalvia included 3 species (*Anondonta californiensis*, *Neritina reclivata* and *Mercenaria campechiensis)* and Oligochaeta included 1 species *Nais simplex.* Shannon diversity index demonstrated that in experiment-1, higher diversity in macro-benthos community was found in C_2 compared to T_2 and T_3 (p<0.05) as well as other treatments. However, in experiment-2 C_2 also showed higher species diversity than that of T_2 (p<0.05). In experiment-2, Menhinick's richness of macro-benthos species was found higher in C_2 compared to T_2 and T_4 (p<0.05). In contrast, it was found insignificant in experiment-1. Finally, Pielou's evenness indices was found higher in T_3 compared to T_1 and T_2 in experiment-1 (p<0.05). Nevertheless, it was higher in C_2 in experiment-2 than that of T_2 and T_4. In conclusion, different diets or even aquatic environment with no diets might contribute in community structure of macro-benthos species. Therefore, further studies should be conducted to go for more micro-community structure of macro-benthos.

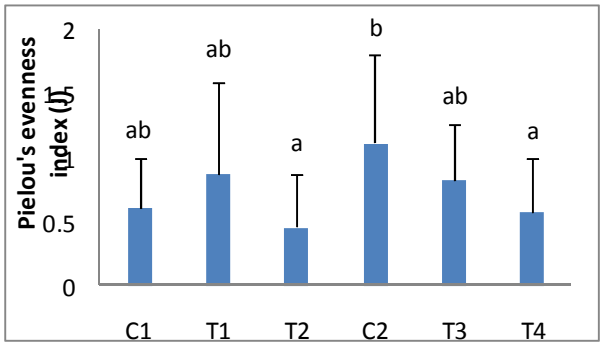

Fig. 1. Pielou's evenness index (J) indices of macro-benthos community in tilapia ponds in experiment-2.

INFLUENCE OF DIETARY POLYUNSATURATED FATTY ACID AND BETA GLUCAN ON IMPROVED MATURATION AND IMMUNE STIMULATION OF ROHU CARP (*Labeo rohita)*

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There are many admired and scrumptious fishes in Bangladesh. Rohu, *Labeo rohita* is top most delicious carp fish and market price is high comparing with other carps. But the production of fish larvae is routinely hampered by significant mortality rates. At present, the fish farmers of Bangladesh are facing a great problem with poor survival rate of fish fry after stocking in the culture pond. To improve this condition biofunctional compounds or immunostimulants are considered as an effective tool for enhancing immune status of cultured organisms. The present study is undertaken to evaluate the effects of PUFAs enriched squid extracted lipids on enhanced maturation, spawning, early embryonic and larval development and dietary beta glucan in enhancing immunity of *L. rohita*. Fishes were collected from the wild source (beelof Netrokona) and stocked in the two separated ponds in which one is control and another is treatment. Initially the average length and weight of controlled group were 42.7 cm and 985.4 gm, and the treated group was 43.4 cm and 1114.2 gm, respectively. *L. rohita* of treated group was fed with supplemental diet enriched with 1% squid extracted lipids as a source of PUFAs and 10% barley powder or mushroom as a source of beta glucan and finely chopped squid meal for four months(February-May) whereas controlled group was fed the same diet except PUFAs and beta glucan. Histomorphology of liver and serum calcium ion concentration (blood will be collected from live rohu carp) and vitellogen protein content indices will be used to clarify gonadal maturation and a spawning trial will be conducted to spell out the reproductive performances. GSI, HSI and VSI were measured as 4.5, 0.59 and 0.64, respectively. Acetylcholinesterase (AChE) activity, lysozyme activity and cell count of erythrocytes ($\times 10^3/mm^3$) and leucocytes ($\times 10^6/mm^3$) will be measured using standard methodology to explain the immunomodulatory effects of beta glucan. We are expecting that treated group will exhibit an advanced gonadal maturation and higher reproductive performances in spawning trial. Higher fertilization rate, hatching rate and survival rate of offspring are also expected in treated group compared to control. Higher serum Ca^{2+} level, AChE activity, lysozyme enzyme activity in treated fishes are also expected. Higher WBC of the blood cell count is also expected. Therefore, the present study will focus the enhanced spawning performances and immune status of *L. rohita* owing to PUFAs and beta glucan supplementation in diet.

EVALUATION OF GROWTH, PRODUCTION AND ECONOMICS OF RIVERINE THREATENED LONG-WHISKERED CATFISH *Sperata aor* BASED ON DIFFERENT PROTEIN LEVEL OF FEED IN POND

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Growth, production performances and economics of riverine threatened long-whiskered catfish *Sperata aor* were evaluated for six months in four treatments (each with three replications) having an area of 0.002 ha each with an average depth of 1.0 m. During the culture period, the fingerlings of *Sperata aor* were collected from Padma River in Rajshahi region and same stocking density (60/dec) was followed and supplied different protein containing (26, 29, 32 and 35% crude protein) formulated feeds in all treatments (T_1, T_2, T_3 and T_4). The effects of dietary protein on growth, production and economics of *Sperata aor* culture were evaluated by analyzing different growth parameters. Among the treatments, maximum growth in terms of weight gain was recorded in T_4 (321.22±4.40g) and lowest was recorded in T_1 (147.79±2.85g). Length gain (26.93±0.40cm), SGR (1.60±0.01 %bw day^{-1}), ADG (1.90±0.02g) also followed the same trend as weight gain. The best food conversion parameter like FCR (2.80±0.09) was also observed in T_4 but PER (1.16±0.0) was observed in treatment T_1. Similarly, the highest survival rate (96.67±0.76%) and condition factor (0.78±0.03) of fish were in T_4 in which 35% protein containing feed was used. The total production was also highest in T_4 and it was 5175.00±95.10 kg/ha/6 months. The best net benefit (1583196±1672 BDT/ha) of *Sperata aor* culture was achieved from T_4 where CBR was 1.57 ± 0.004. Findings indicated that, the fish fed with 35% protein containing feed have been found to be effective for better growth of the *Sperata aor*.

TOTAL REPLACEMENT OF FISH OIL WITH PALM OIL IN FEED AND THE EFFECT ON GROWTH PERFORMANCE, PROXIMATE COMPOSITION AND FATTY ACID PROFILE IN RED SEA BREAM *Pagrus major*

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This study was to determine the comparative effects of dietary fish oil (FO) with palm oil (PO) on growth performance, proximate composition and fatty acids (FAs) composition in red sea bream *Pagrus major*. The red sea bream (5.1 g) were reared in 60L glass aquaria and were fed two diets: 10% Pollock liver oil based (F10 diet) and 10% PO based (P10 diet). The growth performance, proximate composition, and the fatty acid profiles of the whole body and the dorsal muscles were analyzed using the standard methods. Growth performance, feed efficiency, and proximate composition were not affected by the dietary treatments. Total replacement of FO with PO reduced the saturated fatty acids (SFA) content while the mono-unsaturated fatty acids (MUFA) content increased. The contents of the poly unsaturated fatty acids (PUFA) in crude lipid and polar lipid of the dorsal muscles did not differ significantly between the treatments. However, the muscle ∑ n-3HUFA intake and retention ratio was significantly higher in fish fed the P10 diet (3.9) than the F10 diet (1.3). This study suggests that, the partial replacement FO with PO can be conceivable in formulating a red sea bream diet.

MAGGOT MEAL AS A POTENTIAL SUBSTITUTE OF FISH MEAL INGREDIENT IN PRACTICAL DIETS OF RAINBOW TROUT, *Oncorhynchus mykiss*

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This study was undertaken to evaluate the use of housefly maggot meal (maggot meal, MM) as a potential substitute of fishmeal (FM) in the practical diets of rainbow trout *Oncorhynchus mykiss* with the aim of developing low FM practical diets. MM is an animal protein sources ingredient produced from insect housefly *Musca domestica*. Four isonitrogenous and isocaloric diets were formulated for this experiment. Diet MM0 was the control diet containing 15% FM, without the incorporation of MM. Diets MM6, MM12, and MM18 were obtained by including graded levels of MM (6%, 12% and 18%) with the replacement of FM (33%, 66% and 100%, respectively) from the control diet. Triplicate groups of 25 rainbow trout (initial average weight 14.60±0.13 g) were reared in 60L glass tanks for 12 weeks. There were no significant differences (p>0.05) in growth and feed performance among all treatments except group MM6. The growth decreased slightly as elevation of MM inclusion. The N and P retention values (35.10~38.48% and 39.91 ~ 44.08%) in fish fed experimental diets did not show significant difference. The total amino acid composition of rainbow trout did not show any significant difference between the control and experimental groups. The fatty acids 16:0 and 16:1 of fish whole body were increased significantly (p<0.01) with the inclusion levels of MM in the test diets, while 18:2n-6 was decreased. The phagocytic activity of head kidney leucocytes of rainbow trout and phagocytic index were not affected with the substitution of FM by MM, except the MM6 group. There was no difference in superoxide production in phagocytes among all groups. This study concludes that MM is being able to completely replace FM in the diet of rainbow trout and can meet the nutrient requirements of this species. Thus, maggot meal can be a potential substitute of fish meal in rainbow trout diets.

EFFECTS OF DIETARY POLYUNSATURATED FATTY ACIDS AND BETA GLUCAN ON MATURITY AND IMMUNITY OF PABDAH CATFISH, *Ompok pabda*

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Biofunctional compounds such as polyunsaturated fatty acids (PUFAs) and beta glucan through dietary inclusion are currently in demand and actively being studied to recognize their roles on physiological condition especially on reproduction and immune system, respectively. The aim of this study is to evaluate the effects of PUFAs enriched squid extracted lipids on enhanced maturation, spawning, early embryonic and larval development and dietary beta glucan in enhancing immunity of endangered Pabda catfish *Ompok pabda*. The *O. pabda* were collected from Brahmaputra river and stocked in the cisterns. Treated group was provided supplemental diet enriched with 1% squid extracted lipids as a source of PUFAs and 10% barley powder as a source of beta glucan, and finely chopped squid meal for four months (March-June/2018) whereas controlled group was fed the same except PUFAs and beta glucan. Histomorphology of liver and serum calcium ion concentration indices were used to clarify gonadal maturation and a spawning trial in late August was conducted to spell out the reproductive performances. Acetylcholinesterase (AChE) activity and cell count of erythrocytes ($\times 10^3/mm^3$) and leucocytes ($\times 10^6/mm^3$) were measured using standard methodology to explain the immunomodulatory effects of beta glucan in association with PUFAs enriched diet on *O. pabda*. Treated group attained significantly higher ($p<0.01$) weight increment compared to the control group and significantly higher ($p<0.05$) length increment was also found. In comparison with the control group, treated group exhibited an advanced gonadal maturation and higher reproductive performances in spawning trial. Though spawning occurred in late August, the fertilization rate (78.67 ± 1.33%), hatching rate (70.21±0.73%) and survival rate (65.54±1.94%) of offspring were significantly higher in treated group compared to control. Consequently, early embryonic and larval development was observed. During spawning season, lipid granules and normal morphological alteration were observed in case of treated fish liver, whereas less lipid granules with more histological alteration of liver were observed in control group. Serum Ca^{2+} level in treated female was significantly higher ($p<0.05$) compared to the controlled female. The AChE activity was significantly higher ($p<0.01$) in the treated group (63.93 ±1.48 nmol/min/mg protein) than the controlled (44.43±2.65 nmol/min/mg protein) fed with no beta glucan and PUFAs. WBC of the blood acts as defensive element against the external and unwanted intrusive element and results of WBCs count cell ($\times 10^6/mm^3$) in blood of *O. pabda* which fed with beta glucan in associated with PUFAs were found significant increased ($p<0.05$) in number as compared with the control. The study suggests that supplementation of dietary PUFAs and beta glucan improve the spawning performances and immune status of *O. pabda*.

GONADAL MATURATION CYCLE OF SILVER POMFRET (*Pampus argenteus*) FROM THE BAY OF BENGAL, BANGLADESDH

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Reliable reproductive parameters are essentials for studying the conservations and managements of a fish stocks. The present study was carried out with an aim to identify the gonadal maturation cycle of *Pampus argenteus* from the Bay of Bengal. For this study the standard length-weight relationship, condition factor, GSI, oocyte diameter and the cyclic histological changes in gonadal maturation have been conducted from 346 fishes during 2016-2018. The standard length-weight relationship was $W= 0.0764SL^{2.795}$ and the logarithmic equation being log W= -1.11685 + 2.795 log SL. The slope 'b' was less than 3.0 which indicates allometric growth of this species. The monthly mean condition factor (K) was varied from 4.0110 to 4.6409 with an average of 4.3420 and the monthly mean relative condition factor (Kn) was varied from 0.9117 to 1.0489 with an average value of 1.0032. The maximum mean values of hepatosomatic index (HSI) were found in May 1.1450±0.16 for males and 1.60±0.24 for females, where the minimum mean values of HSI were found in September for males 0.4209±0.11 and in June for females 0.4100±0.14. Highest oocyte diameter was observed in the month of May (135.1 17.9 µm) and June (132.9±11.8 µm) where ovaries were in full mature conditions and the lowest was in July where new eggs initiated development for the next spawning season. The fecundity was found to vary from 26,109 to 3, 50,371 with mean value of 1, 02,019 nos of eggs. The highest GSI value was observed in the months of April to June and second higher values of GSI was also observed in the month of October (0.93±0.68) which indicates the second phase of gonadal maturation in this species. Maximum number of eggs in the ovary was in yolk granule stages in these months with a number of post-ovulatory follicles which also indicates the ovarian development to a peak leading to the spawning season in May and June. A number of spermatids were also seen in males in the following months. From the detailed observations, it may be concluded that *P. argenteus* shows two peak of spawning, one in May-June and second one is in October which will be helpful for successful conservation strategies and establishment of artificial breeding.

STUDY ON THE FEEDING BIOLOGY OF GREEN MUSSEL (*Perna viridis*) IN MOHESHKHALI CHANNEL, COX'S BAZAR, BANGLADESH

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Green mussel (*Perna viridis)* is distributed widely in the Indo-Pacific regions including the coastal waters of Bangladesh. As it is a commercially important species and has demonstrated a great culture potential in tropical countries, so this study explored how the food and feeding habits of green mussels are related with natural abundance of plankton in Maheskhali. The study was mainly undertaken to identify the plankton taxa that are preferentially ingested and rejected by *P. viridis* in different physiological and environmental factors like size, weight, sex, breeding seasons and different months. This recent result showed that *P. viridis* selectively influenced by phytoplankton abundance and composition as they are mostly filter feeder. Hence, the zooplanktons were also contributed to the stomach content at a little amount. The study also demonstrated that *P. viridis* selectively ingest *Coscinodiscus* spp round the year. The rotifer and copepod were also found mostly in the diet of *P. viridis*. But some species of phytoplankton as *Chaetoceros* and *Bacteriastrum* were actively rejected by green mussel though these species were dominated in the sea water. The Bacillarophyceae, Dinophyceae and Zooplankton group are actively selected and Chlorophyceae, Cyanophyceae and Pyrrophyceae are strongly rejected (Table). Highest numbers of plankton in the gut of the green mussel were found during the month of November and December and the least were in March and September. The larger length and weighed green mussel were found with highest number of phytoplankton and zooplankton in their gut content. The female contain highest number of plankton than the male. When green mussel was in developmental stage, it was found with large number of plankton in the gut content than the spawning and resting phase. In the whole diet, phytoplankton contributed 87% and zooplankton contributed 13%. The overall information about the food and feeding habit of green mussel from the being study will be helpful in the farming sites of the coastal regions of Bangladesh.

Plankton Variable	Plankton found in sea water	Plankton found in gut	Electivity Indices value
Bacillariophyceae	54	94.67894	0.273603
Chlorophyceae	8.633085141	4.42767396	-0.32199
Cyanophyceae	6.906475019	1.79622642	-0.5872
Dinophyceae	4.172661991	4.90566038	0.080742
Pyrrophyceae	7.410072156	5.98742038	-0.10619
Zooplankton	18.92086385	27.46789	0.184248

TWO NEW RECORDS OF MARINE DEMERSAL FISHES IN BANGLADESH COAST

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Cruise operated by research vessel RV Meen Sandhani was carried out as a part of the of stock assessment program of marine fish species in the Bay of Bengal, Bangladesh under the 'Sustainable Coastal and Marine Fisheries Project' of DoF in January 2018. In the cruise, two species of bony fishes *Lepidotrigla bispinosa* (Steindachner, 1898) and *Parapercis alboguttata* (Gunther, 1872) were recorded for the first time in the Bangladesh water. We conducted morphological and morphometric analysis to confirm the identification of these collected fish species before genetic analysis. For molecular identification, mtDNACOI barcode region and partial 16s rRNA gene region were sequenced. This finding provides the evidence of the presence of these species in Bangladesh water.

BEACH POLLUTION AND SUSTAINABLE TOURISM IN ST. MARTIN'S ISLAND, COX'S BAZAR, BANGLADESH

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Beach environment have a close association with tourism in St. Martin's Island. Beach ecosystem is being degraded continuously both by natural process and anthropogenic causes (e.g. haphazard tourism). The present study was conducted in St. Martin's Island, which has immense tourism potential with its extraordinary features. Direct observation and key informant interview method were used to collect data. From the findings, it can be stated that the beach is being polluted with plastic, oil etc. Tourist throwing non-biodegradable materials into the sea. They roam in the beach at night disturbing turtle in laying an egg. There are a lot of dogs who bite local people, tourist, and turtle. There are a lot of measures existing in the beach to protect the Island environment but these are not enough and some should be modified. We identify the existing problems and recommend some measures to protect our beach and tourism.

DIVERSITY AND SEASONALITY OF THE HORN SNAILS *Pirenella* IN KUTUBDIA ISLAND, COX'S BAZAR, BANGLADESH

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The molluscan fauna, horn snails *Pirenella* are common in tidal mudflat areas, but their taxonomy and abundance is not well known in Bangladesh. In a one year study period, July 2017 to February 2018, this study identified two species of horn snail *P. alata* and *P. cingulata* from the Kutubdia Island, and documented their habitat preference and seasonality. The average population of horn snails, as determined by the quadrate (0.25 m^2) and line transect (130 m) methods, was 88±10, 11±5 and 18±3 individuals/m^2 in the mudflat, salt marsh and mangroves zones, respectively. This data suggests that bare mudflat is the most preferred habitat by the horn snails than that of the salt marsh and mangroves. Moreover, their numbers were 37±5 individuals/m^2in rainy season and 40±6 individuals/m^2 in winter season, thus no marked seasonal variation was observed in the abundance of horn snails *Pirenella* in Kutubdia Island.

ECO-ENGINEERING POLYCHAETE *Diopatra* (POLYCHAETA: ONUPHIDAE) FROM THE COAST OF COX'S BAZAR, BANGLADESH

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Ecosystem engineering organisms, such astube-building polychaetes can create, modify, or maintain habitats as well as alter the distribution and abundance of many other aquatic species by their activities. The aim of this study was to identify tube-building polychaete species, and to document their ecological role in the intertidal mudflats of Cox's Bazar and Kutubdia Island. Two types of tube-building polychate were identified upto genus level as '*Diopatra* sp. A' and '*Diopatra* sp. B' and provided their descriptions with 11 taxonomic keys. Tube-building polychaetes occuring in the study area were found to be used as habitat for macro-algae and invertibrates. Specifically, 70% of collected *Diopatra* tubes were facilitating macro-algal growth, i.e. used as an attachment substrate for macro-algal community. Moreover, five types of invertebrates, such as polychaetes, crab, bivalve, pistol shrimp and sea anemone were attached with the tubes, occurring at a density 18 individuals/m^2.

THREE NEW RECORD OF FISHES (PISCES: PERCIFORMES) FROM THE BAY OF BENGAL COLLECTED FROM THE SOUTH-EAST COAST OF BANGLADESH

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Three new record of fishes i.e. *Apogonichthyoides pseudotaeniatus* (Gon, 1986), *Cryptocentrus maudae* (Fowler, 1937) and *Stegastes apicalis* (De Vis, 1885) belonging to the family Apogonidae, Gobiidae and Pomacentridae, respectively under the order of Perciformes were reported for the first time from Bay of Bengal, Bangladesh based on morphological and molecular confirmation. The fishes were sampled from the catch of local fishermen between May 2017 to July 2018 while set gill net on the coral reef in Saint Martin's Island. Species level identification was carried out using morphological characters according to original descriptions. The partial mitochondrial COI and 16s rRNA gene region have been sequenced as DNA barcoding for molecular identification. Sequence analysis was carried out through different Bioinformatics tools *viz.* Geneious 9.0.5, DNASP6 and MEGA6. Sequences were matched with the DNA sequence data of NCBI and BOLD database using BLAST search engine. Regarding distribution, these three species were not ever reported in Bangladesh and not even recorded from other maritime localities of the Bay of Bengal.

ADDITION OF THIRTY-TWO NEW RECORDS TO THE FISH INVENTORY OF BANGLADESH FOUND OFF SAINT MARTIN'S ISLAND THROUGH MORPHOLOGICAL ANALYSIS AND DNA BARCODING

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DNA barcoding appears to be an advance approach for taxonomic identification, characterization, and discovery of newer species, facilitating biodiversity studies. A study has been conducted to assess the diversity of reef associated fishes found off Saint Martin's Island of Bangladesh and to prepare DNA barcode library of them. The fishes were collected from May 2017 to July 2018. Species level identification was carried out using morphological characters according to original descriptions.DNA barcode information on the mitochondrial COI gene and/or 16S rRNA gene sequences was obtained for molecular identification of the collected samples. Sequences were matched with the DNA sequence data of NCBI and BOLD database using BLAST search engine and phylogenetic analysis was made using computer program MEGA. A total of 128 marine fish species were successfully DNA barcoded from SMI belonging to 49 families of 9 orders. Most importantly, a total of 32 marine fish species have been confirmed as a new distributional records in Bangladesh, of which 26 species are reef associated. These newly recorded reef fishes are *Ostorhinchus cookie, Lepidamia kalosoma, Istiblennius dussumieri, Blenniella periophthalmus, Caranx heberi, Valenciennea muralis, Amblyeleotris downingi, Cryptocentrus cyanotaenia, Istigobius ornatus, Plectorhinchus macrospilus, Bodianus neilli, Pomadasys andamanensis, Pomadasys guoraca, Lethrinus crocineus, Lutjanus fulvus, Parupeneus indicus, Parapercis clathrate, Filimanus similis, Chromis cinerascens, Chlorurus rhakoura, Plectropomus pessuliferus, Sphyraena putnamae, Synodus variegatus, Apogonichthyoides pseudotaeniatus*, *Cryptocentrus maudae*and *Stegastes apicalis*. The other non-reef fish species are *Leiognathus daura, Leiognathus longispinis, Equulites leuciscus, Opistognathus variabilis, Chrysochir aureus* and *Saurida micropectoralis*. Among the newly recorded fish species, the order Perciformes solely contributes 30 number of species (93%). The present study endows the remarkable addition of species record to the country's fish inventory.

FIRST RECORD OF MARINE CRABS OF GENUS *Doclea*, *Phalangipus*, *Arcania*, *Ixa* AND *Ethusa* FROM BANGLADESH COAST

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Crabs are decapod crustaceans of the infraorder Brachyura**.** Among benthic communities, crustaceans are important members because more number of species present for human consumption and a tremendous variety of small species contribute to the complexity and functioning of tropical ecosystems. Sometimes identification of crab is confusing due to change of their body coloration with environmental condition. The samples were colectedfrom South coast of Bangladesh and from Saint Martin's Island. The samples were bought to the laboratory, cleaned with brush, and morphological identification done using appropriate references. Four genus were newly identified as *Doclea, Phalangipus, Arcania*, *Ixa* and *Ethusa*in Bangladesh on the basis of the morphology of the carapace. The species were *Docleaovis, Phalangipuslongipes, Arcaniagracilis*, *Ixacylindrus* and *Ethusarugulosa*. Among them *Doclea*and *Phalangipus* belong to the family Epialtidae, *Arcania* and *Ixa* belong to the family Leucosiidae and Ethusa falls into the family Ethusidae. These five crab genera are recorded for the first time in Bangladesh. Results of this study provide the information about the variation of the crabs found in the south coast of Bangladesh.

CULTURE POTENTIAL OF GREEN MUSSEL (*Perna viridis*) IN THE COASTAL REGION OF BANGLADESH: APPLICATION OF SITE CAPABILITY RATING SYSTEM

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Green mussel (*Perna viridis)* is the warm water mussel species that is distributed widely in the Indo-Pacific regions including the coastal waters of Bangladesh. As it is a commercially important species and has demonstrated a great culture potential in tropical countries, therefore, analysis of the potentiality of green mussel culture in the coastal areas of Bangladesh is a crying need for both the economic benefit and food security. This dignified study deals with perceiving the possibility of green mussel culture in the coastal land locked channels like Reju Khal and Maheshkhali Channel along with Naf river estuary. The perseverance was assisted by application of site capability rating system which includes all the biophysical parameters and phytoplankton abundance that preset distinct features for the culture sites to rank. For proper application of this rather new-fangled method, five stations were selected in the study sites sequentially from upstream to downstream and specified parameters were selected to be measured and the qualitative and quantitative study of planktons for almost over a year. From all the denoted data, all the parameters were found to be acceptable in Maheshkhali channel and Naf river estuary for green mussel culture with slight variation in salinity, temperature and turbidity due to the concurring landslides and freshwater runoff but in Reju khal the parameters were found in somewhat unacceptable range due to high salinity variation. Maheshkhali Channel bears the highest ranking of all the stations; among which the station 2 (Near Chaufaldandi) and station 3 (Near Khurushkul Bridge) rank higher than others. That means Maheshkhali Channel is more suitable than the others in terms of culture feasibility. Naf river bears the second highest ranking and Reju khal bears the least ranking. Which means the Naf river is moderately suitable and the Reju khal is least suitable for green mussel culture initiation. It is hoped that, proper utilization of this data stream will open a new horizon of success in culture of non-conventional fishery organisms and create a massive field of economic beneficiary in the blue economy of our country along with forging the export potential.

CONCENTRATION AND HEALTH RISK ASSESSMENT OF HEAVY METALS IN COMMON MARINE FISHES OF THE COX'S BAZAR, BANGLADESH

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A study was conducted to explore the heavy metals contamination in common pelagic and demersal fishes from the Cox's Bazar region of the Bay of Bengal coast of Bangladesh during the period from November 2017 to December 2018. The fish samples Churi (*Trichiurus haumela*), Surma (*Euthynnus affinis*), Loittya (*Harpodon nehereus*) and Ilish (*Tenualosa ilisha*) were collected from Cox's Bazar Sadar Fishery Ghat once in a season throughout the pre-monsoon (February to May), monsoon (June to September) and post-monsoon (October to January) seasons. Fish muscle tissue was dried at 110^0C, powdered with pestle and mortar and stored until chemical analysis. Heavy metals were analyzed after digesting the homogenized samples in a mixture of nitric and per-chloric acid. The digested samples were then centrifuged and the supernatant analyzed. The heavy metals copper (Cu), zinc (Zn), chromium (Cr), lead (Pb), cadmium (Cd) and mercury (Hg) concentration were analyzed using AOAC 19TH Edition (2012) By ICP-OES method. The result showed that over the three seasons Zn was detected in all fish samples while Cu detected only post-monsoon season, and other heavy metals (Cr, Pb, Cd, and Hg) were not detected, could be due to collection of marine fishes from deep sea where the sea was calm and far from the industrial and human interferences. The Zn concentration in Churi, Surma, Loittya, and Ilish were ranged from 4.02 to 6.23, 4.02 to 12.46, 2.64 to 4.50 and 4.73 to 11.10 mg/kg, respectively, and concentration of Cu was 0.66, 1.36, 4.01 and 1.38 mg/kg, respectively during study period. The results of the study found that all detected heavy metals were within the acceptable range. Consequently, it could be assumed that the studied fishes are harmless for human health and study concluded that food safety measures will be ensured by marine fishes of Bangladesh.

DIVERSITY ASSESSMENT OF SCLERACTINIAN CORAL WITH FIFTEEN NEW RECORDS FROM SAINT MARTIN'S, ISLAND IN BANGLADESH

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Saint Martin's Island is the only island in Bangladesh where coral colonies are found and still supporting coral reef ecosystem in northern most part of the Bay of Bengal. To investigate the present status and diversity of Scleractiniancoral (i.e. hard coral) species, several underwater surveys have been made to offshore of the St. Martin's Island. The photographs of the specimens were taken from 1 to 5 meters of the water depth employing scuba diving and coral identification was done using the books: Coral of the World (Veron), Coral Species in Indonesia (Suharsono) and Indo-Pacific Coral Finder. In this study, 45 Scleractinian species were found belonging to 16 genera of 9 families. Among them 15 Species were newly recorded in Bangladesh marine water, *viz. Acropora hyacinthus, Pavona clavus, Coscinaraeaexesa, Tubastrea faulkneri, Dipsastraealizardensis, D. maritima, D. veroni, Goniastreastelligera, Favitesacuticollis, F. melicerum, F. complanata, F. pentagona, Plesiastreaversipora, Gonioporaalbiconus* and *G. norfolkensis*. Therefore, the present study increases the total number of hard coral species from previously reported 66 to 81 and the families from 10 to 12. This new records signifies previous sampling gaps in this area and suggests necessity of more extensive study and monitoring on coral fauna for taking conservation policy of coral ecosystem in Bangladesh.

IMPACTS OF BAN TO SUPPLYING MOTHER SHRIMP TO HATCHERIES FROM THE BAY OF BENGAL

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Frozen shrimp contribute 84% to fisheries product export of which, only Black Tiger (*Penaeus monodon*) contribute 67%. It happens due to the supply of Post Larvae to the growers from 49 Hatcheries. These hatchery owners buy mother shrimp/ spawners from the shrimp trawlers who catch it from the Bay of Bengal. Black tiger shrimp is breeding intermittently throughout the year. The breeding time of fin fishes in the Bay of Bengal is May to July. January to July is the peak time to catch mother shrimp and March is the peak month and December is the lean month. Mainly natural/rainwater starts to come into farm/gher from May. About 60% farmers those have no underground water facilities; they stock PL from May to July. January & February is another period of stocking PL where underground water/tidal water being used. Usually, September to November is offseason of mother shrimp landing. There are four major shrimp spawning ground where most of the mother shrimp are being caught e.g. Kohinoor Point, West of Kohinoor Point, Elephant Point and Saint Martin. The location of the mother shrimps areas is from longitude $91^0$00' to $91^0$50' and Latitude $20^0$30' to $21^0$10'. After enacted ban on 2015 to enhance the natural stock of fish by protecting fishing from May 20 to July 23, mother shrimp catch also stopped. Thus reduce the production and export of BT shrimps significantly. The catch data from two years before and two years later of ban were analyzed and found 46% less landing after enacted the ban.

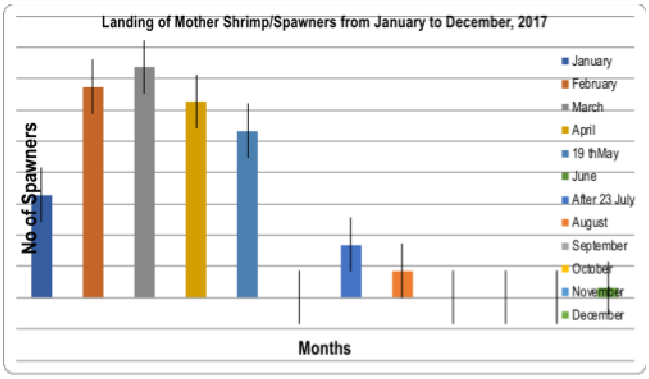

Fig 1: Landing of Mother Shrimp/Spawners from January to December, 2017

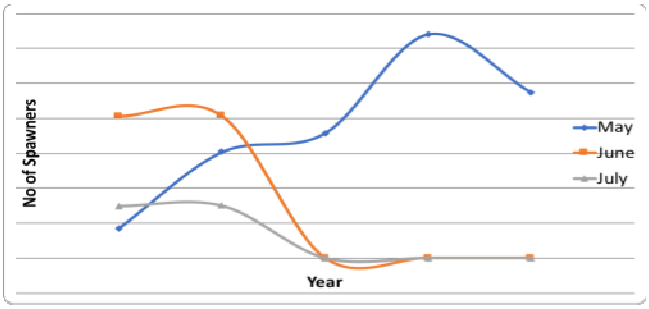

Fig 2: Before and After Ban Impacts of Mother Shrimp Supply to Hatchery

SHIFTING PATTERN OF PHYTOPLANKTON PHENOLOGY AND SPECIES RESPONSE TO CLIMATE CHANGE AND EUTROPHICATION IN GYEONGGI BAY

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To test the hypothesize "shifting pattern of phytoplankton phenology and dominant species can be brought by synergistic effect of climate change and eutrophication" we conducted a detailed case study on phytoplankton species during 1992-1997 and 2001-2010, nutrients and climatic factors during 1992-2010 and 1960-2010, respectively, in Gyeonggi Bay. Climatic and ecological regime shifts were detected during the 1990s and 2000s, respectively. The asymmetric relationship between climate and ecological regime shift probably depends on macrotidal system configurations that are more resistant to environmental perturbation. The spring diatom blooms (i.e. *Paralia sulcata*) observed in the 1990s have moved forward to winter blooms (i.e. *Thalassiosira nordenskioeldii*) in the 2000s because early winter warming has been induced by higher light and precipitation, which has removed prior light limitation and control of diatom blooms. Summer blooms during 2000s are triggered by enhanced nutrients, which leads to frequent and recurring dominance of dinoflagellates, nanoflagellates and diatoms, supporting the hypothesis that summer phenology might be brought about by local processes such as eutrophication, as well as by climate change. Temperature associated with climatic factors (i.e. reduced wind speed and suspended solids) that had negative impact of *P. sulcata* and, consequently, maintain proper temperature and nutrients for *T. nordenskioeldii*. This result suggests that oceanic climate change shifted phytoplankton phenology and community structure that may have effect on the structure of marine food webs.

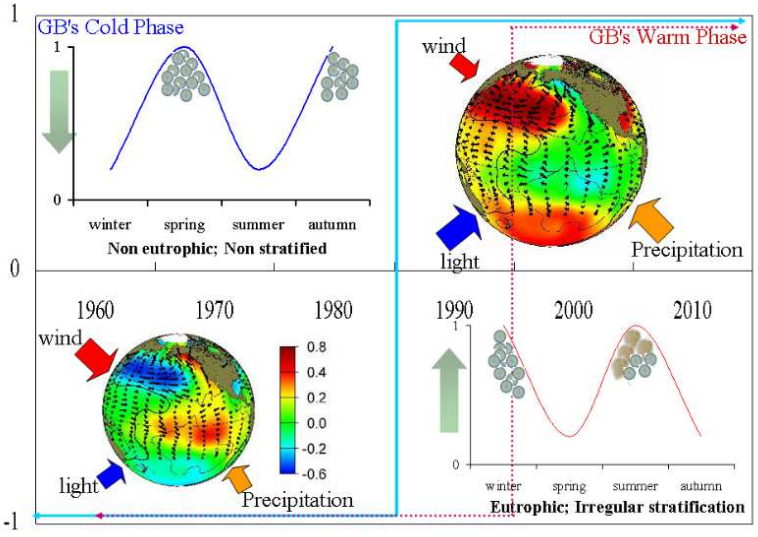

Fig. 1. Hypothetical features of regime shift in the Gyeonggi Bay during the last five decades.

ASSESSMENT OF THE MICROPLASTIC INGESTION IN RED MULLET *Mullus barbatus*, FROM NEUM BAY, BOSNIA AND HEREZEGOVINA

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The marine biodiversity of the Adriatic Sea is under the high anthropogenic pressure and climate changes that cause structural changes in whole flora and fauna. Significantly increased the degree of pollutants, primary microplastics may affect the marine animals and accumulate in their digestive system which can make a possible change on philological status and develop the disease. Furthermore, POPs often bounded to the MP may penetrate the cell membranes in the small intestine and thus reach the cardiovascular system, causing various toxic effects. This paper will give detailed data about the possible negative effects of pollution of microplastics in the digestive system of the red mullet *Mullus barbatus*, from Neum Bay of Bosnia and Herzegovina. It has been analyzed total 60 specimens on the three different localities within the two season (spring and winter). During the study we have indentified approx. 30 to 150 particles per adult sample, which have been further quantified and qualified. Most common plastic is polyethylene, which probably comes from derelict fishing gear, cosmetics and clothes.

PROXIMATE COMPOSITION AND TRADITIONAL METHOD OF CONSUMPTION OF DOG FISH SHARK (S*qualus acanthias*) IN COX'S BAZAR REGION

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The present study was conducted to assess the proximate composition and traditional method of consumption of dog fish shark (*Squalus acanthias*) in Cox's Bazar region of Bangladesh during the period from July 2016 to December 2016. Data relevant to landing, marketing, and utilization of dog shark were collected from randomly selected 10 fishermen, 8 retailers, 20 consumers, 6 fish processors by personal interviewing with a pre-tested well-structured questionnaire. In past, shark capture was considered as a by-catch of hilsa, lakkha and other marine fish species. But from the current study it was found that different kinds of nets and long lines were used to capture the shark species in the Bay of Bengal. The retail price of the fresh fish was 100-150 BDT/kg whereas dried fish was sold 250-300 BDT/kg in the landing center. Moisture, protein, fat, carbohydrate and ash content of the shark was found as 74.29%, 14.51%, 7.02%, 2% and 2% respectively. It was found that the tribal community and some Buddhist communities of Cox's Bazar prepared different product as well as fish curry, curry with egg, bouillon, and fry from the raw dog fish shark and bouillabaisse from dry fish. They used different locally found ingredients in different composition to make these products such as salt, chilly, turmeric, green chili, coriander, onion, garlic, ginger, cumin, mustard oil etc. Among these products the most popular one was bouillabaisse and bouillon which was served with Myanmar noodles. The dog fish shark products were considered as a delicious food item by the tribal people of the area. Following the same methods, same kinds of products were replicated in the FIMS laboratory and a panel test was conducted among 20 panelists with different parameter scoring from 1 to 7. Therefore, the findings of the present study suggested that the dog fish shark can be a very good alternative protein source for the low income family of the country as the price, nutritional quality and availability of the fish is reasonable for them. However, this small shark should be captured in a sustainable manner so that the original fish stock will not be depleted.

RESPONSE OF BENTHIC COMMUNITY STRUCTURE TO HEAVY METALS IN COASTAL AREA OF BANGLADESH

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Benthic macroinvertebrates are often used to assess the ecological integrity of aquatic ecosystems. Thus the present study was undertaken to examine the response of benthic community structure to heavy metals using bivariate/ multivariate techniques along Chittagong coast. A total of 28,799 organisms from 23 taxa were counted from the 24 samples analyzed. Three dominant taxa as polychaeta, amphipoda and bivalvia were found. Taxa richness and density of individual taxa were less at stations S1, S2, S3 and S4. On the other hand, mean concentration of heavy metals in sediments followed the order of Fe (32,525.6 µg.g-1) > Mn (569.77 µg.g-1) > Zn (93.71 µg.g-1) >Pb (55.97 µg.g-1) > Cu (41.59 µg.g-1) >Ni (31.50 µg.g-1) > Cr (28.96 µg.g-1) > Co (10.34 µg.g-1) respectively. High contents of metals were found in the S1, S2, S3 and S4 area, while lower concentrations were found in the S5, S6, S7 and S8 (Sawndip Island). Spearman rank correlation was then employed to explore the relationships between the major axes of heavy metals and benthic community structure. Strong and significant correlations were found between these axes. Amphipoda one of the dominant taxa exhibit significant, strong, negative correlation with Cu, Pb and Cr concentration with significant coefficient of determination (r2 = 0.63p<0.01; r2 = 0.64, p< 0.01 and r2 = 0.52, p< 0.04) and lesser densities of Amphipoda (r = - 0.99, p< 0.05, r = - 0.77, p< 0.01 and r = - 0.86, p< 0.01) was observed in sediment. Polychaeta and Bivalvia showed the significant, strong positive correlation with all metals with significant coefficient of determination.

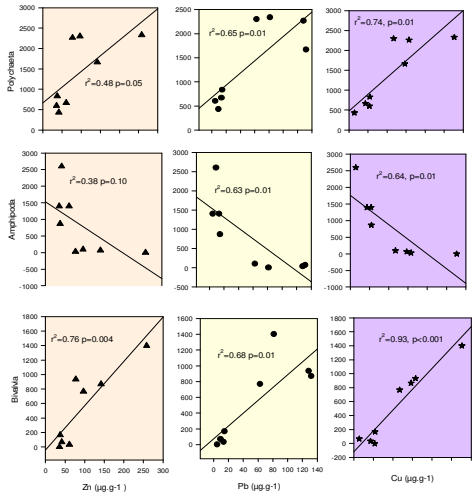

Fig. 1. Relationship between heavy metal concentration and macrofaunal abundances of three dominant groups.

ESTIMATION OF PROXIMATE COMPOSITION OF NILE TILAPIA (*Oreochromis niloticus*) FED COMMERCIAL FEED WITH OR WITHOUT DIFFERENT LEVELS OF SEAWEED (*Hypnea* sp.) SUPPLEMENTATION

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Nile tilapia (*Oreochromis niloticus*) is very popular fish in Bangladesh because of its easy culture process, low price and nutritional value. So, different types of researches have been done in Bangladesh to improve the meat quality of tilapia. This study is about proximate analysis of Nile tilapia (*O. niloticus*) when red seaweed (*Hypnea* sp.) is used as supplementary feed. In this experiment, 30 similar sized tilapia fingerlings of 30 days were kept in each of 10 aquariums and reared for a period of 3 months. The fishes were treated with five treatments - T1 (5% sea weed), T2 (10% sea weed), T3 (15% sea weed), T4 (20% sea weed) and C (Commercial feed) with a replica for each. After 3 months, fishes were killed for sample preparation. The dead fishes for different treatments were separately minced in a chemical tissue grinder and dried in an oven at 100°C. Moisture was estimated from difference of the weight of wet and dry sample. Proximate analysis was accomplished with dry sample and the values were later readjusted for weight wet. Highest percentages of moisture, ash, protein and lipid were found in T4 (75.57±0.88) %, T4 (6.13±0.13) %, T3 (14.68±0.38) % and C (6.87±1.02) % respectively.

Table 1. Proximate composition after three months rearing period

Treatments	Moisture (%) (Mean ± SEM)	Ash (%) (Mean ± SEM)	Protein (%) (Mean ± SEM)	Lipid (%) (Mean ± SEM)
C	74.01±0.69	4.96±0.71	14.09±0.53	6.87±1.02
T1	74.69±0.57	4.98±0.30	14.43±0.19	6.18±0.90
T2	74.72±0.12	5.00±0.25	14.54±0.10	5.23±0.18
T3	75.52±1.41	5.89±0.37	14.68±0.38	4.48±0.16
T4	75.57±0.88	6.13±0.13	14.20±0.12	3.89±0.87

Values are mean ± SEM of duplicate groups of 30 fishes.

Moisture content and ash content increases whereas lipid content decreases with the increasing amount of seaweed supplement. That means seaweed has positive impact on moisture, ash and protein but it reduces lipid content. Overall, seaweed supplementation is beneficial and improve the nutritional value of Nile tilapia.

ISOLATION AND BIOACTIVE POTENTIALS OF FUNGAL ENDOPHYTES FROM COAST OF THE BAY OF BENGAL, BANGLADESH

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From the ancient time, natural products made from living organisms such as plants, animals and microbes have a pharmacological activity that can be used as a source for the development and discovery of new drugs. Very recent fungal endophytes grew attestation at the scientists of the research for its diversified secondary metabolites and their bioactivity. Our Bay of Bengal is nearly untapped source of fungal endophytes and their bioactive potentials. Therefore, this investigation was carried out to explore fungal endophytes and their bioactive potentials from the Bay of Bengal. A total of three fungal endophytes from two seaweeds were isolated and purified and these are MW-1 and MW-2 from *Dictatadi chotoma*, HM from *Hypnea muciformis*. All the fungal strains were cultivated at room temperature for 21 days in Potato Dextrose Agar (PDA) medium. Antimicrobial study was conducted using the Disc diffusion method against a wide range of Gram-positive and Gram-negative bacteria, testing of antioxidant properties using the DPPH scavenging method and cytotoxicity was observed using the Brine Shrimp Lethality Bioassay. All extracts obtained from fungal endophytes were tested at 100 µg/disk concentration for the screening of antibacterial activity and some of them showed mild to moderate activity against tested human pathogenic bacteria. All extracts were subjected to the DPPH scavenging test in order to evaluate the free radical scavenging activity of the fungal extracts. Fungal strain MW-1 (IC_{50}=9.47µg/ml) and MW-2 (2.97µg/ml) showed significant antioxidant activity comparing with the standard (9.01µg/ml). All extracts obtained from endophytic fungi were screened for probable cytotoxic activity using brine shrimp lethality bioassay. The extracts showed very low LC_{50} values (µg/mL), such as extracts MW-1(0.50 µg/mL) and thus, demonstrated their potent cytotoxic activities. Preliminary chemical screening by Thin Layer Chromatographic Technique of the seaweed and fungal extracts revealed the presence of different compounds such as flavonoids, anthraquinones, couramins, isocoumarins etc. Overall, these findings indicate that Fungal endophytes from the Bay of Bengal may be the ideal target for the discovery of potential bioactive compounds or leads for new drug development.

BREEDING BIOLOGY OF GREEN MUSSEL (*Perna viridis*) IN THE COASTAL REGION OF BANGLADESH

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A thorough study on the reproductive biology of *P.viridis* and defining the accurate times of collecting spat is essential to develop the green mussel culture technology in Bangladesh. Therefore, the main purposes of this study were to accurate determination of the dynamics of the gonadal development through histology, and linking how condition index is related with the spawning of the green mussel. In order to attain our objectives, 20 green mussel were collected from November 2017 to October 2018 on monthly basis from Moheshkhali Channel, Chawfaldandi, Cox's Bazar. After bringing the samples in the laboratory, body length, body weight, muscle weight, and dry weight were recorded. The general reproductive condition of the population were assessed by calculating mean gonadal index (GI). From the histological analysis, the sex ratio of male and female was found to be 1:0.8837 and the evidence of hermaphroditism in *P. viridis* were documented. There was a significant relationship between length and weight where R^2 value was found to be 0.9161, indicating a positive correlation between them. The female CI (gm/cm³) value (13.8375) was relatively higher than male (11.7942), and the highest values were observed during the month of February and June. The highest value of female GI were observed to be 2.1 and 2.4 in the month of January and February, respectively, and a minor increase was observed in the month of June.GSI value was found to be generally higher in female than male. The histological analysis confirmed that the major spawning occurred in November to March and a minor spawning was also noticed during June to July. The study confirmed that the spawning of green mussel (*Perna viridis*) occurred twice in a year with major spawning season from November to March (from early winter to spring) and a very minor spawning during the month of June to July (early monsoon).The finding of the present study would be helpful to develop the culture system and artificial breeding technique of green mussel in near future in Bangladesh.

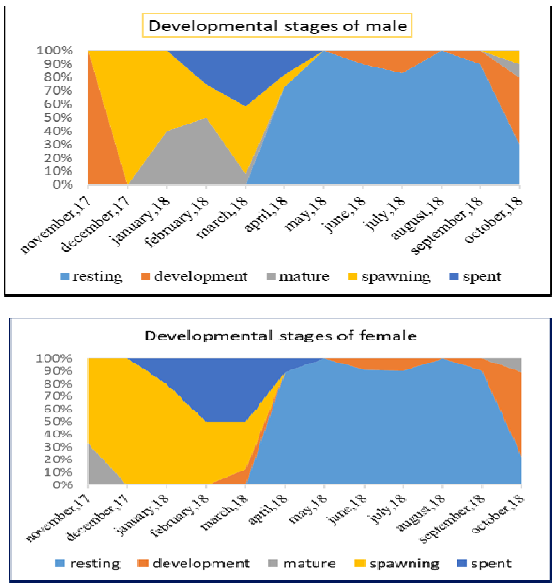

Fig. 1. Dynamics of the gonadal development of green mussel in the coastal areas of Bangladesh

SPONGE AND SPONGE ASSOCIATED BACTERIA OF SAINT MARTIN'S ISLAND INHIBITING FISH PATHOGEN

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Marine sponges and their associated bacteria are known to produce diversified antibiotics and antimicrobial compounds. This study was conducted to identify native marine sponge of the Saint Martin's Island and their associated bacteria inhibiting fish pathogen. Seven sponge samples were collected from different location of Saint Martin's Island. These sponges were identified based on their morphological characteristics as *Niphateserecta, Mycale macilenta, Plakortis dariae, Cliona celata, Haliclona rosea, C. carteri* and *C. viridis* (Fig. 1). Antibacterial activity of ethyl acetate extracts of the sponges was screened following the disc diffusion method. Among the sponges, the ethyl acetate extracts of *P. dariae* exhibited distinct antibacterial activity against fish pathogenic bacteria *Aeromonas veronii* and *Stenotrophomonas maltophilia* (Fig. 2). The active compound was separated by Thin Layer Chromatography technique. Ethyl acetate and Methanol at 9:1 ratio was used for separation of the active compound. One non polar compound was found in the TLC plate that strongly inhibited the same fish pathogenic bacteria. The Rf value of that compound was 0.92. A total of 180 bacterial isolates were screened for their antibacterial activity against 8 different fish pathogens by agar well diffusion assay. Among them, isolate WS1A inhibited the growth of *S. maltophilia* and isolate YS5 inhibited the growth of *S. maltophilia* (Fig. 3). These two isolates were identified by 16S rRNA gene sequence as *Bacillus subtilis* and *Shewanellachilikensis*, respectively. These bacteria were isolated from *H. rosea* and *M. macilenta* sponges, respectively.

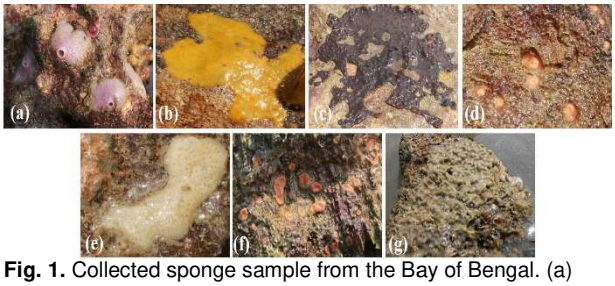

Fig. 1. Collected sponge sample from the Bay of Bengal. (a) *N. erecta*, (b) *M. macilenta*, (c) *P. dariae*, (d) *C. celata*, (e) *H. rosea*, (f) *C. carteri*, (g) *C. viridis.*

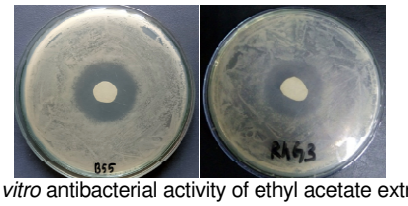

Fig. 2. *In vitro* antibacterial activity of ethyl acetate extracts of *P. dariae* against *A. veronii* strain B55 and *S. maltophilia* strain RhG3.

Fig. 3. Inhibition zone of isolate WS1A and YS5 against fish pathogenic *S. maltophilia* (strain RhG4).

ANALYSIS OF BIOACTIVE COMPOUNDS AND ANTIOXIDANT ACTIVITIES OF RED SEAWEED *Gracilaria tenuistipitata* FROM BANGLADESH

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Body cells naturally produce oxidants during metabolic processes which are usually neutralized by antioxidants. An imbalance between oxidants and antioxidants, in the favor of oxidants, can cause oxidative stress; which is responsible for many degenerative diseases. Scientists are searching for natural sources of antioxidants to prevent this type of physiological problems. In some recent studies, seaweeds have been found to be a very good source of bioactive compounds and natural antioxidants. This study was designed to analyze the presence of bioactive compounds and antioxidant activities of different crude extracts of *Gracilaria tenuistipitata*. Methanol, ethanol and water were used as solvents to get crude extracts. Presence of terpenoids, saponins, phlobatannins, cardiac glycosides and tannins were qualitatively assayed and FT-IR was performed to identify different functional groups. Total phenolic content (TPC) was determined by Folin-Ciocalteu method and total flavonoid content (TFC) was determined by aluminum chloride method. 2,2-Azino-bis(3-ethylbenzothiazoline-6-sulfonic acid (ABTS) radical scavenging assay and Phosphomolybdenum assay were performed to determine total antioxidant activity. Qualitative assays showed best result in water extract followed by methanol and ethanol extracts in terms of the presence of phlobatannins, tannins, cardiac glycosides, terpenoids and saponins.FT-IR analysis showed the presence of phenols, carboxylic acids, ketones, ethers, aromatics, alkanes, ethers and sulfonates in different extracts. TPC and TFC were highest in water extract (42mgGAE/g and 258.33 mgQE/g respectively). In phosphomolybdenum assay, absorbance at 695nm were 0.88, 0.45 and 0.56 for water, ethanol and methanol extracts respectively, which shows better antioxidant capacity of water extracts. ABTS radical scavenging of water extract was 66.6% followed by 43.90% for methanol and 37.3% for ethanol extracts. So, it can be concluded that, *G. tenuistipitata* can be a good source of natural antioxidants.

ANALYSIS OF SECONDARY METABOLITES AND ANTIOXIDANT PROPERTIES OF BROWN SEAWEED, *Sargassum coriifolium*

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The importance of marine macroscopic algae as a source of functional components has been well recognized due to their valuable health beneficial effects. Marine algae are potentially ample sources of vastly bioactive secondary metabolites which are convenient for the development and improvement of pharmaceutical drugs. In this study, the secondary metabolites and antioxidant activity of different crude extracts- water, ethanol, methanol and butanol of *Sargassum coriifolium* were determined. Phytochemical screening and Fourier transform infrared (FT-IR) analysis were performed to identify the chemical composition of the crude extracts. Antioxidant activity was assayed by total antioxidant capacity for phosphomolybdenum and 2,2-Azino-bis(3-ethylbenzothiazoline-6-sulfonic acid (ABTS) assays. The various extracts contained terpenoid, saponin, phlobatannin, cardiac glycosides, tannin and phenolic at varying concentrations. FT-IR results confirmed the presence of phenols, carboxylic acid, ketones, ethers and aromatics. The concentration of total phenols showed the highest in water extract followed by ethanol and methanol. Water extract showed the highest antioxidant activity measured by different assays such as phosphomolybdenum (2.06 mg ascorbic acid equivalent) and ABTS (98.38%) followed by methanol and ethanol. These results shows that *S. coriifolium* algae exhibit significant secondary metabolites and antioxidant activity, a property that could lead to their application in one of many useful for pharmacological as well as in functional food application.

BIOPROSPECTING BACTERIAOF THE SAINT MARTIN'S ISLAND TO CONTROL MOTILE AEROMONAS SPETICAEMIA AND STREPTOCOCCOSIS IN FISH

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The present study was conducted to isolate and identify bioprospecting microbes from soil and sponge inhibiting fish and shrimp pathogen(s) and find out their potentials as biocontrol agents against motile *Aeromonas*-septicaemia and streptococcosis in fish. Bacteria were isolated from marine sediment and sponge of Saint Martin's Island. Bacteria were isolated on Starch Casein Agar and Marine Agar. A total of 50 bacterial isolates were randomly selected and phenotypically identified based on their colony, morphological, physiological and biochemical characteristics. *In vitro* antimicrobial activity of the isolates were screened through agar well diffusion method, of which six soil isolates and three sponge isolates exhibited inhibitory effects against fish pathogens *Aeromonas veronii*, *Enterococcus faecalis*, *Pseudomonas fluorescens* and *Stenotrophomonas maltophilia*. Most of the isolates inhibited the *A. veronii* B55 and 19, *S. maltophilia* RhG4, and *E. faecalis* FF11. Two isolates CD223 and WS1A were selected as for *in vivo* experiment. A group of 20 *Labeo rohita* fingerlings was fed the strain WS1A mixed with commercial feed for 90 days. A control group fish were fed normal feed. After that, five fish from each group were intramuscularly injected with a virulent strain *A. veronii* B55 (107 cfu/ml) and observed for 7 days. In this study, all of the probiotic-treated fish survived with the expression of any disease symptom whereas, all of the control group fish died with prominent disease symptoms. A group of *Oreochromis niloticus* fingerlings was artificially infected with *E. faecalis* F1B1 and FF11 and then different groups of fish were fed the methanolic extract of extracellular products (ECP) of strain CD223 at the rate of 2.86, 5.71 and 11.43 mg/kg fish/day. In this study, the highest survival rate of 100% was obtained in fish fed the ECP at a rate of 5.71mg/kg fish/day. Survival of control group fish was only 30%. In case of a prophylactic assay, *O. niloticus* were fed the methanolic extract of ECP of strain CD223 at the rate of 5.71mg/kg fish/day for 14 days. After that, artificial infection was done with *E. faecalis* strains F1B1 and FF11 by the immersion method. Survival of the ECP treated fish that were challenged with *E. faecalis* F1B1 and FF11 were obtained 100 and 90%, respectively. Whereas, only 20% fish survived in the control group. Based on the 16S rRNA gene sequence analysis, the strains WS1A and CD223 were identified as *Bacillus subtilis* and *B. haynesii*, respectively.

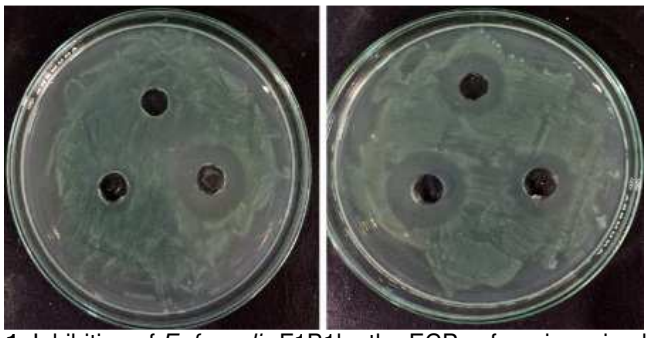

Fig. 1. Inhibition of *E. faecalis* F1B1by the ECPs of marine microbes.

ADVANCEMENT IN SOFT SHELL MUD CRAB FARMING IN BANGLADESH: A FOOTPRINT TOWARDS EXPLORING BLUE ECONOMY

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Soft shell crab farming is a newly growing aquaculture industry around the world. In Bangladesh, farmers are practicing soft shell crab farming in traditional ways. Over the last three years, a series of experiments were conducted in both laboratory conditions and field level to improve the existing culture practice using *Scylla* sp. by focusing on the two major area; (1) development of an artificial feed for soft shell mud crab and (2) chelipeds removal. We developed an artificial feed for crab culture by adding different level of natural and artificial attractants. Evaluation of growth and molting performances revealed that though trash fish performed better than most of the feeds but diets containing Nappi, semi-fermented squid paste, and glycine added formulated feed performed in the same level as trash feed. Crabs diet formulated with nappi+glycine outperformed in average weight gain (65.15±12.5 g), total yield (1954.6 g) and molting duration (36 days) than trash fish. As chelipeds are the major organ responsible for cannibalistic behavior of crab and limits the soft shell crab farming; declawing through autotomy significantly reduced the molting duration (29.88 ± 6.59 days for both claws and 26.367±5.729 days for all legs ablation) and increased yield (2876g in both claw ablation and 3141.5g in all legs ablations) than the control (40.28±7.21 days and 2052g respectively). Aurotomy also allows simultaneous culture of two or more crabs within a box that can improve the profitability of soft shell crab farming and would help the long term sustenance of soft shell crab business.

VERTICAL VARIATION AND RISK ASSESSMENT OF HEAVY METALS IN THE SEDIMENTS OF SHIP BREAKING AREA, BANGLADESH

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Heavy metals (Zn, Pb, Cu, Cr, Ni, Mn) concentration were measured in sediment of three layers (at the depth of 0-10 cm, 10-20 cm, and 20-30 cm) to determine the vertical variation and risk assessment in the sediments of Ship Breaking Area, Bangladesh. The study areas were separated into Ship Breaking site and control site for comparative analysis. The mean concentration of heavy metals (µg/g) in affected sites at the depth of 0-10 cm were Zn-104.24, Cu-61.86, Pb-101.30, Cr-39.40, Ni-39.95, Mn-658.80, at the depth of 10-20 cm were Zn-138.53, Cu-63.64, Pd-111.43, Cr-38.47, Ni-37.27, Mn-649.28 and at the depth of 20-30 cm Zn-55.54, Cu-45.26,Pb-15.79, Cr- 34.52, Ni-36.27, Mn-630.20. The PLI values for all study sites are less than 1 except S2, S1 and at S4 (PLI >1), which is considered to be polluted. The result demonstrated that the concentration of Pb, Zn, and Cu were higher than average shale values. The I_{geo} and E^i_r values showed that the affected areas are low in ecological risk except Pb, and CF values suggested that affected sites are moderately contaminated with Zn, Cu, and Cr and very high contaminated with Pb and all of these were present between the depth of 0-10 cm and 10-20 cm. Commercial ship breaking activities has been started since 1974, so the heavy metals settled down gradually on sediments at different layers. There are no previous studies found on the vertical distribution of heavy metals in Bangladesh coast.

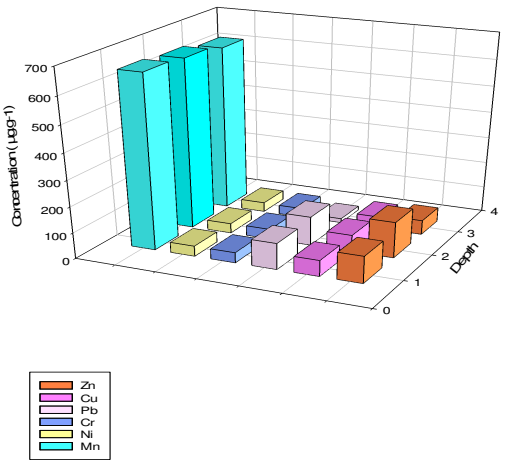

Fig. 1. Vertical variation of heavy metals of three layers of sediment of ship-yard in Bangladesh.

CONTRIBUTION OF MARINE BOTANICAL RESOURCES FOR ENHANCING BLUE ECONOMY OF BANGLADESH

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Bangladesh embarks on ocean-based blue economy to steer its economic growth. There are many sectors both living and non-living resources which are contributing to the blue economy either directly or indirectly. The potential of marine plant species has attracted less attention but holds untapped potential for blue growth in Bangladesh. This study was conducted to assess the potential of marine botanical resources (e.g. mangrove, seaweeds, salt marshes and sea grass ecosystem) as the drivers of blue growth in Bangladesh. Secondary information was collected and thematic analysis has done as the methodological approach. The findings suggest these resources sectors are providing a number of ecological and economic services such as food, tourism, fishing, livelihood, protection, medicine, shelter, and carbon sequestration as potential contribution of blue growth. However, these ecosystems face different threats and stressors such as degradation that may hamper their capacity to deliver the services. Considering their greater role in enhancing blue economy application of sustainable management approach should be a priority. Finally this study submits for ecosystem based management to ensure better economic outcome and balanced ecological condition of these ecosystems.

STUDY ON MARINE SHRIMP SPECIES OF BANGLADESH THROUGH EXPEDITIONS OF THE RESREACH VESSEL, MEEN SANDHANI

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In Bangladesh, shrimp plays a significant role in economy because of its context of foreign exchange earnings. About 36 species of shrimp are known to be found in marine water of Bangladesh. However, this number is controversial since no decisive study was conducted on the diversity of marine shrimp species in the EEZ of Bangladesh. A study is being conducted with collaboration between Department of Fisheries and Sher-e-Bangla Agricultural University, Dhaka where the shrimp samples are being collected from 2018 through the regular voyages of research vessel, RV. Meen Sandhani. Collected specimens have been analyzed by morphological study and DNA barcoding by sequencing of mtDNA COI gene or 16S rRNA gene fragments for accurate identification. Until now 20 marine shrimp species were identified which are *Metapenaeus tenuipes, Metapenaeus brevicornis, Metapenaeus lysianassa, Metapenaeus dobsoni, Metapenaeus monoceros, Parapenaeopsis uncta, Parapenaeopsis coromandelica, Parapenaeopsis hungerfordi, Parapenaeopsis sculptilis, Nematopalaemon tenuipes, Solenocera melantho, Solenocera crassicornis, Exhippolysmataen sirostris, Macrobrachium rosenbergii, Macrobrachium lamarrei, Macrobrachium mirabile, Penaeus monodon, Penaeus indicus ,Exopalaemonstyliferus* and *Alpheus sp.* In the morphological study, various morphological characteristics were assessed including shape and color of the body, total length (TL), standard length (SL), body length (BL), abdominal length (AL), carapace length (CL), carapace width (CW), uropode length (UL), second pereopod length, rostral length (RL) etc. The shape, color and number of teeth of the rostrum were considered as the most important identifying characters. Hope the study will demonstrate the diversity and make a conclusive inventory of marine shrimp species in the marine water of Bangladesh.

SINGLE CELL PARTICLES OF RED ALGA AS NOBEL FEED INGREDIENT FOR CULTURING SEA CUCUMBER IN RECIRCULATING AQUACULTURE SYSTEM

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Marine macroalgae have been reported as a potential substitute protein source for aquaculture. These received progressively consideration as an ingredient of fish feed. Among them red alga, *Pyropia yezoensis* (Nori) is one of the important candidates. The cell wall of the alga is composed of three kinds of polysaccharides that is not easily digested by aquatic organism. Enzyme treated single cell particles has shown a positive promise to use as a new dietary feed ingredient for aquatic organisms. Sea cucumber has great potential as an aquaculture species in South-East and East Asia because of its nutritional and medicinal value. With great demand in the Asian markets, makes it valuable species for aquaculture and therefore it is necessary to increase production through intensive aquaculture system. Therefore, a study was designed to assess the enzyme treated single cell particles of red alga as dietary ingredients for culturing the sea cucumber in Recirculating Aquaculture System (RAS). The results of the experiment showed that sea cucumbers fed the algal diets increased gradually compared to the non-algal diet. The highest growth was observed in the higher inclusion level of single cell algal particles. Total weight gain, mean weight gain and net yield were significantly higher in the algal diet ($P<0.05$). Though the specific growth rate (%) was not different between the treatments ($P>0.05$) however, feed conversion efficiency (FCE) was also higher in the higher inclusion rate compared to control ($P<0.05$). Biochemical analysis of the body muscle showed that the highest gain of protein (%) was observed in the high percentage of algal diet and significantly different. Highest protein efficiency ratio (PER) was also observed in the red algal diet and lowest was found in the control. There were no mortality and evisceration was observed during the experiment. Enzyme treatment breakdown the cell walls and make it single cells. Improved growth was observed due to the improved digestibility by cell wall degradation. Results of the experiment suggest that single cell particles of red alga is a Nobel dietary ingredient and could be used in the formulated diet of sea cucumber as a cheaper source of ingredients for commercial aquaculture.

Sea cucumber

Red alga

Sea cucumber

CULTURE SYSTEM ESTABLISHMENT OF GREEN MUSSEL (*Perna viridis*) IN MOHESKHALI CHANNEL: FOOTPRINT OF A NEW ERA IN AQUACULTURE

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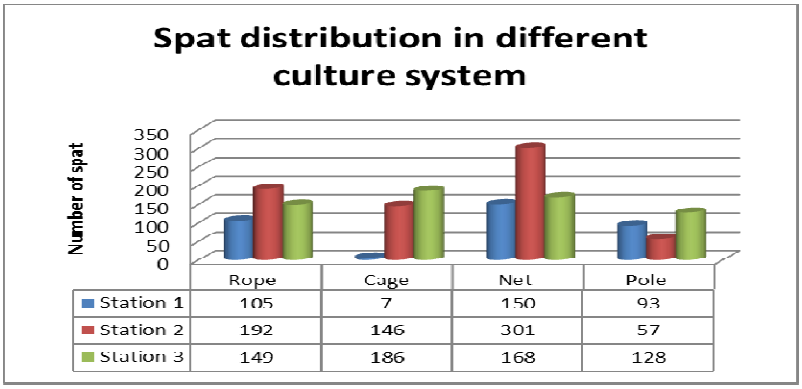
The coastal water of Bangladesh is enriched with diverse variety of fin fishes as well as shellfishes including crustaceans and mollusks. Among the mollusk Green mussel (*Perna viridis)* is known as the warm water mussel species which is distributed widely in the Indo-Pacific regions including the coastal waters of Bay of Bengal. As it is a commercially important species and has demonstrated the potentiality of culture in tropical countries, therefore, analysis on the potentiality of culture techniques is a crying need for ensuring economic benefit and food security. The aim of this research is to depict the feasibility of green mussel culture system in the coastal belt of Cox's Bazar ensuring the ecological and economical sustainability. This study also investigates the establishment of culture systems of green mussel in Moheskhali channel under a pilot project. This study used hanging method in three sites of Moheskhali channel as Caufaldandi, North khuruskul and South khuruskul and four types of substrates were used in this culture establishment process as hanging rope, rope cage, bamboo pole and rope net. This research conducted from October 2017 to September 2018. This study focused on the culture system suitability and feasibility. Research findings showed that rope cage and hanging rope type substrates has high spat settlement. Moheskhali channel is suitable for green mussel culture due to optimal water quality and plankton abundance which revealed in the culture potentiality and feeding biology of *Perna viridis*. For the betterment of potential mollusk fishery in coastal region of Bangladesh there are very much possibility for further research to improve the culture system which will be technically more sound. The establishment of green mussel culture system will provide the supplementary source of income for small-scale fishermen in the vulnerable coastal region which will provide significant contribution to the Blue Economy of Bangladesh.



	Rope	Cage	Net	Pole
Station 1	105	7	150	93
Station 2	192	146	301	57
Station 3	149	186	168	128

EFFECTS OF CHITOSAN COATING ON CHEMICAL, MICROBIOLOGICAL AND SENSORY CHARACTERISTICS OF *Labeo rohita* FILLETS DURING FROZEN STORAGE

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Fish is considered to be more perishable than meat due to its nature. Enzymatic, microbial and chemical reactions are mainly responsible for the loss of freshness and quality of fish. Various food additives and chemicals in the processing industries are being used to improve the quality and shelf life of the product. However, excessive use of chemical additives has proved to be carcinogenic. Therefore, it is important to develop a safe and cost-effective method for the preservation of value added fishery products to meet up the huge consumer demand. Chitosan [b-(1, 4)-2-amino-2-deoxy-D-glucopyranose], which is mainly made from crustacean shells, is the second most abundant natural polymer in nature after cellulose. Due to its antibacterial and anti-oxidative activity, film-forming property, biocompatibility and biodegradability, chitosan has attracted much attention as a natural food additive. The present study was conducted to investigate the effects of chitosan coating on chemical, microbiological and sensory characteristics of *Labeo rohita* fillets during frozen storage. Fish fillets were obtained from fresh *L. rohita* using sterilized knives and cutting boards. Two fillets were obtained from each fish after removing the head and bone. Fish were filleted and dipped for ten minutes into different treatments: distilled water (control); 0.5% chitosan solution (0.5% CH); 1% chitosan solution (1% CH); and 2% chitosan solution (2% CH). Treated and untreated fillets were then stored at -4 ± 1 °C for 14 weeks. The chemical (proximate composition, pH, thiobarbituric acid reactive substances (TBARS), total volatile basic-nitrogen (TVB-N)), microbiological and sensory characteristics of all the fillets were analyzed periodically.

The results of this study showed that there was no significant (p>0.05) variation observed in crude protein, crude lipid and ash content among the treatments on dry matter basis. However, significant (p<0.05) variation was observed in moisture content during the storage period. The initial pH of fresh *L. rohita* fillet was 6.56. The pH values were decreased initially within 2 weeks then it was gradually increased during frozen storage time and the values were comparatively lower in CH treated fillets. The TBARS values of *L. rohita* fillets were increased significantly ($P < 0.05$) with the increasing of storage period. The increment of TBARS value was comparatively higher in untreated (control) fillets than that of treated fillets. Similarly, TVB-N values were increased significantly ($p< 0.05$) during the storage period. The total viable count of bacteria in CH treated fillets were comparatively lower and values were within acceptable limit (7 log CFU/g). Sensory evaluation results also revealed that fillets coated with 1% CH and 2% CH were acceptable (score above 4.0) during the storage period. Results of this study indicate that chitosan coating extended the shelf life and quality of *L. rohita* fillets during frozen storage. Considering the cost and solubility of CH, it is suggested to use 1% CH for the enhancement of shelf life and quality of frozen *L. rohita* fillets.

NOVEL APPROACH FOR DEVELOPMENT OF HIGH QUALITY STABILIZED MINCE FROM TILAPIA *(Oreochromis niloticus*) AND PANGAS (*Pangasianodon hypophthalmus*) TO FORMULATE SECONDARY CONSUMER PRODUCTS

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To develop stabilized fish mince it is very important to prevent the oxidation during storage. To avoid the negative effect of synthetic antioxidant, antioxidants from natural sources were searched. For this reason, carotenoid from carrot was extracted. Carrot slices were kept in frozen storage at -18 ºC and heat treated by blanching at 100 ºC boiling water for 1 min for better release of carotenoids bound by protein and for reduction of water from carrot. To reduce maximum water content, carrot slices were treated with double volume of 2-propanol at refrigeration temperature for 12 hours. About 60% water was removed by this treatment. Carrot slices were heated with four volume of 2-propanol at 60ºC temperature for four hours for extraction of carotene from carrot. Extracted solution was evaporated to obtain carotenoid concentrate. Carotene content was found to be 1.5 ml/100g of carrot. The content of beta-carotene in the petroleum-ether and carotenoid extract solution was determined spectrophotometrically. The absorbency was measured at the wavelength of 450nm using the spectrophotometer. The concentration of beta carotene was found 0.665 g/100ml. This carotenoid concentrate will be used in unwashed whole fish mince of pangas to find out the anti-oxidative effect of carotene and to stabilize the whole fish mince during storage.

PRODUCTION, CHEMICAL PROPERTIES AND SHELF LIFE STUDY OF STABLE FROZEN ILISH CUBE FROM INDIAN RIVER SHAD HILSA (*Tenualosa ilisha*)

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Hilsa (*Tenualosa ilisha*) is a high-lipid, popular food fish species that enjoys high consumer preference. The lipid in fish readily goes into aerial oxidation and becomes unstable at room temperature. In a new formulation of ilish cube from hilsa fish, a balance was made in the ingredients and additives for stabilizing lipids in the products. Stabilized cube of standard size (2.0 cm^3 cube, 12g weight), having similar to ilish taste and flavour was made from ilish mince and frozen in the dice at -28^oC for 24 h. Frozen cubes were wrapped by aluminum foil and kept stored at -20^oC for 6-8 months for bio-chemical analysis and shelf life study.

Moisture content (% wet weight) dropped from 65.26% in fresh hilsa to 49.37% in ilish cube. Crude lipid, protein and fiber contents in ilish cube were 16.80%), 22.71% and 10.05%, respectively which were higher than fresh hilsa. TVB-N value was increased progressively throughout the storage period at freezing temperature. TBA and peroxide values, representing the degree of rancidity in the products, were in the acceptable range. Frozen storage did not impart any undesirable rancid taint to the ilish cube.

A 9-person trained panelist group monitored the product in every month for a total period of 8 months using a 5-point hedonic scales for taste, flavor, color, consistency and solubility as attributes. All the sensory attributes were slightly decreased with the progress of storage period but it was within the acceptable limit (p<0.05), indicating that polyunsaturated fatty acids in hilsa cubes were effectively stabilized by the processing methods and the products were safe for human consumption up to at least 6 months.

PRODUCTION AND QUALITY ASSESSMENT OF FISH POWDER FROM *PANGAS (Pangasius hypophthalmus)* FISH USED IN PANGAS SOUP

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Pangas is a relatively fast-growing fish species that has great potential for production and export in Bangladesh. With the aim of supplying ready-to-cook pangas products, like soup or noodles for all classes of consumers, pangas powder was formulated. For pangas powder formulation after necessary treatments, fish was dried and packaged in polythene pouch to store at room temperature. To compare the qualities of pangas soup, two basic powder products, powder from naked pangas fillet and powder from pangas fillet with skin were prepared. A small pack 2.0 g pangas powder was used to prepare 1-serving size of soup (250ml) using two types of powders. In case of both naked pangas fillet and pangas fillet with skin powder, crude protein, lipid, ash and fiber contents were determined. All the proximate composition values were increased in the powder products when compared with fresh fish. Peroxide value in powder from naked pangas fillet (28^0C) at '0' month was 2.80±0.10 mEq./kg of oil that reached to 10.30±0.26mEq./kg of oil after 6th month of storage. In case of pangas powder from fillet with skin (28^0C) it was however, 3.20±0.20 mEq./kg of oil at '0' month that reached to 9.40±0.46 mEq./kg of oil after 6th month of storage. The TVB-N value of powder from pangas fillet at '0' month was 1.28±0.06 mg/100gm and reached to 12.48±0.26 mg/100g after 6th month of storage, while in pangas powder from fillet with skin, it was 1.10±0.04 mg/100gm at '0' month that reached to 10.97±0.21 mg/100g after 6th month of storage. TMA-N value in pangas powder from fillet at '0' month was 0.85±0.01 mg/100g and reached to 3.79±0.01 mg/100g after 6th month of storage. On the other hand, in powder from pangus fillet with skin it was ranged from 0.75±0.01 mg/100g at '0' month to 3.04±0.01 mg/100g after 6th month of storage period. Peroxide, TVB-N and TMA-N values increased progressively throughout the storage period in both the powders. All the sensory attributes were slightly decreased with the progress of storage period but it was within the acceptable limit. Pangas soup prepared from pangas fillet powder were more acceptable by the panelists compared to those prepared from pangas fillet with skin powder.

PRODUCTION, BIO-CHEMICAL QUALITY AND SHELF LIFE STUDY OF NEWLY DEVELOPED "ILISH KHICHURI" FROM INDIAN RIVER SHAD ILISH (*Tenualosa ilisha*)

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Ilish, *Tenualosa ilisha* (Hamilton, 1822), is a tasty and beneficial fish. The poly-unsaturated fatty acids of ilish, mostly ω-3 fatty acids, reduce the risks of heart disease in human body. However, branched muscular pin bones restrict it from being eaten by a wide variety of consumers like children and modern young, old and disabled or foreigners, who also love tasty ilish. In the new formulations of 'ilish khichuri' a balance was made in the ingredients by treatments and additives for stabilizing lipids and proteins. Frozen-stored stock of standard size (1.0 cm^3, 8 g), having similar to ilish tastes and flavours was made from ilish mince. With this frozen ilish stock a 1–serving size of "Ilish khichuri" (250g) was cooked. Before that the stocks were frozen at -40°C for a day and then stored at -20°C for shelf life and quality analysis. A standard recipe for ilish khichuri was developed. The developed stock and cooked khichuri were tasted by a 5 member trained panel in every month using a 5-point hedonic scale of taste, flavor, color, consistency and solubility as attributes. Protein, lipid, ash and fiber contents were found higher in "ilish stock" than fresh ilish fish. Peroxide, TVB-N, TMA-N, TBA and histamine content were found increasing in the stock as the storage time increases but all the studied chemical parameters were within the acceptable limit throughout the storage period. A highly tasty, as perceived by the panelists, was developed by cooking khichuri with the ilish stock. Both protein and lipid contents were substantially improved in khichuri. All the sensory attributes were very appealing and acceptable in both the stock and khichuri.

PRODUCTION OF CRISPY FISH PICKLE FROM PANGAS (*Pangasius hypophthalmus)* FISH

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Pangas (*Pangasius hypophthalmus*) catfish is one of the world's fastest growing freshwater species in aquaculture. The fish farmers practicing aquaculture have reported reduced profit margin now a days. However, there is a scope to increase fish consumption by developing different types of innovative value added ready-to-eat or ready-to-cook convenience fish products, demand for which has increased due to social and cultural changes in recent years. Crispy fish pickle from the pangas catfish was developed first time through stabilizing the mince with natural anti-oxidants and then stored at ambient conditions. In order to produce crispy fish pickles, different mixture of ingredients were used and multi-vitiate heating process were applied. Chemical qualities and nutritive values were determined with the stored product. The products were evaluated by 9- member trained panelists group using 5-point hedonic scales for taste, flavor, color and consistency as attributes. Results showed that pangas pickle could be stored up to 6 months without losing its fresh flavour and taste.

VARIATIONS IN CHEMICAL PROPERTIES BETWEEN FRESH INDIAN RIVER SHAD *Tenualosa ilisha* AND ITS NEW PRODUCTS, ILISH CUBE AND ILISH POWDER

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The Indian river shad ilish, *Tenualosa ilisha*, is a very popular high priced tasty fish along the Southeast Asia and Middle-east from Myanmar to Persian Gulf. It is locally called "*Ilish*" in Bangladesh and India. Ilish is a highly fatty fish with huge pin-bones. Recently, two products ilish cube and ilish powder were developed from this valuable fish. The objective of the current study was to compare the chemical properties between fresh ilish and its products: ilish cube and ilish powder. Ilish products were manufactured by stabilizing lipids in the fish, in order to retain original taste of fish, since unsaturated fatty acids in lipids are mainly responsible for unique taste and flavour of fresh fish. Results indicated that chemical properties were not similar in the three samples. Crude protein, lipid and fiber contents were found to be higher in ilish powder than fresh ilish and ilish cube. Only the ash contents were found higher in ilish cube (3.35%) than that of fresh ilish (1.35%) and ilish powder (2.65%). Total lipid in all the three samples were high - ranging from 15.13% to 27.35%, while crude ash contents were 1.35% to 3.35% and fibers were 0.7% to 10.05%. The most abundant fatty acid detected was C14:0 in fresh ilish, ranging from 7.11% to 36.07%. Other major fatty acids detected were C16:0 and C18:1. Saturated fatty acids (SFAs) were found to be higher in ilish cube (55.37%) than fresh ilish (45.38%) and ilish powder (51.4%). Monounsaturated fatty acids (MUFAs) were higher in ilish powder (35.78%) than fresh ilish (35.07%) and ilish cube (32.55%). In case of polyunsaturated fatty acids (PUFAs), fresh ilish contained higher value (19.07%) than ilish powder (12.78%) and ilish cube (12.06%). The amino acids profile study showed the most abundant acid was glutamic acid for all the three samples. Major amino acids were glutamic acid, aspartic acid, lysine, leucine and glycine, the quantity being ranged from 2.56% to 16.56%. Essential amino acids (EAAs) were higher in ilish powder (50.50%) than other two samples and non-essential amino acids (NEAAs) were detected higher in fresh fish (59.94%) compared to powder (49.39%) and cube (52.35). The ratio of omega-3: omega-6 (4.44) and EAAs: NEAAs (1.02) were found higher in ilish powder than other samples, but ratio of P/S was found to be higher in fresh ilish. Vitamin E (7.6×10^6 µg/100g) and K (982.5 µg/100g) were higher in fresh fish, while both cube and powder were higher in vitamin A (1023.1µg/100g) and D (157.3µg/100g) contents, respectively. The levels of DHA, EPA, EAAs, and vitamins in all the three samples explained the usefulness of these products in human health.

SHELF-LIFE EXTENSION OF SLICED PANGUS FISH (*Pangasius hypophthalmus*) BY VACUUM AND MODIFIED ATMOSPHERE PACKAGING STORED AT 4°C

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Vacuum and modified atmosphere packaging is a widely used packaging technique used for displaying chilled fish, meat and their various products in developed countries. In view of this, the quality and shelf-life of sliced pangus fish (*Pangasius hypophthalmus*) was evaluated by biochemical and microbiological analysis under no pack (control), vacuum pack and modified atmosphere packaging with 100%N_2 in 3 days interval during 15 days of refrigerated storage (4°C).

The pH value was in the range of 5.99 to 6.90 during the storage period in all samples. There were no significant (p<0.05) differences in pH values among three packaging conditions almost all storage days except on 6th and 9th day where significantly (p<0.05) lower pH values were observed in vacuum pack sample compared to that of control (no pack). The initial total volatile base nitrogen (TVB-N) value was 2.38 mg/100g in sliced pangus fish, then decreased on 3rd day, and later gradually increased until the end of storage. There were no significant differences (p<0.05) observed on TVB-N values among three packaging conditions at each storage days. The initial peroxide value (PV) was 0.85 mEq/Kg fish oil in sliced pangus fish and then fluctuated throughout the storage period. The pH, TVB-N and PV values of the samples under all packaging conditions were within the acceptable limit during the storage period. The initial total viable count (TVC) of sliced pangus fish was 4.32 log CFU/g, indicated an acceptable initial quality of fish. The TVC gradually increased with increasing the time in all packaging conditions. There were no significant (p<0.05) differences in TVC values among three packaging conditions until 6th day of storage. However, significantly (p<0.05) lower TVC values were observed in vacuum pack sample on 9th day of storage compared to that of no pack and N_2 pack samples. The TVC values exceeded the 7 log CFU/g, which is considered as the upper acceptable limit for fresh and frozen fish on approximately 7th day for no pack and N_2 pack sample, 10th day of storage for vacuum pack sample. Total coliforms and fecal coliforms counts were within the acceptable limit in all packaging condition during the storage period. Considering the bacterial counts, the shelf-life was determined at approximately 7 days for no pack and nitrogen pack sample and 10 days for vacuum pack sample.

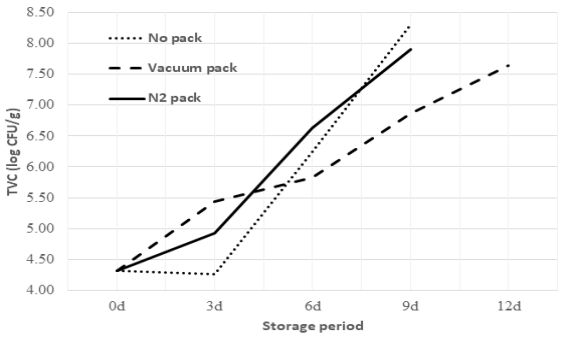

Fig. TVC of Pangus fish under vacuum and MAP condition at refrigerated storage

EVALUATION OF CONSUMER'S PREFERENCE AND ACCEPTABILITY OF FRESH FISH AND ITS PACKAGING IN THE SUPER-STORES OF DHAKA CITY

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The proper packaging can reduce the qualitative and quantitative losses of dry fishes during storage and distribution. In light of this, consumer's acceptability and willingness to buy the fresh and packaged raw fish in the super-stores of Dhaka city was investigated by survey method utilizing structured questionnaire. Total 290 shoppers/consumers, selected purposively based on the availability during the face-to-face interview from different outlets of four retail superstores in Dhaka city (Shwapno, Meena baazar, Prince Bazar, Nandan etc.) were surveyed in January 2018.

In the superstores, 59% consumers were male and 63% have small family size (up to 4 members). Most of the consumers (83%) were highly educated having bachelor degree and half of the consumers involved in mid to higher class job. Consumers purchase 40 different fish species in those superstores and 75% consumers prefer marine fishes. Among the consumers, 43% purchase iced fishes, and 35% purchase fresh & iced fishes. Around 71 % consumers purchase fishes weekly and 53% spend 1001-5000 BDT monthly. Around 58% and 38% consumers were satisfied and moderately satisfied, respectively on purchasing fishes in the superstores. However, 57% and 39% were satisfied and moderately satisfied, respectively on the overall quality of the fishes in the superstores. Most of the consumers (85%) preferred to buy larger fish as whole instead of cut portions. Around 58% consumers would prefer to buy packaged sliced of larger fish under refrigeration storage and rest not. In case of packaged fishes, around 50% consumers would prefer on 500 or 1000g pack. In addition, 54% consumers agreed to pay 10-15% excess price for getting quality products by proper packaging. Therefore, there is a scope to produce packed slice of larger fish which can be easily sell for a longer period at refrigerated condition in the superstores.

Table: Consumers Preference for fishes and opinions toward quality and packaging

Sl No	Variables	Category	Freq	%
1	Preference of marine fish	Yes	217	74.8
		Moderate	7	2.5
		No	65	22.5
2	Type of fish purchased	Fresh	64	22.2
		Iced	125	43.1
		Frozen	1	0.4
		Fresh+ Iced	100	34.5
3	Buying Interval of fishes	Daily	8	2.8
		Weekly	206	71.2
		Fortnightly	45	15.4
		Monthly	30	10.3
4	Monthly expenditure for fishes	≤1000	8	2.8
		1001-5000	154	53.1
		5001-10000	83	28.5
		>10000	45	15.4
5	Satisfaction on fish purchasing in superstores	Yes	167	57.6
		Moderate	109	37.7
		No	13	4.6
6	Satisfaction on fish quality in superstores	Yes	164	56.6
		Moderate	113	39.1
		No	12	4.2
7	Preference of buying large fish as	Whole fish	246	84.8
		Cut fish	44	15.1
8	Preference on buying slice of larger fish	Yes	168	58.1
		Moderate	21	7.1
		No	101	34.8
9	Preference on buying packed RTC fish	Yes	90	31.0
		Moderate	23	8.1
		No	177	61.0
10	Preferable Pack Size	250	19	6.7
		500	71	24.6
		750	11	3.9
		1000	75	26.0
		2000	15	5.3
		No comment	97	33.4
11	Agrees on 10-15% excess price for packaging	Yes	155	53.5
		No	37	12.7
		No comment	98	33.8

SHELF-LIFE EXTENSION OF DRIED PUNTI (*Puntius* sp.) UNDER VACUUM AND MODIFIED ATMOSPHERE PACKAGING

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The quality and shelf life of a dried small fish Punti (*Puntius* sp.) was evaluated by the biochemical and microbiological analysis under no pack (control), aerobic (sealed), vacuum and modified atmosphere packaging (MAP) with 100% N_2 in 15 days interval during 90 days of storage period at room temperature.

In the study, around 12% salt was observed in dried punti fish at dry matter basis which has a significant preservative effect. The initial moisture content was 14.43% in dried punti fish and then gradually increased around 1% up to 45th day of storage and then remained steady with some fluctuations, which was within the acceptable limit in all packaging conditions during the storage period. The initial TVB-N value was 2.8 mg/100g in dried punti fish. Overall low increasing trends of TVB-N values was observed in vacuum pack samples compared to others during the whole storage period. However, the TVB-N values of dried punti were within the acceptable limit during the storage period in all packaging conditions. The initial peroxide value (PV) was 2.08 mEq/Kg fish oil. PV value remained almost steady during the storage period in vacuum and nitrogen pack samples. Significantly ($p<0.05$) lower PV was observed in all packaged samples compared to that of control samples during the storage period which was also within the acceptable limit. The initial total plate count (TPC) of dried punti fish was 4.44 log CFU/g. The TPC gradually increased under all packaging conditions throughout the storage period. Comparatively lower TPC were observed in vacuum and MAP samples compared to that of air and unpack sample throughout the storage period. The TPC exceed the 5 log CFU/g in unpack and air pack sample on approximately 10th day and nitrogen pack on 35th day and vacuum pack on 45th day of storage, which is considered as the upper acceptability limit for dried fishes. There was no fungal growth observed in all types of samples during the storage period. The total coliforms and fecal coliforms were within the acceptable limit under all packaging condition during the storage period. Based on the bacterial count, the shelf-life was determined at approximately 10 days for unpack and air pack sample, 35 days for nitrogen pack sample and 45 days for vacuum pack sample. Therefore, vacuum pack is a better option to increase the shelf life of dried fishes, which could be useful for the dried fish traders in Bangladesh.

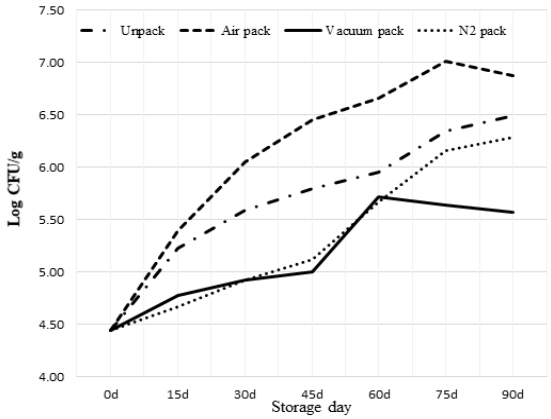

Fig. : TPC (log CFU/g) of dried Puti fish under different packaging condition

EFFECTS OF DIFFERENT TYPES AND CONCENTRATIONS OF LOW-COST BINDER ON GELLING ABILITY OF FISH BALL FROM LOCALLY AVAILABLE FISH IN PATUAKHALI

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The study was conducted to investigate the effect of different types (wheat, rice, corn, potato and starch) and concentrations (0. 5, 10, 15, 20 and 25%) of low-cost binders on the gelling ability of fish ball from locally available fish (Pama, Tuna, Rita and Tulardandi) in Patuakhali. Textural quality was determined in terms of Softness/Firmness (S/F), Chewiness/Rubburiness (C/R), Folding test (FT) and color by trained 10 panelist using sensory methods. Proximate composition of selected fish, binder and its concentration were determined by standard AOAC method and bacteriological study was carried out according to the Aerobic Plate Count (APC) method. Based on S/F, C/R, FT and color results, Pama fish ball had better textural quality than other fish ball. Among five binder, wheat binder used fish ball from selected fish (Pama) had better textural quality than other binder used. Further, fish ball were prepared from Pama fish using six concentration of selected wheat binder where 25% concentration of wheat binder had better textural quality than other concentration used. Significant different in bacterial load was observed between fish and resulted fish ball. In any dilution (10^{-3} to 10^{-7}), higher bacterial load was obtained in the fish ball sample than raw fish sample. Higher moisture, protein and lipid content was 82.66%, 15.4%, 3.00% in fish than fish ball sample 70.27%, 14.6%, 1.75%, respectively. Ash content was higher (1.76%) in fish ball than fish sample (0.87%). Therefore, maximum utilization of low-cost fish, and better textural and sensory quality of fish ball could be obtained from Pama fish. Wheat powder at 25% concentration could be used as low-cost binder for preparation of value-added fishery products.

UC DAVIS CHIMNEY DRYER: A LOW-COST IMPROVED TECHNOLOGY FOR QUALITY DRIED FISH (*Harpadon nehereus*)

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Fish drying is a traditional method of fish preservation that provides cheap dietary sources of animal protein in Bangladesh. However, traditional method produces low-quality dried fish due to different problems associated in it. The aim of the present study was to produce improved quality dried fish using UC Davis chimney solar dryer. The study also compared the changes of sensory, microbial and biochemical quality of Bombay duck (*Harpadon nehereus*) dried fish produced from improved method vs. collected samples produced by traditional method. The sensory quality of dried fish was evaluated by quality index method, microbial examination was performed according to standard plate count method and AOAC method was followed for evaluation of bio-chemical composition. The results indicated excellent and highly acceptable organoleptic characteristics of dried fish produced from improved method. The result of APC, TEC, TViC and TSC count of improved dried fish was 4.32×10^4 CFU/g, 4.8×10^5 CFU/g, 1.3×10^2 CFU/g and 0 CFU/g respectively (all values were within the permissible limit), comparing with the count in traditionally produced dried fish samples found to be 7.72×10^7 CFU/g, 2.6×10^2 CFU/g, 3.9×10^5 CFU/g and 5.0×10^4 CFU/g, respectively (all values exceeded the permissible limit). The protein, lipid, ash and moisture content of improved dried fish was 48.98%, 6%, 20.95% and 23.97%, respectively while the traditional dried fish was 44.46%, 5.86%, 21.29% and 28.29%, respectively. The TVB-N content of improved and traditional dried fish was at 0.040 mgN/100g and 0.135 mgN/100g in sterile packed and 0.162 mgN/100g and 0.149 mgN/100g in polyethylene packed respectively. The above results confirm that UC Davis chimney dryer produced better quality dried fish compared to traditional one both in initial and storage time, while shelf life of both dried fish was extended under sterile packed conditions.

COMPARATIVE STUDY OF BACTERIAL LOAD AND ORGANOLEPTIC QUALITY CHANGES BETWEEN LEAN FISH AND FATTY FISH IN FRESH, ICED AND NON-ICED STATE UNDER LABORATORY CONDITION

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The present study was conducted on the bacterial load and organoleptic quality changes between lean fish (*Oreochromis niloticus*) and fatty fish (*Pangasius hypophthalmus*) in fresh, iced and non-iced state under laboratory condition during January/2017 to June/2017. For the investigation of bacterial load and organoleptic quality changes of fish, Kazir bazar fish market of Sylhet Sadar Upazila was selected. The study concentrated on the organoleptic quality changes and Total Viable Count (TVC). The highest bacterial load was observed in non-iced pangas at 8 hours interval in the month of May and the lowest bacterial load was in iced tilapia at 6 hours interval in the month of April. The highest mean bacterial load in non-iced tilapia at 8 hours interval was 5.75±0.05 log cfu/g and the lowest mean bacterial load in iced tilapia at 6 hours interval was 5.25±0.07 log cfu/g. The study reveals that the bacterial load in both tilapia and pangas in fresh, iced and non-iced state complies with ICMSF standard. The observed results were both statistically significant ($P<0.05$) and insignificant ($P<0.05$) for both types of species, state of fish and preservation time (hours).The highest bacterial load was observed at the highest temperature (35^0C) in the month of May and the lowest bacterial load was found at the lowest temperature (24^0C) in the month of April. It reveals that the growth of bacterial load depends on the temperature.

EFFECTS OF VACUUM AND MODIFIED ATMOSPHERE PACKAGING ON SHELF-LIFE OF TILAPIA FISH (*OREOCHROMIS NILOTICUS* L.) AT REFRIGERATED STORAGE

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Quality and shelf-life of sliced tilapia fish (*Oreochromis niloticus*.) was evaluated by biochemical and microbiological analysis under no pack (control), vacuum pack and modified atmosphere packaging with 50% CO_2 & 50% N_2 and 50% CO_2 & 50% O_2 in3 days interval during 18 days of refrigerated storage (4°C).

The pH value was in the range of 6.18 to 7.39 during the storage period in all samples. There were no significant (p<0.05) differences in pH values among four packaging conditions until 6thday of storage. However, significantly (p<0.05) lower pH values were observed in all samples on 9th and 12th day of storage compared to that of control (no pack) sample. The initial total volatile base nitrogen (TVB-N) value was 1.68 mg/100g in sliced tilapia fish and then gradually increased with time and highest value was observed7.56 on 12th day in control sample. However, there were no significant differences (p<0.05) observed on TVB-N values among all packaging conditions at each storage days. The initial peroxide value (PV) was 1.07 mEq/Kg fish oil in sliced tilapia fish and then fluctuated between 0.40 and 8.05 during the storage period. The initial Thiobarbituric acid reactive substances (TBARS) value was 0.26 mg/100mg malonaldehyde/kg in sliced tilapia fish and then gradually slowly increased until 9th day of storage in all packaging condition and then decreased on 12th day of storage in all packaging except control sample. However, significantly (p<0.05) lower TBARS value was observed in all samples on 12th day of storage compared to that of control sample. The pH, TVB-N, PV and TBARS values of the samples under all packaging conditions were within the acceptable limit during the storage period. The initial total viable count (TVC) of sliced tilapia fish was 4.17log CFU/g, indicated an acceptable initial quality of fish. The TVC gradually increased with increasing the storage period in all packaging conditions. However, significantly (p<0.05) lower TVC were observed on 6th, 9th, 12th day of storage in all packaged samples compared to that of control sample. The TVC values exceeded the 7 log CFU/g, which is considered as the upper acceptable limit for fresh and frozen fish on approximately 8th for no pack, 11th for vacuum, 12th for MAP-2 and 15th day of storage for MAP-1 sample. Considering the bacterial counts, the shelf-life was determined at approximately 8 days for no pack, 11 days for vacuum pack, 12 days for MAP-2 and 15 days for MAP-1 sample. Therefore, the MAP-1(50% CO_2& 50% N_2)is the best packaging to increase the shelf-life of fresh fishes, which can be utilized by the superstores to display their products with extended shelf-life. **Acknowlegement:**This study is supported by a grant of BARC, NATP-2.

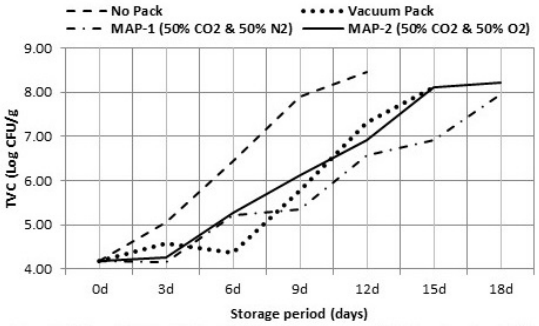

Fig. : TVC (log CFU/g) of sliced tilapia under vacuum and MAP packaging at 4°C

DOES THE MARINATION REDUCE THE MICROBIAL LOAD IN FRESHWATER FISH AND SHELLFISH?

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Marination of fish is done by mixing of spices with fish to tenderize or to change taste, texture and structural properties of fish resulting in a product with characteristic flavor. The present study was conducted during October, 2017 to July, 2018 to investigate the marination with turmeric, chili, ginger and garlic can reduce microbial density in different freshwater fish and shellfish and to identify those groups of marinades or spices which have the best reducing ability. The samples were collected from three different markets of Noakhali of Bangladesh. The whole experiment was divided into five treatments-T_1 was without marinades; in T_2 turmeric and chili were used as marinades which was divided into two different treatment depending on the refrigeration time i.e. T_2 (30 min) and T_2(1 hr) and in T_3 ginger and garlic were used as marinades and divided into two different treatment-T_3 (30 min) and T_3(1 hr). The total bacterial count (TBC) of *Oreochromis mossambicus, Anabas testudineus*, *Channa punctatus* and *Macrobrachium rosenbergii* in T_1 was 5.5×10^7, 4.5×10^8, 4.9×10^8 and 5.1×10^7 cfu/g. But in T_2 (30 min) and T_2 (1 hr) treatment, the TBC of *O. mossambicus, A. testudineus, C. punctatus* and *M. rosenbergii* was comparatively lower than T_1. And in T_3 (1 hr) treatment, The TBC of experimental fish and shellfish samples was the lowest among five different treatment [T_1, T_2 (30 min), T_2(1 hr), T_3(30 min) and T_3(1 hr)]. The microbiological analysis showed that natural compounds from the pest of turmeric, chili, ginger and garlic reduced microbial density in marinated fishes stored at 4^0 C for 30 min and 1 hr than non-marinated fishes and between these two groups of marinades the garlic and ginger paste showed the best result. The aims of this research were to show how easily, chiefly and effectively we can reduce microbial density in food. If we can take some effective governmental and non-governmental initiatives to spread this knowledge among our people, we can protect large number of life from food borne bacterial diseases. Besides, peoples of overseas countries who used to eat raw fish can follow this technique to protect food from bacterial contamination. T_1- without marinades; T_2 (30 min)- with turmeric and chili (refrigerated for 30 min); T_2(1 hr) -with turmeric and chili (1 hr); T_3(30 min)- with ginger and garlic (refrigerated for 30 min); T_3(1 hr) - with ginger and garlic (1 hr).

AN EXPERIMENT TO PRODUCE SAFE AND QUALITY DRY FISH BY THE GREEN HOUSE MECHANICAL DRYER

Syed M Istiak and Md. Ismail

This experiment deals with the design, construction and performance evaluation of Sunlight based Green House Mechanical Dryer. This experiment was conducted in Cox's Bazar in 2016. There were three marine fish species had used to produce dry fish. A three no 16 feet long, 6.5 feet width and 7 feet height dryer were constructed to dry 400 kg freshly harvested Bombay (*Harpadon nehereus*, Hamilton, 1822), Ribbon (*Lepturacanthus savala*, Cuvier, 1818) and Croaker (*Johnius macrorhynus,* Mohan,1976) fish per batch. The entire frame of the boxes was covered by transparent celluloid polyethylene and kept a door to enter and exit the product. Installed a 1000 Watt heater, one fan blower in one side and set up an exhaust fan into another side to pass the moist air. The drying temperature and air velocity were controlled by the regulators. At day time sunlight was used to heat the raw fish and at night/ cloudy day/rainy day heater was used to maintain certain heat. The drying air was forced to the house where the product is to be dried. Cleaned and washed 400 kg Bombay duck, 400 kg Ribbon and 400 Kg Croaker were dried simultaneously into three GHMD. Bombay duck and Ribbon were hanging into the house with sting and Croaker was placed into rack. Moisture contents were going down to 65% at day-1, 30 % at day -2 and 15% at day-3 of Bombay duck and Croaker and moisture contents was 65% at day-2, 30 % at day -4 and 15% at day-5 of Ribbon Fish respectively. Raw vs dried fish production ratio was 7:1 kg for Bombay duck, 5:1 kg for Ribbon and 5:1 kg for Croaker. The Organoleptic test was done by Torry Scale and it was 7.5.

QUALITY ASSESSMENT OF SUN-DRIED FISH AND OVEN-DRIED FISH

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The aim of the present study was to assess and compare the nutritional quality of sun dried fishes and oven dried fishes during July 2016 to December 2016. Five fish species (*C. punctatus, M. cavasius, M. pancalus, C. striatus* and *W. attu*) were collected from the Chalan *beel* area and brought to the laboratory of Department of Fisheries of University of Rajshahi. All species were processed and dried by the sun rays and in the oven (105°C). Then the nutritional analyses were done by using standard method. The highest lipid content was found in oven dried *W. attu* (11.32±0.30%) and the lowest was found in sun dried *C. striatus* (5.48±0.70%). The highest protein content was found in oven dried *M. pancalus* (77.12±0.36%) and the lowest was found in sun dried *M. cavasius* (55.38±0.67%). The ash content was varied from 4.34±0.23% (oven dried *M. pancalus*) to 18.43±0.77% (oven dried *M. cavasius*). The highest moisture content was observed in sun dried *C. punctatus* (13.07±0.57%) and the lowest was observed in oven dried *M. cavasius* (6.25±0.24%). Calcium content was varied from 5.34±0.36 mg/100g (sun dried *M. cavasius*) to 29.31±0.47 mg/100g (oven dried *C. punctatus*). Iron content was ranged from 0.82±0.00 mg/100g (sun dried *M. cavasius*) to 2.82±0.04 mg/100g (oven dried *W. attu*). No significant difference was found between the sun and oven dried fishes for proximate composition (lipid, protein, ash and moisture) and mineral content (calcium and iron).

COMPARATIVE SHELF LIFE ASSESSMENT OF HAOR-CAGE AND POND-REARED TILAPIA (*Oreochromis niloticus*) APPLYING APPROPRIATE MULTIVARIATE TECHNIQUES

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The freshness and shelf life of *haor*-cage and pond reared tilapia were assessed applying quality index method (QIM) scheme and shelf life of tilapia of these two different environments was compared. Different rearing environment influenced shelf life of tilapia; while the maximum shelf life, assessed from ice stored fish samples, was found to be 12 days for cage and 15 days for pond reared tilapia. The calculated quality index (QI) evolved linearly with storage time on ice (QI_{cage} = 3.1125x – 4.0214, R^2 = 0.9851; QI_{pond} = 3.6563x – 4.4653, R^2 = 0.9796). The multivariate canonical discriminant analysis (CDA) was used to classify the new sample as either from *haor*-cage or pond reared tilapia on the basis of their biochemical, microbiological and proximate analyses. The results of CDA showed that the discriminant model predicts the group affiliation perfectly. The principal component analyses (PCA) exhibited distinct separation of cage and pond reared fish samples based on these features also. ANOVA results showed that storage time had significant effect on sensory, biochemical and microbiological parameters of *haor*-cage and pond reared fish. The sensory, biochemical, microbiological and proximate analyses of fish flesh were carried out at every 3 days interval throughout ice storage. The pH and TVBN values showed maximum acceptability of samples for 12 days on *haor*-cage and 15 days on pond reared fish. The microbial and sensory assessment was in support of the biochemical assessment. The study seems to be useful in setting standards and guidelines which could be used by the Fish Inspectors in the enforcement of sensory quality of fish destined for the native and international markets.

PROXIMATE COMPOSITION AND TRADITIONAL METHOD OF CONSUMPTION OF DOG FISH SHARK (S*qualus acanthias*) IN COX'S BAZAR REGION

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The present study was conducted to assess the proximate composition and traditional method of consumption of dog fish shark (*Squalus acanthias*) in Cox's Bazar region of Bangladesh during the period from July 2016 to December 2016. Data relevant to landing, marketing, and utilization of dog shark were collected from randomly selected 10 fishermen, 8 retailers, 20 consumers, 6 fish processors by personal interviewing with a pre-tested well-structured questionnaire. In past, shark capture was considered as a by-catch of hilsa, lakkha and other marine fish species. But from the current study it was found that different kinds of nets and long lines were used to capture the shark species in the Bay of Bengal. The retail price of the fresh fish was 100-150 BDT/kg whereas dried fish was sold 250-300 BDT/kg in the landing center. Moisture, protein, fat, carbohydrate and ash content of the shark was found as 74.29%, 14.51%, 7.02%, 2% and 2% respectively which was analyzed in BCSIR, Dhaka. It was found that the tribal community and some Buddhist communities of Cox's Bazar prepared different product as well as fish curry, curry with egg, bouillon, and fry from the raw dog fish shark and bouillabaisse from dry fish. They used different locally found ingredients in different composition to make these products such as salt, chilly, turmeric, green chili, coriander, onion, garlic, ginger, cumin, mustard oil etc. Among these products the most popular one was bouillabaisse and bouillon which was served with Myanmar noodles. The dog fish shark products were considered as a delicious food item by the tribal people of the area. Following the same methods, same kinds of products were replicated in the FIMS laboratory and a panel test was conducted among 20 panelists with different parameter scoring from 1 to 7. Therefore, the findings of the present study suggested that the dog fish shark can be a very good alternative protein source for the low income family of the country as the price, nutritional quality and availability of the fish is reasonable for them. However, this small shark should be captured in a sustainable manner so that the original fish stock will not be depleted.

PREVALENCE OF MICROBIAL LOAD IN TWO DIFFERENT SUN DRIED FISH PRODUCTS COLLECTED FROM LOCAL FISH MARKET OF NOAKHALI SADAR, BANGLADESH

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The present study was designed to investigate the bacterial load in two different sun dried fish products (*Odontamblyopus rubicundus* and *Goniolosa manmina*) collected from local fish market named Sonapur of Noakhali district from May to August, 2018. For this, Total Bacterial Count (TBC), the incidence of *Salmonella* and *Vibrio* spp. were determined by using serial dilution and spread plate techniques. The study revealed that maximum TBC (3.5×10^7 CFU/g) and *Salmonella spp.* (1.6×10^6 CFU/g) were found in dried Chewa fish (*Odontamblyopus rubicundus*) while in dried Chapila fish (*Goniolosa manmina*), TBC was found as 2.3×10^6 CFU/g and *Salmonella spp.* were completely absent. No *Vibrio* like colonies was observed in any of the dried fish samples. The TBC of these dried fish were higher than the recommended acceptable limits. This study also revealed that the TBC was comparatively higher in the sample of dried Chewa fish than the sample of Chapila fish. Besides, the densities of *Salmonella spp.* were observed in the sample of dried Chewa fish whereas no *Salmonella spp.* were isolated from dried Chapila fish sample. It was a good sign that *Vibrio* like colonies were totally absent in both samples of dried fish (Fig. 1). Findings of this investigation suggested that some effective measures such as ensuring scientific methods of fish drying, using of good quality raw materials, hygienic handling practices, good quality packaging materials, training of the fisher folks and increasing the awareness of mass people about food safety should be taken.

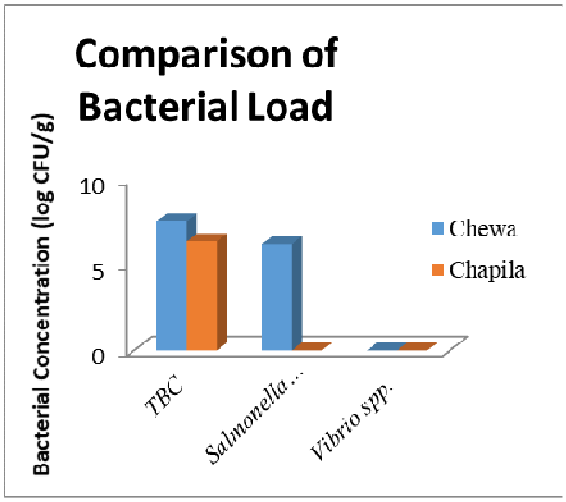

Fig. 1. Comparison of bacterial load between dried Chewa and Chapila fish (log transferred data)

DEVELOPMENT OF SALT-SMOKE-DRIED FISH PRODUCTS AND ITS QUALITY ASSESSMENT

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This study was carried out to assess the changes in nutritional and microbiological aspects of fresh, smoked, salt-smoke-dried (SSD: treated with salt, smoke and sunlight), control dried (CD: treated only with sunlight) tengra (*Mystus tengara*) and batashi (*Neotropius atherinoides*) during storage at ambient temperature (26-28^{o}C) and refrigeration temperature (4^{0}C). The study was done to investigate the effect of natural preservatives salt and smoke on the shelf life of the product over the storage period. The moisture content of fresh tengra and batashi was 76.06% and 75.81%, whereas 18.80, 18.10% and 18.36% for SSD and CD respectively. Fresh tengra had 13.45% protein, 7.46% lipid and 2.80% ash. The initial value of protein, fat and ash content of SSD tengra was 63.40, 19.95 and 16.55% respectively on dry matter basis. The initial value of protein, fat and ash content of SSD batashi was 65.93, 17.09 and 16.90% on dry matter basis. During 60 days of storage, moisture increased whereas protein, fat, and ash content decreased considerably. The initial TVB-N and SPC value for SSD tengra was 5.86 mg/100g and 1.02×104 CFU/g respectively. During storage period the TVB-N and SPC value slowly increased and the values reached to 18.21 mg/100g and 3.32×104 CFU/g respectively for salt-smoke-dried tengra stored at ambient condition whereas 11.81mg/100g and 2.14×104 CFU/g respectively for the products stored at refrigeration temperature. During storage period TVB-N and SPC value slowly increased and the values reached to 17.94 mg/100g and 4.2×104 CFU/g, respectively for salt-smoke-dried batashi, stored at ambient condition whereas 11.20 mg/100g and 2.42×104 CFU/g, respectively for the products stored at refrigeration temperature. The overall quality of salt-smoke-dried product was better than control dried product, based on organoleptic, nutritional and microbial conditions. Information obtained from this study cleared that combination of salting, smoking and drying is efficient from producing smoked-dried fish product. From the overall performance, the products kept at refrigeration temperature showed better shelf life than the products stored at ambient temperature.

PRESENT STATUS OF FISH OFFAL PRODUCTION AND UTILIZATION IN THE FISH MARKETS OF NOAKHALI

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The study was conducted from March 2018 to July 2018 to assess the quantity of fish offal produced in different fish markets of Noakhali and to identify the future prospects of fish offal utilization. Interviews were taken from fish cutters, fish offal collectors and traders for collecting different information related to fish offal production and utilization. The weight of offal of different fresh and marine fish were determined by the help of fish cutter in the fish market. The weight of offal/kg of Catla, Grass Carp, Boal, Pangas, Rui, Tilapia, Common Carp, Shoal, Kalibaus, Silver Carp, Bighead Carp, Sarpunti and Koral fish were 0.15±0.02 kg, 0.14±0.024 kg, 0.10±0.01 kg, 0.11±0.02 kg, 0.14±0.011 kg, 0.24±0.06 kg, 0.12±0.02 kg, 0.11±0.002 kg, 0.12±0.006 kg, 0.11±0.012 kg, 0.084±0.008 kg, 0.19±0.018 kg and 0.13±0.02 kg respectively. The weight of fish offal/kg was reduced with the increase of the size of fish. A great quantity of fish offal were produced in the fish markets of Noakhali by the fish cutters. The yield of fish offal in three big fish markets of Noakhali were estimated to be about 72.3 metric ton per year where fish scale was about 18.4 metric ton per year. Fish scale, air bladder and PG were collected and processed by the fish cutters and all other offals like fish stomach, fin etc. were discarded as waste. Although PG was collected by some fish cutters but most of the cutters didn't know how to collect PG. After drying of fish scale and air bladder, fish cutter send them to Cumilla, Dhaka and Chattogram for processing and exporting. However, fish stomach, fin and other fish offals can also be utilized to produce fish silage, poultry feed, fish feed and agricultural manure which were discarded as waste material. Therefore, training proper awareness program can be provided to the fish cutters so that they can properly collect PG and utilize other fish offal.

Table 1. Amount of fish offal/kg of different fish species

Name of Fish	Catla	Grass Carp	Boal	Pangas	Rui	Tilapia	Carpu	Shol	Kalibaus	Silver Carp	Bighead Carp	Sarpunti
Weight of offal/kg	0.15 ±0.02	0.14 ±0.024	0.10 ±0.01	0.11 ±0.02	0.14 ±0.011	0.24 ±0.06	0.12 ±0.02	0.11 ±0.002	0.12 ±0.006	0.11 ±0.012	0.084 ±0.008	0.19 ±0.018

STUDY OF SANITARY CONDITIONS AND QUANTITATIVE ESTIMATION OF BACTERIAL FLORA IN TANK GOBY (*Glossogobius giuris*) FISH AND POND

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Present study measured physico-chemical parameters like water temperature, dissolve oxygen (DO) and pH of pond water; bacteriological study that included aerobic plate count and presence of enteric bacteria in pond water, sediment and fish samples in winter and summer season. Mean water temperature (°C), dissolve oxygen (mg/l), and pH were 19±3, 30±4, 5.6±0.5, 5.1±0.2, 6.8±0.4 and 7.1±0.3 in winter and summer respectively. In winter total viable bacterial count in water ranged from 9.15×10^3 to 6.20×10^4 CFU/ml and in sediment ranged from 7.72×10^7 to 3.80×10^8 CFU/g. In summer, it ranged from 7.74×10^4 to 4.67×10^5 CFU/ml in water and 4.84×10^8 to 2.77×10^9 CFU/gin sediment. On the other hand, in fish, total viable plate count (TVC) ranged from 8.17×10^5 to 1.12×10^6 CFU/g in winter and 4.60×10^6 to 3.06×10^7 CFU/g in summer from the pond. Gram-negative rods (77%) and motile bacteria (78%) were dominated. Enteric bacteria were also present in the pond. The presence of enteric bacteria in the pond waters, sediments and fish samples suggested that waters were polluted from external sources. The apparent difference in the bacteriological condition of the two seasons makes it justifiable to assume that bacteriological condition has some direct or indirect relationship with different seasons.

QUALITY ASSESSMENT OF HEAD-ON AND HEAD-LESS MARINE SHRIMP (*Fenneropenaeus indicus*) IN THE DISTRIBUTION CHANNEL OF CHITTAGONG REGION

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The present study was carried out in August 2016 to August 2017 to assess the quality of head-less and head-on marine white shrimp (*Fenneropenaeus indicus*) collected from different fish markets of Chittagong region. Quality assessment included sensory evaluation, microbial quality analysis and total volatile base nitrogen (TVB-N). In this study, it was noticed that average DP of headless shrimp (H_1,H_2) were 3.24±0.36 and 2.74±0.19 and head-on shrimp (H_0) was 2.14±0.15 that indicates that the quality of the head-on shrimp was relatively better than the headless shrimp. Total bacterial count of headless and head-on shrimp were beyond the acceptable limit (>10^5 cfu/g or 7 log cfu/g); but no substantial difference (ANOVA, p<0.05) was found among different shrimp samples. In case of total coliform concentration, a significant difference (p<0.05) was found. No substantial difference (ANOVA, p<0.05) in the fecal coliform density was found. The concentrations of *Salmonella-Shigella* observed in different headless and head-on shrimp samples with significant differences (ANOVA, p<0.05). The acceptable zero tolerance of *Salmonella* was overshadowed. In case of *Vibrio* spp. in shrimp samples which is beyond the acceptable limit (>10^2 cfu/g or 2 log cfu/g) in headless shrimps and within acceptable limit in head-on shrimp. The TVB-N contents of head-on and headless white shrimp were varied between 13.75±1.25 mg N/100g to 25±1.88 mg N/100g which was within the acceptable limit. Therefore, the result highlighted the better quality and lower quantity of pathogenic bacteria in head-on white shrimp *(F. indicus)* than the head-less shrimp in the fish market.

Table 1. Bacterial concentration (log cfu/g) measured in different headless and head-on shrimps

Shrimp (*F. indicus*)	Parameters				
	TBC	*Salmonella* like colonies	*Vibrio* like colonies	TC	FC
H_1	11.48±0.20	7.83±0.49	4.84±1.52	6.72±0.43	11.38±2.21
H_2	12.83±0.76	7.36±4.07	2.18±1.99	4.86±1.83	1.31±0.92
$H_。$	13.24±0.64	3.72±1.52	1.143±0.87	6.36±1.11	1.83±1.73

COMPARATIVE ANALYSIS OF COMMUNITY EMPOWERMENT PROCESSES BETWEEN HAOR AND FLOODPLAIN AS IMPACTED ON POS-HARVEST FISHERIES LOSS REDUCTION

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This study presents a comparative analysis of the community empowerment processes between two different types of stakeholder's groups - i) the actors who do not follow the good fish handling practice; ii) the actors who follow the good fish handling practice. The study was conducted in 10 fish landing centers at 5 haor Upazilas – Karimganj sadar, Tarail, Nikli, Kotiadi and Itna of Kishoreganj district based on natural harvest without any management approach and 10 floodplain based cultured fisheries at Daudkandi Upazila of Cumilla District under CBFM. It was done by seventy (70) questionnaire interviews (35 interviews in each stakeholder) which were selected randomly to collect empirical data. Statistical tools (SPSS, Excel) were used for analyzing data. Preliminary results showed that in the Haor area in Kishoregan, the who follow good handling practice has monthly income, electricity facilities, literacy rate and semi pakka or pakka residence are 26765-taka, 87.79%, 77.23% and 44.45% respectively. On the other hand, the actors who do not follow the good handling practice has monthly income, electricity facilities, literacy rate and semi pakka or pakka residence are 18545-taka, 81.33%, 70.67% and 38.22 % respectively. In Daudkandi floodplain area, the actors who follow good handling practice has monthly income, electricity facilities, literacy rate and semi pakka or pakka residence are 35450-taka, 97.01%, 84.56% and 68.90% respectively. On the other hand, the actors who do not follow the good handling practice has monthly income, electricity facilities, literacy rate and semi pakka or pakka residence are 21387-taka, 88.56%, 72.35%, 55.56 %, respectively. Post-harvest fisheries loss reduction situation was better in Daudkandi floodplain than haor area. Community empowerment processes was found better in practice in Daudkandi floodplain fisheries and their livelihood conditions were also found comparatively better than Kishoreganj haor areas.

EFFECTS OF *DADON* ON THE CATCH, QUALITY AND POS-HARVEST LOSS REDUCTION OF OPEN WATER FISHERIES IN KISHOREGANJ HAOR

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Dadon, associated with its impacts on catch, quality and post-harvest loss reduction of open water fisheries were studied in 10 fish landing centers under 5 haor Upazilas- Karimganj sadar, Tarail, Nikli, Kotiadi and Itna of Kishoreganj district. It was done by questionnaire interviews (QI)of two fishermen groups: one was '*dadon*receiver' and the other was *dadon non receiver* . Sixty (60) interviews (30 interviews in each group) were randomly selected to collect empirical data. Preliminary results of research revealed that *dadondar* – the aratdar had taken 4 to 6% from *dadon* receiver and 2 to 3% commission from *dadon* non receiver, while auction fish in the auction center (arat). The highest number of *dadon* receiver was found in Morichkhali (av. 238) and lowest in Karimganj (av. 32). Maximum quantity of money taken as *dadon* by fisherman was found in Chamraghat (Tk.6,18,888.7) and minimum in Nikli (Tk.4,750). The average rate of commission was higher in Nikli (5.25%) and lower in Kargaon (3%) and no difference was found in the variation of species, size and quality of captured fishes. On average 45.79%, 49.71% and 4.5% fishers used katcha floor, concrete floor and SS table respectively during auctioning. About 53.13% *dadon* receiver used fresh water and 42.19 % *dadon* receiver used good quality utensils for carrying captured fishes. Thirty six percent fishers used bamboo basket, 23.77% plastic drum, 35.17% plastic crate and only 5.03% fishers used ice box for carrying captured fish. Both the groups did not use ice after harvesting and before auctioning. *Dadon* was found to have serious tangible impact on the socio-economic conditions of surveyed fishers. Commission against *dadon* was found to be worse than interest from Bank or person, since paying back the *dadon m*oney taken by the fishers became so difficult that with more *dadon* taken at successive years made them indebted life-long to the clutch of money landers. This indention was found to have serious negative impact on catch and quality maintenance of the fishes in haor areas. So, *dadon* was found to be a barrier of the postharvest loss reduction process of the fishes.

ROLE OF GENDER FOCUSED INTERVENTION IN HAOR FLOODPLAIN: CASE OF WOMEN-LED CAGE AQUACULTURE FROM KISHOREGANJ HAOR AREAS

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Haors are natural low-lying watersheds inundated for 5-6 months by flood waters across the northeastern part of the country covering 57 Upazilas under 7 districts and home to about 20 million people. Capture fisheries has long been the main livelihood supplying natural fish highly relished by people. With the decline of natural productivity of haor fishery, researchers and extension providers under Krishi Gobeshona Foundation (KGF) fund took initiatives to bring haors under selective aquaculture like cage culture and pen culture including better post-harvest practices to improve fisher's livelihoods and income.

Fishermen in haors are mainly engaged in fishing, while the fisherwomen involved in wet fish trading, fish drying, net mending, crafting traps and gears but never engage in aquaculture. Bangladesh Agricultural University (BAU) with assistance from local NGO attempted gender focused interventions to bring the fisherwomen in seasonal cage culture in 4 Upazilas of Kishoreganj district. This paper discusses the existing livelihoods and community participations in women-led cage aquaculture as an alternative livelihood for haor areas. In spite of social taboos and traditions restricting women to be engaged in fishery related activities outside home, the gender focused interventions attracted both women and men in groups to the innovative model of cage aquaculture including ancillary activities generating backward and forward market linkages. The interventions include formation of women groups (*Ujandhanu Nadi Matshaya Jibi Somobaya Samititi* -UNMJSS) and *Chongnoagaon Matsaya Samabaya Samiti- CMSS*) from two distinct fishing communities of Sutarpara Union under Karimganj Upazila, Kishoreganj- ethnic fisherwomen (EFW) and mainstream poor women (MPW) groups, respectively, where 10 cages of tilapia monoculture had been demonstrated to each of the groups with hands-on training and inputs.

Results from women groups showed higher rate of adoption of cage aquaculture against traditional fishing with ethnic fisherwomen group compared to non-ethnic mainstream poor fisherwomen. A 4-month cage culture , from 27 m^3 cage obtained production of fish 15.56 $kg.m^{3-1}$ and 14.52 $kg.m^{3-1}$ respectively in EFW and MPW with FCR values of 1.11 and 1.21 in that order (p>0.05). The produce of EFW group were sold by themselves in both wholesale and retail markets, while MPW took assistance of their husbands in selling fish only in wholesale. Accordingly, profit margins were lessened by 9.02% in the later then the former. However, the results of this study were found encouraging towards adopting commercial haor aquaculture as viable alternative livelihood option involving fisherwomen for the resource poor fishing community across the haor floodplain

EVALUATION OF CONSUMER'S PREFERENCE AND ACCEPTABILITY OF FRESH FISH AND ITS PACKAGING IN THE SUPERSTORES OF DHAKA CITY

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The proper packaging can reduce the qualitative and quantitative losses of dry fishes during storage and distribution stage. In light of this, consumer's acceptability and willingness to buy the fresh and packaged raw fish in the superstores of Dhaka city was investigated by survey method utilizing structured questionnaire. Total 290 shoppers/consumers, selected purposively based on the availability during the face-to-face interview from different outlets of four retail superstores in Dhaka city; Shwapno, Meenabaazar, Prince Bazar, Nandan etc. were surveyed in January 2018.

In the superstores, 59% consumers were male and 63% have small family size (up to 4 members). Most of the consumers (83%) were highly educated having bachelor degree and half of the consumers involved in mid to higher class job. Consumers purchase 40 different fish species in those superstores and 75% consumers prefer marine fishes. Among the consumers, 43% purchase iced fishes, and 35% purchase fresh & iced fishes. Around 71 % consumers purchase fishes weekly and 53% spend 1001-5000 BDT monthly. Around 58% and 38% consumers were satisfied and moderately satisfied, respectively on purchasing fishes in the superstores. However, 57% and 39% were satisfied and moderately satisfied, respectively on the overall quality of the fishes in the superstores. Most of the consumers (85%) would prefer to buy larger fish as whole instead of cut portions. Around 58% consumers would prefer to buy packaged sliced of larger fish under refrigeration storage and rest not. In case of packaged fishes, around 50% consumers would prefer on 500 or 1000g pack. In addition, 54% consumers agreed to pay 10-15% excess price for getting quality products by proper packaging. Therefore, there is a scope to produce packed slice of larger fish which can be easily sell for a longer period at refrigerated condition in the superstores.

Table: Consumers Preference for fishes and opinions toward quality and packaging

Sl No	Variables	Category	Freq	%
1	Preference of marine fish	Yes	217	74.8
		Moderate	7	2.5
		No	65	22.5
2	Type of fish purchased	Fresh	64	22.2
		Iced	125	43.1
		Frozen	1	0.4
		Fresh+ Iced	100	34.5
3	Buying Interval of fishes	Daily	8	2.8
		Weekly	206	71.2
		Fortnightly	45	15.4
		Monthly	30	10.3
4	Monthly expenditure for fishes	≤1000	8	2.8
		1001-5000	154	53.1
		5001-10000	83	28.5
		>10000	45	15.4
5	Satisfaction on fish purchasing in superstores	Yes	167	57.6
		Moderate	109	37.7
		No	13	4.6
6	Satisfaction on fish quality in superstores	Yes	164	56.6
		Moderate	113	39.1
		No	12	4.2
7	Preference of buying large fish as	Whole fish	246	84.8
		Cut fish	44	15.1
8	Preference on buying slice of larger fish	Yes	168	58.1
		Moderate	21	7.1
		No	101	34.8
9	Preference on buying packed RTC fish	Yes	90	31.0
		Moderate	23	8.1
		No	177	61.0
10	Preferable Pack Size	250	19	6.7
		500	71	24.6
		750	11	3.9
		1000	75	26.0
		2000	15	5.3
		No comment	97	33.4
11	Agrees on 10-15% excess price for packaging	Yes	155	53.5
		No	37	12.7
		No comment	98	33.8

ECONOMIC FEASIBILITY OF CATFISH CULTURE IN RECIRCULATING AQUACULTURE SYSTEM (RAS) IN BANGLADESH

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Recirculating Aquaculture System (RAS) is a new and unique way to holding and rearing a wide variety of aquatic species under controlled environment. Capital investment is higher for setting up RAS than any other of traditional production system due to the requirement of additional equipment to treat water. So, it is obligate to conduct economic analysis based on real data set for RAS facilities to examine its economic feasibility.

A structured questionnaire was made to conduct survey to collect all economic and technical data. Questionnaire consists of two parts such as (1) input variables (include fixed cost, RAS facility cost, variable cost), (2) output variables (fish culture related information, fish marketing information).Agro3 fish farm was selected for this study as it is the first RAS farm in Bangladesh established in 2016. Economic analysis was conduct using various parameters from the RAS farm on two catfish species *viz*., Pabda and Shing. The ultimate objectives were (1) estimation of net income (per month), (2) payback period determination and (3) estimation of average rate of return.The result shows that cost and return budget varied in respect to different fish species. Total production cost addressing sum of fixed and variable cost were7986714 tk. and 8001100tkfor Pabda and Shing culture, respectively; although fixed cost was same 7452104 tk. Monthly net income from Pabda was 206400tk and from Shing was 399000tk.Payback period was faster for shing culture than the Pabda fish culture, which represent 2 years 5 months for Shing and 6 years 3 month for Pabda. Average rate of return were 42.15% and 16.02% for Shing and Pabda, respectively. Although production cost is greater in Shing culture in RAS technology, it is more profitable than the Pabda fish culture. It can be concluded that Fish culture by RAS technology will be more profitable for economically high value fish.

Table. 1. Various parameters of economic feasibility analyses of Pabda and Shing culture in RAS

Economic model	Unit	Amount	
		Pabda	Shing
Operating cost per kg fish	tk	155.41	98.03
Profit from 1 kg fish	tk	144.59	186.96
Profit in one cycle	tk	497390	1047004
Profit to operating cost	%	93.04	190.71
Monthly net income	tk	206400	399000
Net profit per month	tk	99478	261751
Annual profit	tk	1193736	3141012
Payback period	year	6.24	2.37
Average rate of return	%	16.02	42.15

FACTORS AFFECTING THE ATTITUDES OF FISHERS TOWARDS COMMUNITY DRIVEN CAGE AQUACULTURE IN *HAOR* AREAS, BANGLADESH

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Inland capture fisheries are providing cost of livings of about 1.2 million population in Bangladesh. Overexploitation causing the declination of the abundance of native fish species threatening the livelihoods of haor dwellers . The objective of the research was to explore the economic and non-economic factors affecting fishers attitude and willingness about cage aquaculture. Semi-structured interview, key informant interviews and questionnaire survey using Likert Scale, FGD were applied to obtain factors in Sutarpara village and Changnoagaon village from January to April 2014. In reliability analysis, Cronbach's α values of four scale groupings such as employment, aquaculture, environment and health nutrition were 0.94, 0.70, 0.84, 0.81 and 0.75, 0.81, 0.75, 0.64 in Sutarpara and Changnoagaon respectively.

Pearson's correlation co-efficient (r) was also used for clear understanding on types (positive or negative) and degree (low to high) of relation among the scale grouping and factors. Positive and high correlation were exists in four scales except few. On the other hand, mixed correlation ranging from -0.59 to +0.96 were observed among the scale grouping and both type of factors. The economic factors were fewer in number than non-economic factors. Income source, annual income, urban migration, paddy planting and women involvement (e.g. gender) significantly (p<0.05) affected the willingness for cage aquaculture adoption and return from capture fishing.

The result indicates that changing willingness from fishing to cage aquaculture activities was higher in fishers' groups those had more inclination in fishing activities. Simultaneously, non-economic factors like powerful traders and fishers, traditional believes, taking risk, launching period of cage aquaculture venture and investment duration played vital role in decisions on whether to fish or not.

This type of comparative research are significant for future scientists (social aquaculture researchers) and policy makers related stakeholders such as government and non-government officials for giving emphasis to gather data based on the prevailing economic and non-economic factors to innovate alternative livelihood activity concurrently.

FISH AVAILABILITY AND FISH TRADING SYSTEM IN THREE COASTAL DISTRICTS OF BANGLADESH

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The present study was conducted on fish marketing system, price, fish availability and socio-economic condition of fish retailers in three markets of three coastal districts;. Noakhali, Chandpur and Laxmipur for a period of 5 months from October 2014 to February 2015. Data were collected from retailers through questionnaire survey . The supply chain and marketing channel from fishermen to final consumers were found to passes through a number of intermediaries; local paikers (accumulator), aratdars/wholesalers and retailers. Three types of marketing channels were observed in Chowrasta bazaar, Noakhali; Belcho bazar, Chandpur; and Laxmipur town bazaar in Laxmipur district. The daily supply of fish in Chowrasta bazaar, Belcho bazaar, Laxmipur bazar were 6-7 mt, 3-4 mt and 1-1.5 mt, respectively. It was found that a number of species in the study areas ranged from 25-53 species both from farmed and wild fishes.

The number of fish retailers found in Chowrasta bazar, Laxmipur bazar and Belcho bazar was 150, 37 and 55 respectively. It was estimated that about 60% of the fish supplied in Chowrasta bazar was of natural sources which 15% small fish, 10% is local catfish, 10% marine fish, 10% Hilsa, 10% other mixed fishes and 5% prawn. On the other hand, almost 60% of fishes were sold in Belcho bazar fish market are of major natural fish species of which 15% marine fish, 15% hilsha 10% local cat fish, 10% small fish, 5% prawn and 5% other fishes. In Laxmipur fish market it was found that about 55% are of natural origin of which 15% local cat fish, 10% small fish, 10% marine fish, 10% hilsha, 5% prawn and 5% other mixed fish species.

Major constrains of these markets were poor road and transportation facilities, poor supply of ice and exploitation by middlemen, adequate infrastructure facilities, poor hygienic condition, drainage system, unstable production and price. It was found that socio-economic conditions of fish retailers are slightly improving though the rate of improvements is not significant as desired.

CLIENT SATISFACTION WITH GOVERNMENT FISHERIES EXTENSION SERVICE IN AN UPAZILA IN BANGLADESH

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Client satisfaction is considered as a cornerstone in retaining clients for the growth and survival of an organization. With the aim of determining client satisfaction with government fisheries extension service this research was conducted in Barisal Sadar Upazila. A total of 230randomly selected fish farmers were interviewed using a structured interview schedule. The findings of the study showed that 45% clients were very satisfied with fisheries extension service, while 37% were slightly satisfied.

Among the aspects of fisheries extension service the respondents showed more satisfaction regarding understandability of the message, behavior and skill of extension agents and comparatively less satisfaction regarding method of extension work, timeliness of information and completeness of information. The results of multiple regression analysis represent that gender, education level, frequency of extension contact, and quality of extension service can jointly explain 31.6% variation in overall satisfaction with extension service. This research suggests the use of appropriate extension method, timely supply of complete information, more extension contact, and improvement of service quality for enhancing client's satisfaction with government fisheries extension service.

BEST-WORST SCALE AND PEARSON'S CORRELATION BASED INVESTIGATION ON SOCIOECONOMIC STATUS OF FISHERMEN IN SUGONDHA RIVER OF BANGLADESH

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The investigation was conducted to evaluate the socioeconomic profile of the fishermen, using Best-Worst scale and Pearson's correlation of Sugondha River, Bangladesh during the period of July 2015 to June 2016 by interviewing 200 fishermen. In Sugondha River, 47% fishermen were engaged in fulltime fishing and 56% preferred group fishing. Maximum fishermen (49%) were middle aged and 56% were found Illiterate. Age and income of fishers were positively correlated (r=0.071) (Table 1). Average annual income of most of the fishermen ranged from BDT 56,000-70,000 (32%), where 30% had less than BDT 41,000. 48% women of the fishermen family supported their family by poultry rearing. Although the drinking water facility in area is good enough, 100% used tube-well water, the sanitation condition is not good, 80% fishers used traditional toilet and 15% had no sanitary facilities. Lack of credit facilities was identified as main constraint by Best-Worst scale (Figure 1). Factors of insecure livelihood were dramatically showed by problem tree (Figure 2). Poor socioeconomic conditions of fishermen were forced to overfishing round the year without considering government rules related to aquatic diversity.

Table 1. Pearson's correlation among different variables of the fishermen

	Age	Experience	Income	Saving	Type	Fishing	Housing	Sanitation	Health
Age	1								
Experience	0.937**	1							
Income	0.071	-0.006	1						
Saving	0.219**	0.147*	0.765**	1					
Type	0.421**	0.328**	0.561**	0.856**	1				
Fishing	-0.069	-0.091	0.759**	0.659**	0.462**	1			
Housing	0.101	0.074	0.351**	0.368**	0.333**	0.243**	1		
Sanitation	0.068	0.063	0.540**	0.417**	0.329**	0.280**	0.620**	1	
Health	0.441**	0.359**	0.535**	0.700**	0.679**	0.474**	0.513**	0.365**	1

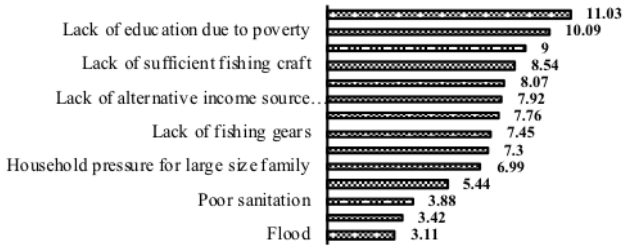

Fig. 1. Best-worst scale value of socioeconomic constraints.

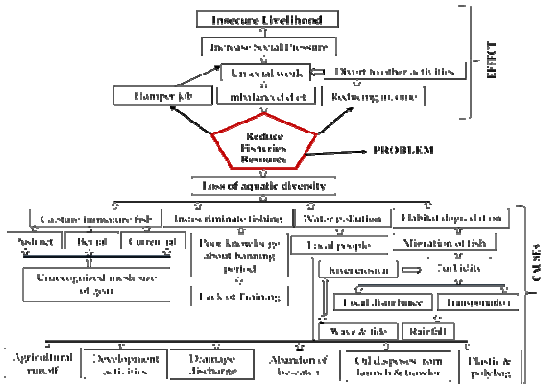

Fig. 2. Problem tree for reduce fisheries resource at Sugondha River.

IMPACTS OF CLIMATE CHANGE ON FISHERIES RESOURCES AND FISHERS' LIVELIHOOD IN KISHOREGANJ HAOR REGION

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This research is an attempt to assess the impacts of climate change on fishers' livelihoods, fisheries resources, water quality parameters and primary productivity of Kishoreganj haor region. Kishoreganj haor region is unique due to its hydro-ecological characteristics and highly sensitive to the climatic events such as flash flood, soil erosion, heavy rainfall, drought, storm surge etc. The present study examines the impacts of climate change on fish availability, sustainable livelihood challenges, and adaptation strategies to the climatic events that the haor region people face. It is found that the frequency and severity of natural disasters have increased in recent years due to climate change, that threat on fishers' livelihood by inundating low fish production, extinction of fish species, low fish availability, destructing houses and other infrastructures in Kishoreganj haor region.

In the present study, a total of 79 species of fishes belonging to 27 families under 9 orders were found during the study period in Kishoreganj haor region. The range of temperature, dissolved oxygen, pH and salinity value were recorded from 28.77°C to 33.30°C , 7.9 to 8.3 , 7.3 to 8.5 mg/l and 0 ppt, respectively. In the present study, a total of 23 species of phytoplankton and 12 species of zooplankton were also found in Kishoreganj haor region. Moreover, fish kidney, gill, liver were also affected due to climate change by rising temperature and changing the water quality parameters. The present study clearly indicates that there is visible decline of fish species and primary productivity during the last decade for negative impacts of climate change. There has not been conducted much empirical research about the impacts of climate change in Kishoregonj haor region, so policy makers can get comprehensive view about this concern by this study and implement policy for the survival of the climate change induced affected haor people.

ROLE OF PANGAS AND TILAPIAFISH IN PROTEIN SUPPLY OF LOW INCOME PEOPLE OF NOAKHALI

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The present study was conducted to assess the role of Pangas and Tilapia fish in protein supply of low income people of Noakhali. Data were collected through a pre-tested well-structured questionnaire and physical observation. The study was conducted over a period of four months (March to June 2018). The Pangas and Tilapia fish consumers of studied areas were engaged in diversified profession viz. day labor (27% and 23%), driver (13% and 10%), private job (13% and 16.67%), farmer (3% and 10%), school teacher (6.67% and 10%) and other (20% and 13%). Monthly income of Pangas and Tilapia fish consumers were varied from BDT 5000-35000.The study revealed that 60% of Pangas fish consumers were well educated, 23% higher educated and 6.67% of were illiterate. The study showed that 56% of Pangas fish consumers consumed only Pangas for their protein source whereas 43% Tilapia consumers relied on Tilapia. 30% of Pangas consumers consumed it 16-20 day per month and 26% of consumers consumed Pangas fish 21-25 day per month. The study showed almost similar findings in case of tilapia fish consumers. 40% of Tilapia consumers consumed Tilapia 16-20 day per month and 30% of consumers eat Tilapia fish (21-25) day per month. 73%Pangas fish consumer and 70% Tilapia fish consumers bought those fish for the less value of the fish compared to others. The present study revealed that monthly incomes were inversely correlated with Pangas fish and Tilapia fish consumption in the study area. Overall comment: Incomplete figure, need clarity about pangas and tilapia consumers - the point is that do they not eat other fish in the period (it could be those who mostly eat pangas and tilapia)

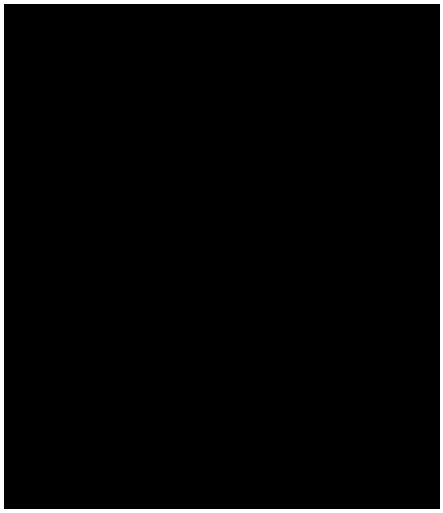

Fig 1. Different source of protein of Pangas fish consumer

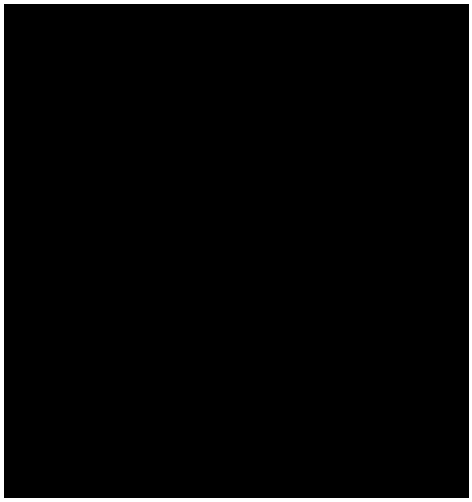

Fig 2. Monthly income profile of Tilapia consumer

PARTICIPATION OF WOMEN IN DRY FISH PROCESSING ACTIVITIES IN A SELECTED COASTAL REGION OF BANGLADESH

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Dry fish processing, a woman dominating employment sector in the coastal region, is a hectic task demanding diverse physical activities concerning several health hazards. With the aim of exploring women's participation in dry fish processing in two selected coastal districts of Bangladesh, this research adopted a mixed method approach and collected quantitative data using a structured interview schedule from 200 randomly selected women residing in six coastal villages under Patuakhali and Barguna district. Qualitative data were collected adopting focus group discussions, case studies, and key informant interviews. This research revealed that due to vulnerable livelihood and managing family and personal expenses women had moderate to high (84.60%) participation in dry fish processing. Women performed all most all the processing activities predominantly most of hazardous tasks, such as cleaning, cutting, salting, and drying. Multiple regression analysis represents that education, self-confidence, intra family empowerment status, personal income, family land ownership can explain 29% variation in women's participation in dry fish processing. This research further established that although women worked for long hours in the dry fish processing, but they are remarkably underpaid than the male workers. The major obstacles of women's participation in dry fish processing activities included physical hazards (penetration of fish spines, injuries during fish cutting, chronic infections from using preservatives, etc.); low salary payment; seasonality; and low social status. Improvement of women's skill in processing work, using modern processing techniques and tools, and fixed working hours with equal salary as male can enhance women's participation in dry fish processing.

ADAPTATION OF THE SUNDARBANS FISHING COMMUNITIES TO CLIMATIC HAZARDS

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For the natural resource dependent communities, adaptation to climate change at the local level is indispensable to face the impacts of climate change. This study assesses the responses of the two Sundarbans mangrove based fishing communities–Mathurapur and Burigoalini–at Syamnagar, Satkhira, Bangladesh using surveys, interviews and focus group discussions during June – December 2018.They are affected by a range of climate induced hazards such as cyclones (e.g. Aila), river bank erosions, salinity intrusions, and short- and long-term flooding. The households respond to these impacts in a range of ways which varied between the communities and within different household groups of each community.

Their common adaptation strategies include controlling river bank erosion using bamboo fencing or cemented blocks, treatment of saline water for drinking, composite-aquaculture, repairing dams and houses, and livelihood diversification. They face a range of obstacles to adapt successfully including very high fees for fishing operation by the Bangladesh Forest Department, robbery by pirates during fishing, scarcity of drinking water, absence of cooperatives, and poor health, credit and infrastructure facilities. In general, the households of Burigoalini have managed to adapt better compare to their Mathurapur counterparts as the former have a better access to housing, land, trainings, and credits. This study suggests direct policy interventions to help the households and communities to adapt better. These include significantly reducing fees for fishing operation inside the Sundarbans waters, establishment of local fishers' cooperatives, strictly controlling pirates as well as improving other social, economic and infrastructure services.

COMPARATIVE ANALYSIS OF COMMUNITY EMPOWERMENT PROCESSES BETWEEN HAOR AND FLOODPLAIN AS IMPACTED ON POST-HARVEST FISHERIES LOSS REDUCTION

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This study presents a comparative analysis of the community empowerment processes between two different types of stakeholder's groups - i) the actors who do not follow the good fish handling practice; ii) the actors who follow the good fish handling practice. The study was conductedin 10 fish landing centers at 5 haor Upazilas- Karimganj sadar, Tarail, Nikli, Kotiadi and Itna of Kishoreganj district based on natural harvest without any management approachand 10 floodplain based cultured fisheries at Daudkandi Upazila of Cumilla District under CBFM. It was done by seventy (70) questionnaire interviews (35 interviews in each stakeholder) which were selected randomly to collect empirical data. Statistical tools (SPSS, Exel) were used for analyzing and calculating data. Preliminary research discovered that in Kishoreganj haor area, the actors who follow good handling practice has monthly income, electricity facilities, literacy rate and semi pakka or pakka residence are 26765-taka, 87.79%, 77.23% and 44.45% respectively. On the other hand, the actors who do not follow the good handling practice has monthly income, electricity facilities, literacy rate and semi pakka or pakka residence are 18545-taka, 81.33%, 70.67% and 38.22 % respectively. In Daudkandi floodplain area, the actors who follow good handling practice has monthly income, electricity facilities, literacy rate and semi pakka or pakka residence are 35450-taka, 97.01%, 84.56% and 68.90% respectively. On the other hand, the actors who do not follow the good handling practice has monthly income, electricity facilities, literacy rate and semi pakka or pakka residence are 21387-taka, 88.56%, 72.35%, 55.56 % respectively. Post-harvest fisheries loss reduction situation was better in Daudkandi floodplain fishery zone than haor area. Community empowerment processes was found better in practice in Daudkandi floodplain fisheries and their livelihood conditions were also found comparatively better than Kishoreganj haor areas.

IMPACT OF FISH BIODIVERSITY ON THE LIVELIHOOD OF FISHERS IN SUNAMGANJ DISTRICT,BANGLADESH

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The study accompanied to investigate the impact of fish biodiversity on the livelihood of fishers in Soma Nadi *Jalmohal* and Dekar *haor* of Sunamganj in NE Bangladesh. The study was conducted by direct interview of fishers using a structured questionnaire, focus group discussions (FGD)and key informant interviews (KII) where more than 80 fishers' households were randomly selected. The findings showed that 71 fish species belonging to 28 families and 10 groups along with two prawn species were recorded, of which 24 species are commonly available, 17 moderately available, 19 rarely available and 13 unavailable species disappeared recently. The fishermen in the study area are mostly dependent on capture fisheries for their livelihoods. It was found that the mean annual income of the fishers from fishing activities was BDT (47838±12232) in Soma Nadi *Jalmohal* and BDT (41047±13069) in Dekar *haor*. Annual income of fishermen varied from BDT 48800 to 135400 (mean 71786±17817) and BDT 34900 to 176100 (mean 62000±22945) in the Soma Nadi *Jalmohal* and Dekar *haor*, respectively. According to this study, 17% fishers from Soma Nadi *Jalmohal* and 69% fishers from Dekar *haor* are trying to shift their profession to other occupations due to lack of income from fishing. The study reveals that most of the fishermen belonged to the age of 22-70 years. Muslim fishermen are most dominant in Dekar *haor* than Soma Nadi *Jalmohal*. In case of education, the highest 40% fishers below V, 35% illiterate, 15% above SSC and the lowest 10% VI-X level were found in Soma Nadi *Jalmohal* and the highest 57% illiterate, 20% below V, 13% class VI-X and the lowest 10% above SSC level were found in Dekar *haor*. Few fishermen received formal training about fish culture from DoF, WorldFish and NGOs. Housing and sanitation condition of the fishermen were not well developed. Nearly all of the fishermen used tube-well water for drinking purpose. The findings of the study showed that in Soma Nadi *Jalmohal* 45% taken health facilities from Upazila health complex, 30% from village doctors and 25% from private practitioner MBBS doctors. However in Dekar *haor* 50% were found to be dependent on village doctors, 30% on Upazila health complexes, 10% on private practitioner MBBS doctor and 10% on kobiraj. Women also participated in various income generating activities to improve their livelihoods along with the household activities. Based on various livelihood parameters, it is concluded that Soma Nadi *Jalmohal* fishermen leading better livelihood status in comparison to the fishermen of Dekar *haor*. As fish diversity of the Soma Nadi *Jalmohal* and Dekar *haor*s decreasing day by day, it adversely affected the livelihood of the fishers in the *haor* region of Sunamganj in Bangladesh.

BARRIERS OF ADAPTATION TO THE IMPACTS OF CLIMATE CHANGE OF FISHERY BASED LIVELIHOODS COASTAL BANGLADESH

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Globally livelihoods of over half a billion-fisher folk are exposed to the multiple adverse impacts of climate variability and changes that affect their capacity to survive. Yet very few studies focused on coastal fishing people and remain in a neglected corner of climate adaptation policy. Based on field work in four fishing communities this study identifies the adaptation barriers of coastal fishing communities of Bangladesh to the impact of climate change using household questionnaires, oral history interviews, and focus group discussions in four fishing communities of Bhola and Patuakhali district. A livelihood framework was used to synthesize the impact of climate change on fishing communities. Existing adaptation strategies with their limitation were also identified to explore their impact on local livelihood and management strategy. The result showed that frequent occurrence of natural calamities like cyclone, storm and tidal surge, fluctuation of temperature and wind velocity due to global climate change deteriorate the situation. The cruxes include, scarcity of cyclone center, damage of embankment, negligence to early warning, inaccessibility of early warning during fishing, aloofness of the government officials and local representatives, acute poverty, attack of pirates, unemployment, inflexibility to credit, illiteracy, lack of skills and alternative income source, insecurity of future generation, poor communication system, sanitation problem, scarcity of medical treatment, outbreak of damning diseases, slight of fishing laws and improper distribution of relief. These factors hinder completion of fishing trips, response to extreme events, safe return of boat and adopt with environmental changes. A number of suggestions are elicited from fishers' perception for effective tackling of climate change that include construction of cyclone center and embankment, mangrove afforestation to protect embankment, assurance of sufficient buoys in boat, helicopter rescue system from fishing place, wireless network or specialized software response system and awareness by navy in case of any sudden adverse climatic condition.

STUDY OF THE CLIMATE CHANGE IMPACTS ON FISHERIES RESOURCES AND FISHERS´ COMMUNITY IN THE SUNDARBANS

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For Sundarbans fishers' communities, social change has constantly been a part of their socio-political lives, while environmental changes were always interim and reversible, so that they understood and attached with the Sundarbans ecosystems as a provider for food and life. However, recent unexpected and irreversible changes brought on by global climate change were challenging this pattern and alter their ecosystems and adjacent rivers into unfavorable environment. Fishers are front-line observers of changes occurring in the Sundarbans and are among the first people to be affected by these changes. In this study, fishers' observation of climate change impacts were collected and analyzed with the tenets of grounded theory. Fish and water sample were collected from Passur, Sela, Sibsa and Kopothakho river of Sundarbans to analyze the impacts of climate change on fisheries resources, water qualities, productivity and fish vital organs. Total 186 species of brakishwater fishes, marine water fishes, fresh water fishes, prawns, shrimps, crabs and lobsters were recorded in the study areas. Among them 164 fish species, 11 shrimps, 5 prawns, 5 crabs and 1 lobster were recorded. The range of pH, temperature, salinity and dissolved oxygen values were recorded from 7.1 to 8.7, 25°C to 32.8°C, 1.5 to 23‰ and 4.3 mg/l to 7.7 mg/l, respectively in the rivers of Sundarbans. The number of identified species of phytoplankton and zooplankton were 29 and 18, respectively. Bacillariophyceae was represented by 15 species which is the highest number. Cyanophyceae and Chlorophyceae were represented by 5 and 3 species, respectively. Two species were recorded from both Zygnematophyceae and Euglenophyceae. Xanthophyceae was represented by one species. Among zooplankton, Maxillopoda, Branchiopoda, Malacostraca, Crustacea and Monogononta were represented by 11, 3, 2, 1 and 1 species, respectively. The number of plankton per liter was highest in the Passur River during both pre-monsoon and post-monsoon. Fishers' observations compiled from the Sundarbans region indicate increased temperatures and changes in weather patterns, increased extreme events, decreased rainfall as well as coastal erosion, sea level rise and siltation shifts in fish species distribution range and migratory and spawning behaviors. Salinity intrusion was gradually increased which lead to alteration in species diversity and productivity, more pronouncedly in sensitive ecosystems of rivers. Fish kidney, gill and liver were affected by increasing salinity and temperature in the rivers of Sundarbans. Shrunk glomerular structure, lumen in the collecting tubuls and increased hyaline droplets in kidney were found due to salinity and sulfate ions. In fish gill, less mucus secretion was observed due to salinity effects. Huge amount of vacoulation and melano macrophagecentres in liver was also observed in most of the fish species due to increased temperature in rivers. The Sundarbans region offer a wide arrangement of resources for diversifying livelihoods of fishers´, but climate change is reducing these options due to frequent extreme events. Specifically, climate change could reduce the resilience of fishers' communities, limiting options for diversification or forcing fishers to abandon their houses or villages.

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