

BOOK OF ABSTRACT

9th Biennial Conference & Research Fair 2022

28-29 May, 2022
Dhaka, Bangladesh

Sustainable Aquaculture, Resilient Fisheries & Overcoming Pandemic Challenges



**Bangladesh Fisheries Research Forum (BFRF), Bangladesh
Universiti Malaysia Sarawak (UNIMAS), Malaysia**



২০ মে হতে ২৩ জুলাই ৬৫ দিন

সাগরে মাছ ধরা সম্পূর্ণ নিষেধ



নিষিদ্ধকালীন মৎস্য আহরণ হতে বিরত থাকুন
সামুদ্রিক মৎস্য সম্পদ উন্নয়নে সহায়তা করুন

সাসটেইনেবল কোস্টাল এন্ড মেরিন ফিশারিজ প্রজেক্ট
মৎস্য অধিদপ্তর

পাতে ফিরছে সুবাসু সব দেশি মাছ

● বাংলাদেশ মৎস্য গবেষণা ইনস্টিটিউট (বিএফআরআই) গবেষণার মাধ্যমে বিলুপ্তপ্রায় ৩৪ প্রজাতির মাছের প্রজনন ও চাষাবাদ প্রযুক্তি উদ্ভাবন করেছে। দেশীয় অন্যান্য মাছ পুনরুদ্ধারে গবেষণা চলছে।

● প্রযুক্তি ব্যবহারের মাধ্যমে এক যুগে দেশীয় মাছের উৎপাদন বেড়েছে প্রায় ৪ গুণ (২.৫০ লক্ষ মে. টন)। ৫ শতাধিক হ্যাচারিতে দেশীয় মাছের পোনা উৎপাদন করা হচ্ছে।

● দেশীয় মাছ সুস্বাদু নেশে প্রথমবার লাইট জিন ব্র্যান্ড প্রদর্শিতা করা হয়েছে।

হালী / বহু	শেলা	ভলপা	বেয়েলী পাবনা	
পাবনা	দেশি সরপুঁচি	চাঁচরা	দেশি কৈ	শিং
মাছর	দারভিনা	জাতপুঁচি	বাটা	বালচাটা / পাথড়ি শুকুম
মেনি / বেদা	ভুকুম	খলিশা	ডোলা	ভুজি আইভ
গজার	হালি	চিতল	পদিয়া	কনিকাউপ
মহাপোশ	বৈগালি / বরাগি	জাপনা	আহসু / আভাচোমা	ফুর্শা / কাহাল বুশি
বাতালি	পুঁথ্যা / নাটোয়া	কবিনা	পিদালি	শইচ্যা চাঁচরা

প্রমুখিত সহায়তার জন্য যোগাযোগ
মোবাইল: ০১৭১১-৭০৪২১১, ০১৭৪৩-৫৪২২০৫, ০১৭১১-৪২১১১, ০১৭১৪-৩০৭৫০২
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বাংলাদেশ মৎস্য গবেষণা ইনস্টিটিউট
মৎস্য ও প্রাণিসম্পদ মন্ত্রণালয়

বাংলাদেশের সামুদ্রিক প্রজাতিসম্পদের টেকসই উন্নয়নের লক্ষ্যে বিএফআরআই কর্তৃক পরিচালিত
উন্নয়ন প্রকল্প

সামুদ্রিক মৎস্য গবেষণা জোরদারকরণ এবং অবকাঠামো উন্নয়ন

প্রকল্পের মূল উদ্দেশ্য

- নিরক্ষণ গবেষণার মাধ্যমে বাংলাদেশে বঙ্গোপসাগরের মৎস্যসম্পদের টেকসই উন্নয়ন ব্যবস্থাপনা কৌশল উদ্ভাবন
- বিএফআরআই এর সামুদ্রিক মৎস্য গবেষণা কেন্দ্রের অবকাঠামোগত উন্নয়ন, গবেষণাগার আধুনিকায়ন এবং প্রশিক্ষণের মাধ্যমে সামুদ্রিক মৎস্য গবেষণায় নিয়োজিত বিজ্ঞানীদের সক্ষমতা বৃদ্ধি

প্রকল্পের আওতায় চলমান উল্লেখযোগ্য গবেষণা কার্যক্রম

- সামুদ্রিক মাছের প্রাকৃতিক প্রজনন ও পোনা উৎপাদন
- বঙ্গোপসাগরের পরিবেশ ও জীববৈচিত্র্যের উপর মাইক্রোপ্লাস্টিক দূষণের প্রভাব নির্ণয়
- সামুদ্রিক মাছের প্রজননকালীন সময়ে মাছ ধরা নিষিদ্ধকরণে মুক্তিযুক্তকরণে মাছের প্রজনন সময় নির্ধারণ
- বঙ্গোপসাগরের সামুদ্রিক মাছের ক্যাটালগিং
- সামুদ্রিক মাছ, কঁকড়ার কৃষিম প্রজনন লাইভ ফিড গবেষণাগার স্থাপন
- বঙ্গোপসাগরের হাংগার এবং রে (Ray Fish) প্রজাতির জীববৈচিত্র্যের তথ্যিক ও ব্যবস্থাপনা কৌশল নিরূপণ
- বঙ্গোপসাগরে বাঁচায় মাছ চাষের স্ফূর্ততা বাড়াই

পৌষা

"সামুদ্রিক মৎস্য গবেষণা জোরদারকরণ এবং অবকাঠামো উন্নয়ন" প্রকল্প
বাংলাদেশ মৎস্য গবেষণা ইনস্টিটিউট

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Sustainable Aquaculture, Resilient Fisheries & Overcoming Pandemic Challenges

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Bangladesh Agricultural Research Council (BARC)
Dhaka, Bangladesh

Book of Abstract

- Aquaculture System
- Fisheries Biology, Genetics and Biotechnology
- Fish Feed and Nutrition
- Fish Disease and Health Management
- Aquatic Environment and Resources Management
- Coastal and Marine Fisheries
- Post-Harvest Processing and Value Addition
- Fish as Nutrition and Safe Fish Production
- Socio-economics and Policy Issues in Aquaculture & Fisheries



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Universiti Malaysia Sarawak (UNIMAS), Malaysia**

9th Biennial Fisheries Conference & Research Fair 2022

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Book of Abstract

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Bangladesh Fisheries Research Forum & Universiti Malaysia Sarawak . 2022. Book of Abstract. 9th Biennial Fisheries Conference & Research Fair 2022. BFRF, Dhaka, Bangladesh. 174 p.

Foreword

Bangladesh Fisheries Research Forum (BFRF) is a national, non-political and non-profit professional organization, which has been involved in developing a network among the fisheries professionals working in different universities, Department of Fisheries, Fisheries Research Institutes, Bangladesh Fisheries Development Corporation, other national and international research and development organizations, non-government organizations, and private sectors in Bangladesh. The novel objective of BFRF is to share and exchange views, knowledge and experiences of the stakeholders gained through innovative and adaptive research, extension and development activities for advancement in the fisheries sector in order to increase fish production, poverty alleviation and livelihood improvement of the rural and urban poor people.

Since its establishment in 2004, BFRF has been organizing Biennial Fisheries Conference and Research Fair in a regular basis. Academicians, fisheries scientists, extension agencies and other relevant stakeholders from home and abroad join the great event with enthusiasm and present their research findings through oral and poster presentations. In addition, displaying the present research and development activities, this event provides an ample opportunity to identify/find out future researchable issues and to formulate recommendations for relevant policy makers and planners to undertake and implement the programs. It is worthy to mention that the 9th Biennial conference entitled “**Sustainable Aquaculture, Resilient Fisheries & Overcoming Pandemic Challenges**” is jointly organized by BFRF and Universiti Malaysia Sarawak (UNIMAS), Malaysia. For the conference, we received more than 172 Abstracts and among them about 80 Abstracts will be presented in 8 technical sessions and rest of them will be presented in poster sessions. There will be a provision to honour the best oral presenters as well as the best posters. Besides, the valuable scientific innovations will be published in the Scopus journal with the help of our distinguished conference partner, UNIMAS. In the inaugural session, BFRF will present confer the life-time achievement award to the Eminent Scientists for their outstanding contribution in the development of fisheries education and research in Bangladesh.

I, on behalf of the Editorial Committee, candidly appreciate the contributors to this Book of Abstracts and look forward to their presentations in the conference. To make the mega scientific event successful, we pursued and received enormous supports from our well-wishers, partners, private sectors, policy makers, donors and NGOs specially the FAO and Worldfish, which are gratefully acknowledged. I would like to thank and express my gratitude to all of the Executive Committee members for their continual assistance, and enthusiastic efforts of the Editorial Committee members for making the two-day event glorious.

Finally, I hope this book of abstracts of the conference will serve as a hub of information of presently explored research areas and their outputs and facilitate in identifying new state-of-the-art research zones for further development of the fisheries sector of the country.

Dr. Md. Rafiqul Islam Sarder

President, Bangladesh Fisheries Research Forum

and

Professor, Bangladesh Agricultural University, Mymensingh

Message from Vice Chancellor of UNIMAS

Assalamualaikum Warahmatullahi Wabarakatuh

It is my great pleasure to welcome all delegates that are present at BFRF for participating. Bangladesh Fisheries Research Forum (BFRF) and Universiti Malaysia Sarawak (UNIMAS) jointly organize this conference.

I am most grateful to Allah, the most gracious and most merciful, for His blessings in giving us this precious opportunity to gather at this memorable event. The **9th Biennial Fisheries Conference and Research Fair 2022** with the theme: "*Sustainable Aquaculture, Resilient Fisheries & Overcoming Pandemic Challenges*" takes an in-depth look at the many issues raised by sustainable aquaculture practices on today, the obstacles and opportunities created by the new products, services and applications. This conference is a step towards achieving our vision in becoming an excellent academic and research institution in order to produce human capital with first class mentality.

I am glad that UNIMAS is given the opportunity to share its aquaculture and fisheries experiences with 5th highest global aquaculture production country 'Bangladesh' through this event. The 2020 edition of *The State of World Fisheries and Aquaculture* continues to demonstrate the significant and growing role of fisheries and aquaculture in providing food, nutrition and employment. It also shows the major challenges ahead despite the progress made on a number of fronts. For example, there is growing evidence that when fisheries are properly managed, stocks are consistently above target levels or rebuilding, giving credibility to the fishery managers and governments around the world that are willing to take strong action. However, the report also demonstrates that the successes achieved in some countries and regions have not been sufficient to reverse the global trend of overfished stocks, indicating that in places where fisheries management is not in place, or is ineffective, the status of fish stocks is poor and deteriorating. This unequal progress highlights the urgent need to replicate and re-adapt successful policies and measures in the light of the realities and needs of specific fisheries. It calls for new mechanisms to support the effective implementation of policy and management regulations for sustainable fisheries and ecosystems, as the only solution to ensure fisheries around the world are sustainable. Through this conference, it is hoped that we can ensure sound scientific research for sustainable use of global aquaculture resources. At the same time, we can preserve the traditional knowledge, and empower the local communities in the root level aquaculture industries.

I would like to take this opportunity to congratulate the organizing committee and the co-organizers for their tremendous effort in making this conference possible.

Last but not the least, I wish all delegates to have fruitful deliberation.

Thank you.

Wabillahi Taufiq Wal Hidayah, Wassalamualaikum Warahmatullahi Wabarakatuh.

Professor Datuk Dr Mohamad Kadim Bin Suaidi
Vice Chancellor

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EFFECT OF PROBIOTIC AND BIOFLOC ON GROWTH AND HEMATOLOGICAL INDICES OF POOL BARB *Puntius sophore*

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With the objectives of to determine the effect of probiotic and biofloc on growth responses and blood hematology, *P. sophore* was collected from the local fishermen of Mymensingh district and transported to the GFB laboratory, BSMRAU. The fish were housed for up to 30 days at room temperature (~ 26 °C) and feed with a commercial diet. Fish were fed with three different types of feeds. The experiment was designed into three treatments providing with commercial diet (T1), biofloc (T2) and probiotic containing diet (T3). Each tank contained 25 fish. Under each treatment, three replicates were used. Commercial diet (T1) was used as control diet. Fish were fed up to their satiation. For growth measurement, Body Weight Gain (BWG), Food Conversion Ratio (FCR), Food Conversion Efficiency (FCE), Specific Growth Rate (SGR), Relative Growth Rate (RGR) and Daily Growth Rate (DGR) were measured. In probiotic treatment BWG, FCE, SGR, RGR and DGR were significantly higher than biofloc and control treatments ($p < 0.05$) whereas, FCR in probiotic treatment was significantly lower than others ($p < 0.05$). All the haematological parameters in three treatments were within the normal range and there is no significant difference among the treatments ($p > 0.05$) except RBC. The level of in probiotic treatment ($2.55 \pm 0.11 \times 10^6 \text{ mm}^{-3}$) was significantly higher than control ($p < 0.05$). Overall, the probiotic treatments showed best performance. This study provides the baseline report of *P. sophore* and indicates that probiotic treated diet might be suitable for domestication of this indigenous species in captivity.

Keywords: Probiotics, Biofloc, *Puntius sophore*

Table 1. Levels of hematological parameters in fish reared at three different diets for 8 weeks

Parameter	Treatments			Analysis of variance			
	Control	Probiotic	Biofloc	Adj SS	Adj MS	F	P
WBC	45.57 ± 1.84 ^a	49.64 ± 6.08 ^a	54.57 ± 5.92 ^a	609.6	304.82	8.26	0.019
LYM	72.00 ± 0.90 ^a	69.33 ± 6.13 ^a	81.00 ± 8.16 ^a	224.2	112.11	2.13	0.199
MON	4.30 ± 0.16 ^a	4.90 ± 0.16 ^a	5.10 ± 0.41 ^a	1.04	0.52	4.73	0.059
GRA	14.70 ± 0.57 ^a	16.10 ± 0.65 ^a	16.53 ± 1.15 ^a	5.51	2.75	2.66	0.149
RBC ($\times 10^6 \text{ mm}^{-3}$)	0.96 ± 0.12 ^b	2.55 ± 0.11 ^a	1.94 ± 0.75 ^{ab}	3.85	1.92	6.48	0.032
Hb (g dL ⁻¹)	11.95 ± 1.41 ^a	12.27 ± 2.21 ^a	11.30 ± 1.93 ^a	1.46	0.73	0.14	0.874
HCT (%)	38.27 ± 1.51 ^a	41.67 ± 1.17 ^a	38.97 ± 0.26 ^a	19.29	9.64	5.19	0.049
MCV (pg)	407.21 ± 67.04 ^a	163.86 ± 6.70 ^b	237.62 ± 100.01 ^{ab}	93424	46712	6.43	0.032
MCH (fl)	128.00 ± 10.61 ^a	48.35 ± 5.43 ^c	72.88 ± 5.13 ^b	9984.1	4992.03	59.27	0.000
MCHC (%)	31.13 ± 2.45 ^a	29.35 ± 4.63 ^a	29.01 ± 4.99 ^a	7.76	3.89	0.15	0.865
RDWC	18.77 ± 2.12 ^a	18.93 ± 0.69 ^a	17.37 ± 0.90 ^a	4.44	2.22	0.77	0.506
PLT ($\times 10^3 \text{ mm}^{-3}$)	23.01 ± 0.91 ^c	34.07 ± 1.72 ^a	29.00 ± 1.63 ^b	183.69	91.84	28.50	0.001

*Data in a row with different superscripts denote significant difference ($p < 0.05$)

STUDY ON THE EFFECTIVENESS OF OXYGEN-GENERATING CHEMICALS AND AERATOR USED IN AQUACULTURE IN BANGLADESH

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An experiment was conducted to assess the effectiveness of oxygen generating chemicals and aerator used in aquaculture from 25th June to 8th August 2019 at wet lab, Faculty of Fisheries in PSTU. The experiment designed in 12 buckets with 4 treatments namely T₁ (Aerator), T₂ {Aci-Ox, (2Na₂CO₃·3H₂O)₂ 1 mg/l}, T₃ {Oxy-Ren, (2Na₂CO₃·3H₂O)₂ 1mg/l} and T₄ {Potassium permanganate (KMnO₄) 4mg/l} each having 3 replications. Two types of water such as pond water and underground water were used. Two carps fish (Rohu and Catla) averaged 120 gm in weight were stocked per bucket checking oxygen saturation level. Dissolved oxygen was measured first after one hour then two hours and then at three hours (3) interval after applying those oxygen generating media. The DO content was higher in T₁ (Aerator), 6.7 mg/l for underground water and 5.6 mg/l in pond water comparing with T₂ (underground water 5.2mg/l and pond water 4.2mg/l), T₃ (underground water 5.2 mg/l and pond water 4.3 mg/l) and T₄ (underground water 5.4 mg/l , pond water 4.4mg/l). In T₄ (KMnO₄) DO concentration was 5.4 mg/l at 3rd hour after applying 4 ppm dose in underwater and similarly 4.3 mg/l in pond water and then observed decreasing trends in latter hours. In T₂ (Aci-ox) and T₃ (Oxy-ren) efficiency level of generating oxygen in water were found to below 5.2 mg/l, and 5.3 mg/l in underground and 4.2 mg/l and 4.3mg/l in pond water, respectively comparing with initial oxygen level of 5 mg/l after one hour of application. Only 17% of H₂O₂ present in Oxy-ren and Aci-ox tablets are not enough for generating oxygen in critical moment in water. An inverse relationship was observed between DO and temperature in this study. The experiment tried to find out the effectiveness by using different doses (1, 2 and 3g) of Bio-ox (T₂) and Oxy-ren (T₃) in both pond and underwater treatment, but it was not generated proper oxygen. T₄ (KMnO₄) was more effective in underground water; stability was 2 and 3 hours after applying doses. DO at 5.4 mg/l was generated after using of KMnO₄ where initial DO was 5.1mg/l in underground water and 4.3mg/l in pond water. From the comparison with aerator and chemicals regarding effectiveness of generating oxygen level in water in the presence of fish, it was found that aerator is more efficient safe medium than chemicals used in aquaculture.

Keywords: Dissolve oxygen, Chemicals, Temperature

ASSESSMENT OF SUITABLE ORGANIC CARBON SOURCE FOR TILAPIA (*Oreochromis niloticus*) CULTURE IN BIOFLOC TECHNOLOGY

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Effective organic carbon sources are key substances for floc formation of Biofloc Technology (BFT) which ultimately controls water quality and helps in fish and shrimp production. This study was designed to identify the suitable carbon sources for Nile tilapia (*Oreochromis niloticus*) in the biofloc system. Two carbon sources (Corn flour, Wheat flour) were evaluated using 80 L tank supported by aeration facilities to keep the dissolved oxygen (DO) more than 5 mg/L. A treatment without a carbon source was used as control. Fingerlings of tilapia of average 10 grams weight were stocked. Stocking densities were 15 fingerlings/tank for a culture period of 42 days. A total of three treatments were applied including Treatment-1 (control), Treatment-2 (Wheat flour), and Treatment-3 (Corn flour) with three replications of each treatment. The average temperature of all treatments was maintained at 25 to 28°C using a thermostat. The dissolved oxygen level was 5-6 mg/L. The average NH₃ level in treatment-3 was found to be the lowest (0.12 ppm) and the highest NH₃ level (0.61 ppm) was recorded from Treatment-1. No significant mortality was observed during the experimental period. Corn flour showed the highest survival rate (93.33%) and the lowest (73.33%) was observed in the control treatment. The final weight gain of fish was also found to be highest in Treatment-3 and it was 15.67 g. It was observed from the study that the application of corn flour as a carbon source showed better performance in biofloc-based tilapia culture.

Keywords: Biofloc technology, Tilapia, Carbon source

**GROWTH PERFORMANCE OF FOUR DIFFERENT FISH SPECIES (*C. striata*,
L. rohita, *C. idella* and *C. batrachus*) CULTURED UNDER IN-POND RACEWAY
SYSTEM (IPRS) AT JASHORE DISTRICT OF BANGLADESH**

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The is one of the modern and fast-growing aquaculture systems in the world, which is just at the experimental stage in Bangladesh. The present research was conducted to observe the growth performance of four commercially important fishes such as *Labeo rohita*, *Ctenopharyngodon idella*, *Channa striata*, *Clarias batrachus* in four concrete chambers (cell) of IPRS (In-pond raceway system). The experiment was performed at the Afil Aqua Fish Ltd., Sharsha, Jashore for a period of 90 days from October 1st 2021 to December 30th 2021. The pond was 2.23 hectares of which 880 m³ was used for four production cells, and each cell size was 220m³. A total of 13000, 4000, 16000, and 152000 individuals with the stocking density of 50/m³, 15/m³, 65/m³ and 552/m³ of *L. rohita*, *C. idella*, *C. striata* and *C. batrachus*, respectively were stocked in each IPRS cell. The average initial weight were 300.46±3.66g, 182.66±1.04g, 285.81±1.19g, 4.46±0.38g for *C. striata*, *L. rohita*, *C. idella* and *C. batrachus*, respectively. Stocked fishes were fed at different percentages (7% to 3%) of their body weight. Water quality parameters such as water temperature, pH, DO and ammonia were recorded at 25.93±0.39, 7.93±0.24, 6.41±0.32 mg/L and 0.024±0.01 mg/L, respectively. Fishes were checked by random sampling fortnightly. The average final weight were 1006.25±4.03g, 399.6±1.67g, 3195.76±1.52g and 170.34±2.11g for *C. striata*, *L. rohita*, *C. idella* and *C. batrachus*, respectively. Though the highest weight increment noticed in *C. idella* (2909.95±2.07 g) but the highest production (11302.15 kg per hectare) gained from *C. batrachus* due to higher stocking density. *C. idella* produced with the highest average daily gain of 27.71±0.25 g/day. *C. idella* and *C. batrachus* had the highest growth performance, whereas *L. rohita* had relatively less growth response in IPRS. Therefore, in terms of growth performance, *C. idella* and *C. batrachus* would be most suitable species for the adaptation and commercialization of IPRS in Bangladesh.

Keywords: IPRS, *Labeo rohita*, *Ctenopharyngodon idella*, *Channa striata*, *Clarias batrachus*

Table 1. The average (±SD) values of weight increment (g), daily gain (ADG g/day), SGR (%), FCR and PER of four species in IPRS

	<i>C. striata</i>	<i>L. rohita</i>	<i>C. idella</i>	<i>C. batrachus</i>
Weight increment	705.79±1.26	216.94±2.24	2909.95±2.07	165.88±2.20
ADG	6.72±0.69	2.06±0.42	27.71±0.25	1.58±0.51
SGR (%)	1.34	0.86	2.68	4.04
FCR	0.8	1.2	0.9	0.9
PER	3.9	2.6	3.4	3.4

PRESENT STATUS OF MUD EEL (*Monopterusuchia*) IN DINAJPUR DISTRICT, BANGLADESH

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The freshwater mud eel (*Monopterusuchia*) has a high export demand due to its nutritional and medical values which could play an important role to uplift the socio-economic condition of fish farmers in Bangladesh. The survey was carried out to understand the present status of mud eel culture in Dinajpur district of Bangladesh. In this study, it was found that the highest number of farmers involved in mud eel culture were hindus and ethnic community (90.30%) whereas mostly female farmers practiced culture in the study region. The education level of 40.38% of respondents was up to the primary level and most of the farmers (67.31%) had a nuclear family. The pond area used to culture mud eel was within 0.5-1.5 decimal in size with an average depth of 3ft. The mud eel was cultured in a combination of other fish species including shing (*Heteropneustes fossilis*), magur (*Clarias batrachus*), koi (*Anabas testudineus*), tilapia (*Oreochromis niloticus*), and Indian major carps. However, it was also found that most of the mud eel farmers (94.23%) used ditched to culture mud eel using plastic, net, triple, bamboo, and other necessary tools to hold water and to prevent the scraping of *M.uchia* from the pond. Farmers supplied different feed including earthworm, river loach, small fish, fingerlings of carp, silkworm pupae, and snail. The study also revealed that about 80.77% of farmers used to take regular farming advice on mud eel farming from aquaculture experts from different NGOs. Farmers reported various problems such as technical, financial, and social issues during cultivation. This study provides baseline information about mud eel culture, their subsistence, and recent practice in the northern region of Bangladesh. Proper training, financial help, and management practice can generate employment directly and indirectly for more people through culture, marketing, and other associated business in the study area.

Keywords: *Monopterusuchia*, Dinajpur

DEVELOPMENT OF SUSTAINABLE AQUACULTURE TECHNIQUE USING AQUATIC MACROPHYTE ASIAN WATER GRASS (*Hygroryza aristata*) AS FEED IN THE COASTAL WETLANDS OF BANGLADESH

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The price of commercial fish feed increased globally which threatens aquaculture as well as food security of poor people all over the world and creates problem for sustainable aquaculture development. Asian watergrass contains desired amount of nutrients and is preferred food of some species of fish particularly the grass carp as well as tilapia and silver barb. This macrophyte can be used as fish feed directly as raw condition or as feed materials in aqua feeds development to reduce aquaculture production cost. An experiment was conducted under four treatments each with three replications using solely *Hygroryza aristata* aquatic macrophyte as fish feed in the tidally inundated coastal wetlands of Bangladesh for six months. Grass carp, common carp, tilapia, mrigal and silver barb were stocked with a similar density at 12,500 fish ha⁻¹ in all treatments, but the species combinations were different among the treatments. The aquatic macrophyte was planted and grown on the bottom soil before stocking of fish in each treatment as feed. Other than the aquatic macrophyte, no feed or fertilizer was applied throughout the study period. Important water quality parameters were measured throughout the study period those were suitable and acceptable range for aquaculture. The survival, growth (weight gain and specific growth rate-SGR) and total production were calculated. The survival of fishes varied from 66.67±8.25 to 91.20±2.88% irrespective of fish species. The growth and total production were found significantly highest in T₃ (5579.04±238.74 kg ha⁻¹) followed by T₂ (4582.21±200.01 kg ha⁻¹), T₄ (4571.52±189.78 kg ha⁻¹) and T₁ (4448.37±237.26 kg ha⁻¹). The findings indicated that the grass carp, common carp, tilapia and silver barb at the ratio of 7.5:1:1:1 with a density of 12,500 fish ha⁻¹ is ideal for polyculture using *H. aristata* aquatic macrophyte as fish feed in the coastal wetlands of Bangladesh. The coastal people are encouraged to apply his technology in their poorly used coastal wetlands that enhance their livelihood as well as increase the total national fish production and economy of the country.

Keywords: Aquaculture, Coastal wetlands, Asian watergrass, Fish production

DOES FARM SIZE AND CULTURE SYSTEMS AFFECT THE PRODUCTIVITY AND PROFITABILITY OF FARMED TILAPIA AQUACULTURE IN BANGLADESH?

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Tilapia is an internationally important fast-growing aquaculture commodity that has high potential for production in Asian region including Bangladesh. However, production varies over farms characteristics including farm size, farming systems and locations. Therefore, using 247 randomly selected Tilapia farmers from 3 major producing districts, this study assesses whether farm size, culture systems and locations affect the productivity, production costs, profitability and the importance of inputs (e.g. seed, feed, fertilizer and labor) in tilapia production under different farm size, location and culture system in Bangladesh. The results showed that production costs, total returns, net returns and BCR were slightly higher in medium and large farms than small farms. The BCR was greater than one (1) for all categories of farms (1.27–1.34) and for all culture techniques (1.13–1.29) which indicated tilapia production is a profitable business. The regression analysis showed that stocking density, feed, labor, lime and water supply were important factors for increasing farm production suggesting more attention should be paid to these parameters for increasing fish production for all the farmers. The results showed that farmers have the scope to increase fish production; however, they need to be economically efficient to sustain tilapia production in the long run. Allocative efficiencies for stocking density, feed, labor, lime, salt, fertilizers and water supply suggest the potential of increasing farm productivity as well as profitability by increasing these inputs. But the use of some of these inputs were found to be inefficient in some farm categories (e.g. labor and fertilizer use in small and large farms, water supply in medium farms, salt use in large farms, respectively) and the application of fertilizer and medicine and feed additives in large farms were found to be efficient. All these results suggest that there is a wide scope to improve production practices of tilapia farming and farmers should be more careful with their use of these variable inputs, in order to improve productivity of the farms.

Keywords: Farmed tilapia, Farm size, Cob-Douglas production function, CFI

**POTENTIAL TOXIC ELEMENTS IN SEDIMENT FROM THE OLD BRAHMAPUTRA
RIVER AT MYMENSINGH, BANGLADESH:
A PRELIMINARY ASSESSMENT FOR ECOTOXICOLOGICAL RISK**

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The study was conducted to investigate the concentrations, distributions, possible sources and potential ecological risk of heavy metals in sediments of the Old Brahmaputra River during the period from July to December 2021. The sediment samples were collected from five different sampling stations (Table 1). The results of the study showed that mean concentrations (mg/kg) of heavy metals were in the order of Ni (58.82) > Cr (32.45) > Pb (21.04) > Cu (14.24) > Cd (3.81) > As (2.02) (Table 1). Spatially the sedimentary metals contents were varied significantly. Source analysis revealed that anthropogenic origin for most of the metals abundances. Element-specific environmental indices revealed that the ecological risks followed the descending order as Cd > Ni > Pb > As > Cu > Cr. According to the sediment quality guidelines, only Ni and Cd were high enough to cause detrimental effects in aquatic organisms. The potential ecological risk factor and potential ecological risk also revealed low to moderate ecological risk. Comprehensively, the river sediments were in the uncontaminated to moderately contaminate with low ecological risk. The study concluded that the river is subjected to anthropogenic disturbances to some extent. Proper management initiatives should be carried out immediately to maintain sound and healthy aquatic environment of the River.

Keywords: Heavy metals, Old Brahmaputra River, Ecological risk

Table 1. Elemental abundances (mg/kg) in sediments of the Old Brahmaputra River

Stations	Heavy metal concentrations (mg/kg)					
	Cr	Ni	Cu	Cd	Pb	As
S1 (ZainulAbedin Park Site)	30.51	58.82	13.89	4.36	32.29	1.07
S2 (ThanarGhat Site)	41.50	53.92	22.09	4.36	23.96	3.24
S3 (Shambhuganj Bridge Site)	37.28	53.92	11.64	4.92	26.04	1.93
S4 (Kewatkhali Boat Ghat Site)	29.06	78.43	14.05	4.92	15.63	2.02
S5 (BAU Botanical Garden Site)	23.91	49.02	9.53	0.47	7.29	1.85
Mean (n=15)	32.45	58.82	14.24	3.81	21.04	2.02
SD (±)	6.95	11.50	4.76	1.89	9.73	0.78
CV (%)	21.43	19.54	33.44	49.55	46.22	38.53
BV (Background value)	92.00	47.00	28.00	0.09	17.00	4.80
LEL (Lowest effect level)	26.00	16.00	16.00	0.60	31.00	6.00
TEL (Threshold effect level)	37.00	18.00	36.00	0.59	35.00	5.90
PEL (Probable effect level)	90.00	36.00	197.00	3.50	91.00	17.00

ASSESSMENT OF HERBAL EXTRACTS FOR GROWTH AND NUTRITIONAL QUALITY OF JUVENILE FRESHWATER PRAWN (*Macrobrachium rosenbergii*) UNDER BIOFLOC TECHNOLOGY

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To assess the potentiality of *Macrobrachium rosenbergii* culture, growth performance and its nutritional quality in Biofloc Technology (BFT), a study was conducted at Biofloc Lab, Sher-e-Bangla Agricultural University from July to November, 2020. Total five treatments were applied including T-1 (Control), T-2 (Extract of Ginger), T-3 (Extract of Amla), T-4 (Extract of Garlic) and T-5 (Extract of Garlic and higher stocking) with three replications. The initial mean stock weight of prawns was 3.14 ± 0.19 , 3.04 ± 0.27 , 3.26 ± 0.16 , 3.36 ± 0.06 and 3.02 ± 0.36 g in T-1, T-2, T-3, T-4 and T-5 respectively. After completing the study duration, the highest mean weight gain and percentage weight gain were 10.9 ± 0.3 g and $297.8 \pm 16.2\%$ noticed in the T-3. The survival rate was maximum ($99.5 \pm 0.8\%$) in the control treatment. The best FCR and SGR were 1.2 ± 0.1 and 2.1% also noticed in the T-3. During the research 35% protein containing commercial feed was given and floc was produced at balanced level which was found 21.7% protein. From the proximate composition analysis, the highest protein percentage of prawn $74.13 \pm 0.68\%$ was found in the T-3. Using extract of amla as feed additive provided the best growth performance and nutritional value for *M. rosenbergii* culture compared to other treatments and also tells the immense possibility of freshwater prawn culture in biofloc in the era of modern aquaculture for mitigating the demand of animal protein.

Keywords: Biofloc, *Macrobrachium rosenbergii*

EFFICACY OF NATURAL AND ARTIFICIAL ATTRACTANTS IN THE DIETS OF SOFT SHELL MUD CRAB

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Commercial farming of soft-shell mud crab in coastal region of Bangladesh has been successfully running over the past two decades with trash fish as crab feed. Future sustainable crab farming needs the replacement of crab feed with artificial diets. No progress has been done yet to culture wild crab with formulated diets. This study has been conducted to formulate a commercial diet for soft-shell mud crab in closed floating cage farming. We did a series of experimental trials with different rations including different concentration of natural, artificial and mixed attractants in laboratory and farm level. The growth rate and molting duration were evaluated by providing different diets and compared with trash fish in four experiments. Trash fish performed better in most trials but diet prepared with nappi, semi-fermented squid paste and glycine performed nearly the same level as trash fish. Furthermore, diet made with nappi and glycine outperformed trash fish. In first three experiments, significantly ($p < 0.05$) higher weight gain, better SGR and lower molting duration were observed in control (trash fish) compared to other treatments. Based on the findings of the first three trial, we developed more potential diets having combined attractants and compared with trash fish. In this trial, diet made with nappi+glycine showed significantly ($p < 0.05$) higher weight gain (65.15 ± 12.5 g) and lower molting duration (36.2 ± 5.9 days) compared to other treatments. However, higher SGR (0.68 ± 0.104 days) were found in control (Trash fish). Overall, in context of FCR and total yield, diet prepared with nappi+glycine showed significantly ($p < 0.05$) lower FCR (1.45) and higher total yield (1954.6 g) compared to other treatments of all four experiments. The result of this study demonstrated that mud crabs accept formulated diets. For better performance, hatchery produced and domesticated crablets should be used. Hence, the development of specific diets for crabs is technically possible by conducting further study on the performance of mud crab at different protein levels and by inclusion of different protein sources in artificial feed.

Keywords: Soft-shell crab, Nappi, Crablet

**CULTURE PRACTICE AND NUTRITIONAL COMPOSITION OF RED SEAWEED
(*Gracilaria tenuistipitata*) IN THE COAST OF BAY OF BENGAL**

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Seaweed is the nutritious algae containing important nutrients for health. There are three types of seaweed available in Bangladesh e.g. green seaweed, red seaweed and brown seaweed. Among them red seaweed *Gracilaria tenuistipitata* is one of the commercial important species available in the coast of Bay of Bengal. In this study, data were collected from seaweed demonstration plot of Bangladesh Agricultural Research Institute in the Cox's Bazar region including Nuniarchara, Naziratek and Rejukhal. Rope-line method was applied for the culture of seaweed. Total 18 ropes, each with 10 meters were placed in three locations. Line to line distance was 15 cm. Average 2.0 gm seed was placed in each 20cm intervals and total 50 seeds were planted in a rope. Seaweed was collected every 20 days interval. Each rope produced about 20 to 25 kg fresh seaweed in each sampling period. All the sites produced average 120 to 130 kg of red algae in a culture period of 6 months. The local market price of fresh seaweed is 25-30 tk/kg and dry seaweed is 150-200 tk/kg. Collected sample was washed and sundried for the laboratory analysis. After proximate analysis it was found that red algae contained protein (20.12%), lipid (2.45%), carbohydrate (28.54%), moisture (11.98%), ash (36.91%) and fiber (3.12%). The rope line method for seaweed culture is easy and cost-effective method that coastal inhabitants can easily afford. Nutritional analysis proved that it is very healthy food item for human consumption. Seaweed and macroalgae can create social and economic benefits to large number of households, basically in coastal people, including coastal women empowering by seaweed cultivation. Seaweed culture could be one of the important items for blue economy and economic development of the country.

Keywords: Seaweed, *Gracilaria*, Nutrient, Blue-economy

AN INVESTIGATION INTO FRESHWATER PRAWN *Macrobrachium rosenbergii* FARMING IN DINAJPUR DISTRICT, BANGLADESH

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A survey based investigation was carried out to understand the present status of freshwater prawn (*Macrobrachium rosenbergii*) farming in Dinajpur district, Bangladesh for a period of one year. The study revealed that prawn was cultured in polyculture systems with finfish in ponds (94.64%) and rice fields (5.36%). Among the farmers, males were 94.64%, and the highest number of the farmers (44.64%) belonged to the age group of 31-40 years. Education level of 64.28% respondents was up to the primary level. Pond areas of just over half of the respondents (51.78) were less than 0.50 acre with an average depth of 1.52 m, and Approximately half of the farmers (51.79%) relied on both groundwater and rain water (51.79%) for culture. Solely farm made feeds were applied by 41.07% of the farmers and commercial feeds by 30.36%. Most of the farmers (66.07%) had no knowledge on nutrient profile of the feeds, and 73.21% farmers had no feed storage facilities. Feeds were applied manually twice daily by over half of the farmers (53.57%). Farm made feeds were formulated using rice bran, rice flour, maize bran, wheat bran, wheat flour, etc. Different social, technical and financial problems faced by farmers were unavailability of seed, electricity, higher price of seed and feed, lack of proper knowledge about prawn farming, etc. The baseline information unpacked that prawn culture was a subsistence and recent practice, and not adopted well by the farmers. Prawn culture can contribute to uplift the socioeconomic status of the farmers as the prawn is a high value cash crop.

Keywords: *Macrobrachium rosenbergii*, Polyculture, Dinajpur

IS AQUAPONICS SYSTEM SUITABLE FOR EMPURAU (*Tor tambroides*) FRIES NURSERY?

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Long-term use of the recirculated water for fish and crop production in the aquaponics system is the major concern in sustainable aquaculture for deteriorating water quality that led to explore the alternative way of short-time use of recirculated water in the aquaponics system which can be in nursery management. Three individual aquaponics (nutrient film “NFT,” deep water “DWC,” media bed “MBD”) along with a new combined aquaponics system (CAS) were used to explore the most suitable aquaponics system for empurau fries nursery. It was done by determining the comparison of growth performance and survival of fish fries and plants along with the cost-benefit analysis among four aquaponics systems. The study was conducted in two phases. Phase 1 comprised of determining the effectiveness test of filters in newly designed CAS and the selection of suitable plant for the second phase. The suitability test for the selection of an aquaponics system for empurau fries nursery was done in the second phase. The polyculture technique was adopted in both phases. The newly designed CAS with filter and the leafy vegetables (*Apium graveolens* var. *secalinum*) were selected from the first phase for further study in second phase. The suitability results in the second phase exhibited that the NFT aquaponics system was significantly better than others. Therefore, the study suggests using the NFT aquaponics system for empurau (*Tor tambroides*) fries’ nursery in short term.

Keywords: Aquaponics system, Nutrient film technique, Polyculture, Leafy celery

IMPACT OF AQUA DRUGS AND CHEMICALS ON FISH HEALTH MANAGEMENT AND PRODUCTION IN GOLAPGANJ UPAZILA, SYLHET

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The study was conducted to identify different aqua drugs & chemicals used by the fish farmers and evaluate their impact on fish health and production in Golapganj Upazila, Sylhet. A survey was carried out for a period of six months from March to August 2021 with 80 fish farmers of carp polyculture, mono-sex tilapia and pangasius culture. Data were collected from fish farmers through questionnaire interview. Thirty aqua drugs and chemicals generally used by the fish farmers were recorded. These aqua drugs and chemicals exerted positive impacts on fish health management while they were applied as disinfectants, oxygen suppliers, toxic gas remover, probiotics, vitamins and growth promoters, etc. Lime was found the most common local aqua chemicals used by the all fish farmers carrying with 95% of effectiveness. This study found the users of disinfectants, oxygen supplier, toxic gas remover, growth promoter, probiotics and vitamins were 91.66%, 70%, 81.66%, 70%, 63.33% and 53.33%, respectively carrying with 90%, 85%, 85%, 80%, 80%, and 80% of effectiveness. Aqua drugs and chemicals showed tremendous success in diseases recovery and the highest recovery rate of EUS, Dropsy, Tail and fin rot diseases, Popeye, Gill diseases, Argulosis, Columnaris were 85%, 85%, 80%, 90%, 85%, 80%, 80%, respectively. Aqua drugs and chemicals also showed significant impacts on fish production. Average carp production in the treated pond is almost 1.38 times higher than that of the control pond. At similar points, the average production of mono sex Tilapia and Thai Pangas in treated ponds were also 1.33 and 1.27 times higher than that of control ponds, respectively. This study indicates the positive impacts of aqua drugs and chemicals on fish health and production using in different culture methods.

Keywords: Aquadrugs, Chemicals, Probiotics

A COST-BENEFIT ANALYSIS OF THE FARMING DIFFERENT FISH SPECIES UNDER IN-POND RACEWAY SYSTEM (IPRS) AT JASHORE, BANGLADESH

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In-pond raceway system (IPRS) is one of the modern and fast-growing fish farming systems in the world, which is introduced very recently in Bangladesh. To adopt and commercialize such a high-cost farming system in the country, it is an urgent need to estimate the cost-effectiveness for the local condition. In this regard, the present study was conducted to estimate the cost-benefits of the farming of four popular and demanding fishes, like *Labeo rohita* (Rohu), *Ctenopharyngodon idella* (Grass carp), *Channa striata* (Striped snakehead) and *Clarias batrachus* (Walking catfish) under IPRS for 90 days from 1 October 2021 to 30 December 2021 at Afil Aqua Fish Ltd., Sharsha, Jashore. A total of 13000, 4000, 16000 and 152000 individuals of *L. rohita*, *C. idella*, *C. striata* and *C. batrachus* were stocked, respectively in each IPRS cell. The four IPRS cells (each with 220 m³) were established within 2.23 hectares pond with well-equipped water raceway system. Stocked fishes were fed with commercially formulated feed of Afil Group at four times a day. Fishes were sampled randomly on fortnightly-basis to monitor the growth performance, health condition and their survival rate. At the same time, water parameters were also monitored to optimize the aquatic health condition. At the end of the 90-day rearing, the total production were estimated from a single cell of IPRS at 5198.8, 12783, 16099.9, and 25879.8, respectively. The total production per hectare were 2331.3, 5732.3, 7219.7 and 11605.2 kg for *L. rohita*, *C. idella*, *C. striata* and *C. batrachus*, respectively. Capital investment was converted into monthly depreciation cost by dividing it through the project life. The total cost of each species was calculated by the addition of depreciation cost and operating costs of three months for four different species. The cost-benefit ratio was 1.19, 3.11, 2.07 and 3.20 for *L. rohita*, *C. idella*, *C. striata* and *C. batrachus*, respectively. It has been revealed that *C. batrachus* showed the biggest figure in respect of higher benefits whereas the lowest outcome found in *L. rohita* among the experimented fishes. Thus, *C. batrachus* would be one of the commercial candidates for the adaptation and commercialization of IPRS in Bangladesh.

Keywords: IPRS, Cost-benefit, *Labeo rohita*, *Ctenopharyngodon idella*, *Channa striata*, *Clarias batrachus*

**ASSESSMENT OF GROWTH PERFORMANCE AND WATER QUALITY
PARAMETERS OF SNAKEHEAD *Channa striata* AND CATFISH *Mystus cavasius*
IN A BIOFLOC BASED COMMERCIAL AQUAFARM**

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Biofloc System (BFT) is considered as intensive aquaculture of commercially important species of fishes. An experiment was designed to assess the growth performance and water quality parameter of Snakehead (Shol) *Channa striata* and Catfish (Gulsha) *Mystus cavasius* in a commercial biofloc based aquaculture farm for eight weeks from September 2020 to November 2020. There were three treatments each with four replications. Concrete hexagonal tank was used with sloping bottom each volume was 25 m³ for this experiment. All tanks were connected with water inlet, water outlet and central aeration system with roots blower. Tanks were disinfected by using KMnO₃. Underground water was used to filled up the tanks. Continuous aeration was supplied and water was prepared using 1 kg unrefined salt and 220 g of molasses per liter of water. Each tank was supplied with 25 g of commercial probiotic as a source of beneficial bacteria. Water quality parameters were measured daily and growth parameters were measured every 10 days interval. All tanks were stocked with fingerlings of Snakehead and Catfish per m³ at a rate of 200 each and 2500 each respectively. The results of the study showed that the pH ranges from 7.95±0.25 to 7.99±0.21 for Snakehead and 7.96±0.75 to 8.83±0.22 for Catfish. Average dissolve oxygen was found 5.77±1.54 in Snakehead and 6.79±0.89 in Catfish. Ammonia was within the limit for Catfish (0.28±0.10); however, the value was found higher in the Snakehead tanks (1.00±0.71 to 1.7±0.93). The survival rate was showed highest for Snakehead (98.6%) and comparatively lower for Catfish (93.42%). Mean weight gain for Snakehead was 139.99 g whereas it was 6.02 g for Catfish. FCR was found higher for Snakehead (1.36). SGR (%) was found 92.61 for Snakehead and 91.0 for Catfish. It was estimated that commercial BFT can produce 62.50 kg Snakehead per meter cube of water, whereas estimated catfish production was 38.22 kg/m³ within the culture period of 6 months, that is much higher than the present pond culture system. Net profit showed 3,450tk/m³ for Snakehead and 2,850tk/m³ of Catfish. The study revealed, both species are important for commercial farming and the production of Snakehead was found better compared to Catfish in BFT. Net production and profitability is much higher in BFT compared to other traditional fish culture system practiced in Bangladesh.

Keywords: Biofloc, Intensive aquaculture, Snakehead, Catfish

TOTAL REPLACEMENT OF FISH OIL WITH PALM OIL IN FEED AND ITS 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 (5.1g) were reared in 60L glass aquaria and were fed with 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 applying the standard methods. The 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 was 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 \sum n-3HUFA intake and retention ratio was significantly higher in fish fed with the P10 diet (3.9) than the F10 diet (1.3). This study suggests that the PO can be used in formulating a red sea bream diet.

Keywords: Red sea bream, Palm oil, HUFA

DEVELOPMENT OF LOCALLY ENGINEERED LOW-COST RECIRCULATING AQUACULTURE SYSTEM (RAS) IN BANGLADESH

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Recirculating Aquaculture System (RAS) is considered as a healthy fish production system and can be located virtually anywhere. In this system fishes are grown at high density under controlled conditions ensuring all environmental parameters that ensures a suitable atmosphere for fish. Mechanization and intensification in aquaculture through recirculating system is therefore important for Bangladesh to compete with the modern world. A survey was conducted to understand the present scenario of the RAS in Bangladesh and found that, lack of expertise, appropriate design and specification for local species, high price tag, higher operational cost and lack of research are the main barrier for the development of the technology. The RAS needs to be efficient, low-cost, and simple to operate.

The present research project is designed to develop a locally engineered RAS system using indigenous technology, available resources through fabrication of important components for intensive culture of high value species. The project developed a layout drawing for RAS maintaining the gravity flow of water with using minimum energy to recirculate water supported by solar power. Developed self-rotatory mechanical filter with solar supported back-wash system to reduce operational cost. Designed and fabricated oxygen cone, fibre glass tanks and PVC supported triple tanks. Research observed that our designed required minimum energy to recirculate water to the system. Locally manufactured RAS equipment is much cheaper and affordable. It can be concluded that, mechanized aquaculture through re-using the water will ensure a reliable, profitable investment and meet the demand of aquatic enterprise to produce fish in a sustainable manner with international standards to ensure food safety issue.

Keywords: Recirculating Aquaculture System, Mechanization in Aquaculture

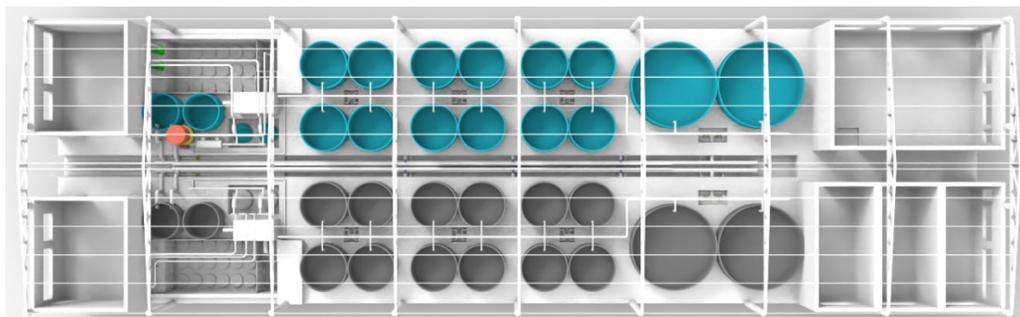


Fig. 1. Layout design for the Recirculating Aquaculture System complex at SAU

CULTURE OF *Heteropneustes fossilis* IN HOMESTEAD TANK: DETERMINING SUITABLE STOCKING SIZE

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Fish culture in household tank can ensure technical simplicity with lower capital investment. It can also ensure higher level of women's participation in the aquaculture sector. Therefore, this study assessed the culture efficiency of different sized *Heteropneustes fossilis* in cemented tank through growth and economic analysis. This experimental study was conducted in homestead tanks in Rajshahi district of Bangladesh for a period of 150 days. A randomized design was followed for carrying out the experiment with three different size groups of fish, each with three replications (Table 1). Fish were feed with floating feed containing 35-40% protein at the rate of 15-10% for 1st 60 days, 8-6% for 2nd 60 days and was reduced to 5-2.50% for rest of the culture period. At the end of the culture period, all fish were harvested and growth and economics were analyzed by one-way analysis of variance (ANOVA) followed by Duncan New Multiple Range Test at 5% level of significance using SPSS. Stocking size of fish had a profound effect on the overall growth and yield performance with significantly higher final weight, weight gain, SGR, survival rate and yield were obtained at treatment T₁, whereas the lowest value of these parameters were obtained at lower sized fish at treatment T₃. Higher stocking size also caused a significant ($p < 0.05$) increase in feed utilization that was depicted by lower FCR value. Finally, higher stocking size was also resulted in a significantly higher economic output in the form of BCR at T₁ and the lowest at T₃.

Keywords: *Heteropneustes fossilis*, Bioflock, Stocking size

Table 1. Experimental layout for tank culture of *H. fossilis*. TS= Tank size, WV= Water volume, SS= Stocking size, SD= Stocking density, CP= Culture period

	T ₁	T ₂	T ₃
TS (ft)	12×10×4	12×10×4	12×10×4
WV (l)	10000	10000	10000
SS (g)	3.79±0.11	3.09±0.13	2.53±0.18
SD (nos.)	5000	5000	5000
CP (days)	150	150	150

Table 2. Final weight (FW), weight gain (WG), specific growth rate (SGR), survival rate (SR), FCR, yield and benefit-cost ratio (BCR) for the tank culture of *H. fossilis*

	T ₁	T ₂	T ₃
FW (g)	52.81 ± 1.10 ^a	39.82 ± 1.58 ^b	30.61 ± 0.39 ^c
SGR(%/day)	1.76 ± 0.02 ^a	1.70 ± 0.04 ^b	1.66 ± 0.05 ^c
SR (%)	90.67 ± 1.51 ^a	88.20 ± 2.62 ^b	87.56 ± 1.26 ^b
FCR	0.65 ± 0.06 ^c	0.90 ± 0.06 ^b	0.99 ± 0.11 ^a
Yield	239.44 ± 6.72 ^a	175.64 ± 9.85 ^b	134.02 ± 2.72 ^c
BCR	2.07 ± 0.11 ^a	1.40 ± 0.10 ^b	1.08 ± 0.07 ^c

**EXPLORATION OF OPEN WATER MUD CRAB FATTENING SYSTEM IN
ASSISTING POVERTY REDUCTION AND MAINTAINING SUSTAINABILITY:
A MALAYSIA PERSPECTIVE**

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Mud crab fattening farming system has been introduced and adopted by many countries. The fattening system is considered to help fatten mud crab at a shorter timeframe and bring lucrative returns to the owner. However, many available mud crab fattening systems are expensive, hard to maintain and the lower income people are not able to purchase the system. To suit the needs of the Malaysian lower income group, an exploratory study was conducted specifically in solving the problem faced by crab finders in farming their own mud crab and gain better income. Through this study, a new innovative design of open water mud crab fattening system was established. The study covered three types of mud crab namely *Scylla olivacea*, *Scylla paramamosain*, and *Scylla tranquebarica*. The system design mimics the natural habitat of mud crab which resulted in 93.75% survival rate and faster growth. The system design created has lower maintenance cost, easy to manage, and can be transformed as a tourism attraction. It was found that the system introduced help elevate the income of the lower group especially during the Covid-19 pandemic.

Keywords: *Scylla olivacea*, *Scylla paramamosain*, *Scylla tranquebarica*

DOMESTICATION OF SELECTED BANGLADESHI NATIVE ORNAMENTAL FISHES IN CAPTIVE CONDITION

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In Bangladesh, several native fishes those are looking attractive in color can be used as ornamental fish but little research work has been done on their domestication, adaptation, and propagation. Therefore, native ornamental fish species *Botia dario*, *Trichogaster fasciata*, and *Mystus tenagra* were selected and live fish samples were collected from the natural sources, the Kushiara river, Sylhet, and Katialbeel, Kishoreganj in March 2021. The fishes were kept in separate 500-liter plastic drums having inlet and outlet facilities for three months. A commercial feed was provided to the fish and they thrived well. Then the fishes were kept in 6 aquaria each having 24'' × 18'' × 18'' in size, are capable of holding 120-liter water and have got proper aeration facility. Different species combinations, stocking densities and uniformity were maintained to observe the adaptive behavior, social interaction among them in the aquarium. Further two exotic species (Goldfish and Sucker mouth) were added to observe the interaction between native and exotic ornamental fishes. The results showed that all three native fishes were adapted and accepted artificial pelleted feed with an approximately 50-60% survival in the aquarium during the experiment. Though the native ornamental fishes had adapted well with the exotic fishes and shared food with them, a feeding dominancy of exotic fishes was observed. Thus, a higher rate of mortality occurred among the native fishes which needs more adaptation. Besides, after one year of domestication in the 500L plastic drum, no breeding response was observed among the Bangladeshi native ornamental fishes. Therefore, the present research should be continued with more native ornamental fishes and availability of live food to get a breeding response in the captive condition.

Keywords: Domestication, Ornamental fish, Indigenous and exotic fish, Breeding

A COMPARATIVE STUDY ON THE EFFECTIVENESS OF NATURAL SOURCE OF HORMONE (CARP PITUITARY GLAND) AND SYNTHETIC HORMONE (OVAPRIM) IN THE INDUCED BREEDING OF *Cyprinus carpio*

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The study was conducted to examine the effectiveness of Carp Pituitary Gland (CPG) and Synthetic Hormone (Ovaprim) for Induced Breeding of Common Carp., (*C. carpio*), at Bachte Shekha Hatchery, Arobpur, Jashore, from November 6, 2021 to December 6, 2021. The 1st dose, both for the male and female brood fish were injected at 0.5mg PG/kg body weight. After 6 hours of the 1st dose, only female brood fish were injected with the 2nd dose of hormone at 3 mg PG/kg body weight. After 6-7 hours of injection of 2nd dose brood fish became ready to spawn. On the other hand, females and males were injected with Ovaprim as 0.5 ml/ kg body weight of the broods. The fertilized eggs were hatched after 42-48 hours of their hormone injection. Finally, the breeding parameters were observed and calculated as per the methodologies. The ovulation rates were 100% for both CPG and Ovaprim. The fertilization rates and the hatching rates were 90.85% and 87.3% respectively for CPG; whereas 92.2% and 87.2% respectively for Ovaprim. But after 15 days of nursing the spawns a significant difference was found there in terms of survival rates. The survival rates were 84.2% for CPG and 74.5% for Ovaprim. After proper monitoring and analysis, it was found that, synthetic hormone express the better performance in terms of fertilization rates and hatching rates, but in terms of survival rate, CPG showed significantly higher result than synthetic hormone.

To prepare the dry PG solution, wet (PG) collected from the local fish market was processed in the lab of Fishtech Hatchery Ltd. Then the solution of dry PG was injected in brood fish of different age and weights (Table 1). The Ovaprim (Trade name OVATIDE), imported from India was also injected near the pectoral fin base as mentioned in Table 2. By using different formula Ovulation rate, fertilization rate, hatching rate and survival rate were calculated and analyzed for both the dry PG and Ovaprim.

Table 1. Selection criteria of brood of common carp by age and weight

Species	Sex	Weight (kg)
Common carp	Male	2
	Female	2.5
	Male	2.3
	Female	3.4
	male	2.7
	female	3.6
	Male	2.3
	Female	3.67

Table 2. Doses of pituitary glands (PG) and ovaprim for female and male broods

Sex	1 st Dose (mg/kg weight)	Inter val (hrs)	2nd Dose (mg/kg wt.)
Male (2 Nos)	0.5	6	-
Female (2 Nos)	0.5	6	3
Male and Female (total 4 nos)	Ovaprim 0.5 ml/ kg body weight		-

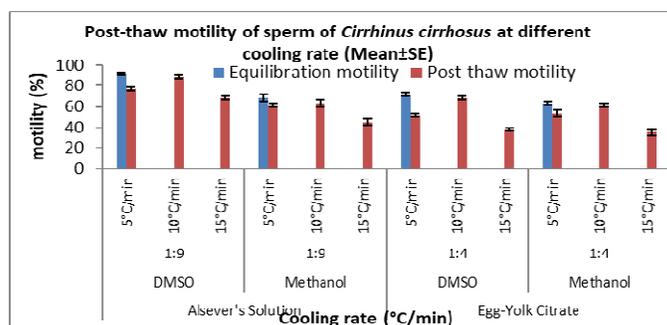
CRYOGENIC SPERM BANKING OF MRIGAL (*Cirrhinus cirrhosus*) AND PRODUCTION OF SEEDS IN COMMERCIAL HATCHERIES

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The study was conducted to standardize the sperm cryopreservation as well as breeding protocols with cryostored sperm of Mrigal (*Cirrhinus cirrhosus*). Quality broodstock of Mrigal was developed by rearing of Halda and Padma river-origin fish. Activation of sperm motility was evaluated in different gradients of NaCl solution (0.1% to 1.1%). In 0.4% NaCl solution, highest motility ($94.0 \pm 2.08\%$) and swimming duration (40.2 ± 0.5 min) of sperm were observed. The toxicity of cryoprotectant (DMSO and methanol) to sperm was tested at different concentrations (5, 10 and 15%) and incubation time (5-40 min) with two extenders (Alsever's solution and egg-yolk citrate). Cryoprotectants with 5% and 10% concentrations produced better motility during 5 and 10 min incubation, but 15% concentration seemed toxic. Best post-thaw motility of sperm was obtained from Alsever's solution plus 10% DMSO at 1:9 dilution through a computer-controlled cooling at $10^\circ\text{C}/\text{min}$ (equilibration motility $91.7 \pm 1.7\%$ and post-thaw motility $88.3 \pm 1.7\%$). Cryostored sperm motility was assessed at monthly interval up to six months, and the post-thaw motility of sperm remained same over the storage period (initial as well as final post-thaw motility was 85%). During induced breeding in three public and private hatcheries in Mymensingh and Jashore regions, the average fertilization and hatching rates were calculated as $37 \pm 1.5\%$ and $29 \pm 4.2\%$ with cryopreserved sperm, whereas $75.3 \pm 7.8\%$ and $64.7 \pm 10.8\%$ with hatchery-origin fresh sperm respectively. The final length and weight of cryopreserved sperm and fresh sperm originated fry were found as $16.23 \pm 0.06\text{cm}$, $36.59 \pm 0.40\text{g}$ and $15.78 \pm 0.14\text{cm}$, $29.01 \pm 0.65\text{g}$ respectively at Mymensingh region and $23.69 \pm 0.36\text{cm}$, $125.62 \pm 5.70\text{g}$ and $14.05 \pm 0.26\text{cm}$, $21.59 \pm 1.29\text{g}$ respectively at Jashore region after 180 days of pond rearing. In all cases, cryopreserved sperm-originated fry showed higher growth than those from fresh sperm and these may be due to the variation in quality of brood fish, individual management practices and different geographic location.

Keywords: Cryopreservation, Sperm bank, *Cirrhinus cirrhosus*, Hatchery



MORPHOLOGICAL VARIATION IN DIFFERENT POPULATIONS OF *Labeo rohita*

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Rohu, *Labeo rohita*, is the most cultivable native species and very popular to farmers due to its good taste, high price and attractive appearance. To evaluate the population status of rohu, landmark based morphometrics were examined by collecting fish from six (06) different hatcheries of Mymensingh (MG=Mymensingh Government hatchery, MP=Mymensingh Private hatchery), Cumilla (CG=Cumilla Government hatchery, CP=Cumilla Private hatchery), Jashore (JG=Jashore Government hatchery, JP=Jashore Private hatchery) and one (01) natural population of Halda river of Hathazari Upazila. A total 280 fish samples were collected of which 40 samples from each population. Morphometric characters along with truss network measurements and meristic counts were applied. Significant differences were observed in all except one morphometric character and 4 (dorsal fin rays, pectoral fin rays, lateral line scales and lateral line transverse scales) of 9 meristic counts. In linear discriminant analysis (LDA), 5 discriminant functions (LD1, LD2, LD3, LD4, LD5) were constructed where LD1 and LD2 covered 47.90% and 20.36% discriminant variables, respectively. The scatter plot of LD1 and LD2 showed different stocks of Rohu with tiny overlapping. In Euclidian dendrogram, two major clusters were constructed where population from Jashore Government hatchery form one cluster and other six populations form another cluster. First cluster were sub-divided into two sub clusters where each subcluster was again subdivided into two groups. In first subcluster, Population from Jashore private hatchery and Cumilla Government hatchery form one group and Cumilla private hatchery form another group. In Second subcluster, population from Mymensingh Government hatchery and Halda river form one group and Mymensingh private hatchery form another group. The result is based on partial analysis of data and further analysis is being done.

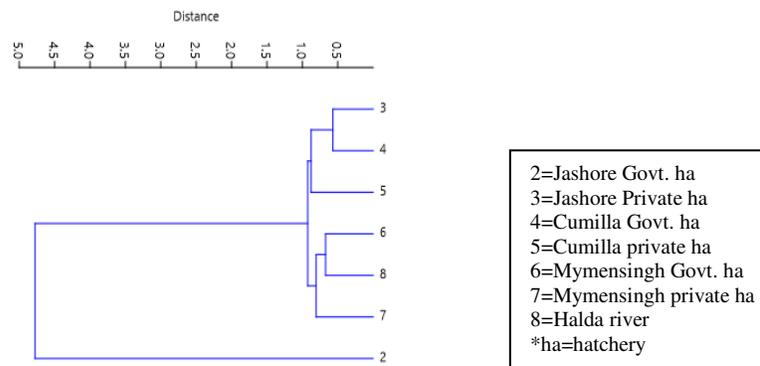


Fig. 1. Paired group dendrogram (UPGMA) based on Euclidean distance.

Keywords: Morphological variation, Meristic counts, Discriminant analysis, *Labeo rohita*

PRELIMINARY STUDY TO DEVELOP CRYOPRESERVATION PROTOCOL OF SPERM OF ENDANGERED BAGRID CATFISH *Rita rita*

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A preliminary attempt was taken to develop a cryopreservation protocol of sperm of *R. rita*. Milt was collected by crushing the testes and suspended in three extenders- Alsever's solution, egg-yolk citrate and urea egg-yolk separately at 1:1 ratio. The physical properties of fresh sperm were examined and found as white in colour, viscous, fishy smell, tadpole shaped, and has motility as $96.67 \pm 2.01\%$, concentration $3.89 \pm 0.60 \times 10^9$ cells/ml, pH 7.73 ± 0.15 and length 290.59 ± 74.50 μm . Activation motility and motility duration of sperm was tested at various osmolalities of NaCl, where motility was improved from 48 to 128 mOsmol/kg, and turned into stable by presenting complete activation at 128 mOsmol/kg. Sperm motility was further decreased with the increase of osmolality of NaCl. Sperm suspended in Alsever's solution showed the highest motility ($96.67 \pm 1.53\%$) and swimming duration (70.0 ± 2.0 min) at 128 mOsmol/kg. The toxicity of three cryoprotectants- DMSO, methanol and ethanol each with 5, 10 and 15% concentration was evaluated and highest sperm motility was recorded at 10% concentration. Alsever's solution with 10% DMSO generated significantly ($p < 0.05$) highest equilibration ($89.67 \pm 5.51\%$) and post-thaw ($79.33 \pm 5.13\%$) motility. For evaluating the effects of cryostorage, sperm was processed with Alsever's solution, egg-yolk citrate and urea egg-yolk with 10% DMSO and stored for six weeks. Sampling at seven days interval retained significantly ($p < 0.05$) highest post-thaw motility of sperm preserved with Alsever's solution among the diluents (extender + cryoprotectant). The basic parameters of sperm of *Rita* are presented in Table 1 and sperm motility during cryostorage is presented in Fig. 1.

Keywords: Sperm, Cryopreservation, *Rita rita*

Table 1. Spermatological characters of *R. rita*

Parameters	Min	Max	Mean \pm SD
Volume ($\mu\text{l}/\text{fish}$)	1950	3000	2518.57 ± 354.09
Volume ($\mu\text{l}/\text{g}$)	2.78	3.00	2.89 ± 0.08
Motility (%)	90	100	96.67 ± 2.01
Concentration (cells/ml)	3.05×10^9	4.55×10^9	$3.89 \pm 0.60 \times 10^9$
pH	7.6	8.0	7.73 ± 0.15
Length (μm)	135.86	372.45	290.59 ± 74.50

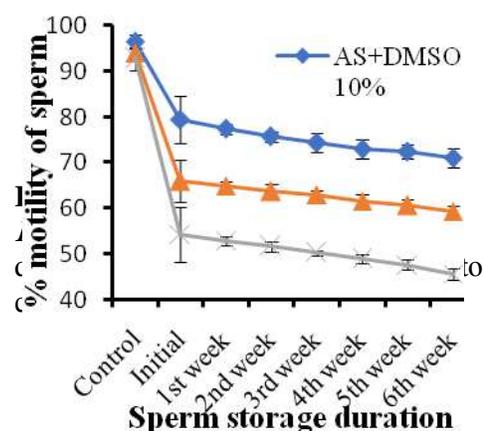


Fig. 1. Post-thaw motility of sperm of *R. rita* at different cryostorage duration in different diluents relative to control.

TAXONOMIC AND GENETIC DIVERSITY OF SHRIMP AND PRAWN SPECIES OF BANGLADESH USING DNA BARCODING

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Shrimps and prawns have an immense contribution in fisheries sector across various nations. In Bangladesh, marine water is enriched with 36 species of shrimps, including 24 penaeid shrimps and the freshwater with 24 prawns, including 18 palaemonid prawns.

A total of 42 samples collected from 6 different places of Bangladesh namely Khulna, Netrokona, Jhalokathi, Bagerhat, Satkhira, and Rangpur during May 2019 to January 2020. Species identification was done through classical (based on identification keys) and molecular method (based on COI gene). Morphological identification revealed that 15 samples were of Penaeidae family and 24 samples belonging to Palaemonidae family. The 15 specimens of Penaeidae family were identified as three genus- *Penaeus*, *Metapenaeus*, *Parapenaeopsis* having 5 different species. Among 30 samples, 19 samples were identified up to species level using COI gene and DUFM-MSR-TS-03, 04, 06, 12, 14, and 23 showed 89-99% identity with *M.kistnense*. DUFM-MSR-TS 01 showed 99.09% identity with *M. monoceros* and DUFM-MSR-TS-10, 17 and 19 were identified as *Macrobrachium* spp. DUFM-MSR-TS 31, 32, and 34 showed identity with *F. indicus*, *M. equidens* and *M. brevicornis*. 3 specimens (DUFM-MSR-TS-35, 36, and 37) reflect their 95-100% identity with *P. styliferus*, *F. smerguensis* and *P. hardwickii*. DUFM-MSR-TS-03 and 04, 06 and 12 were the closest specimen with the minimal divergence of 0.00%. DUFM-MSR-TS-24 showed a maximum divergence of 32.84% with DUFM-MSR-TS-17. The phylogenetic tree showed that DUFM-MSR-TS-03, 04, 06, 12, 14, and 23 has a relation with different strain of *Macrobrachium kistnense*. Among the 19 samples 13 samples gave the same result up to the genus level and five samples up to the species level in both morphological and molecular approach. Our study recommends mitochondrial markers as an efficient tool for resolving taxonomic ambiguity of shrimp and prawn.

Keywords: Genetic diversity, Shrimp, Prawn



Fig 1. Boucher Specimens and their Barcode.

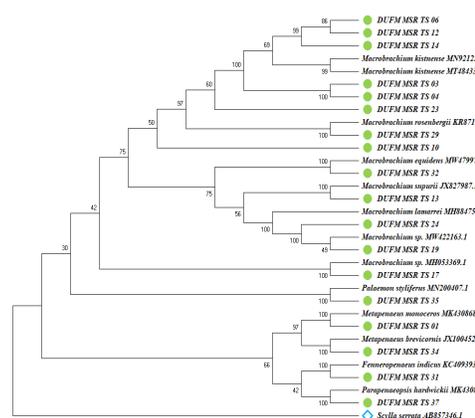


Fig. 2. Molecular phylogenetic analysis by Maximum Likelihood method

DIVERSITY OF THE REEF-ASSOCIATED FISHES OF BANGLADESH

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

Keywords: COI gene, 16S rRNA gene, Diversity, Reef-associated fish

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

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A nutritionally balanced diet and selection of appropriate species are important criteria for aquaculture. The present study was conducted to evaluate the effects of diet containing polyunsaturated fatty acids (PUFAs) and beta glucan on growth performance, feed utilization, maturation, immunity, early embryonic and larval development of endangered Pabda catfish, *Ompok pabda*. In this study, lipids extracted from squid and mushroom powder were used as the source of PUFAs and beta glucan, respectively, and formulated two isonitrogenous diets such as basal or control (CON) diet and treated (PBG) diet with maintaining 30% protein levels. During the study period, similar physicochemical conditions of water such as temperature, pH, and dissolved oxygen (DO) were $26.5 \pm 2^\circ\text{C}$, 7.4 ± 0.2 , and 6.7 ± 0.5 ppm, respectively in each cistern. The results showed that final mean body weight, final mean length gain, food conversion ratio (FCR), specific growth rate (SGR), food conversion efficiency (%), hepatosomatic index (HSI), kidney index (KI), and viscerosomatic index (VSI) were significantly ($p < 0.01$ and $p < 0.05$) higher in fish fed with the PBG diet than those fed with the CON diet. The length-weight relationship and relative condition factor (K) of *O. pabda* were significantly ($p < 0.05$) affected by the PBG diet. The gonadosomatic index (GSI), sperm viability, blood serum calcium ion concentrations (Ca^{2+}), and vitellogenin (Vtg) level were significantly ($p < 0.05$) higher in fish fed with the PBG diet than those fed with the CON diet; which was used as indication of fish maturation. During the spawning season, lipid granules and normal morphological structure were observed in the treated fish liver, whereas fewer lipid granules of liver were observed in the control group. Based on the immunity and stress resistance-related parameters such as hematological indices, antioxidant activity, lysozyme level, respiratory burst activity (RB), blood reactive oxygen species (ROS), complement activity (ACH50 assay), specific IgM, brain AChE, plasma PGOT, and PGPT enzyme activity were significantly ($p < 0.01$ and $p < 0.05$) higher in fish fed with the PBG diet than those fed with the CON diet. The fecundity, fertilization rate ($92.23 \pm 2.69\%$), hatching rate ($87.43 \pm 2.17\%$) and survival ($76.62 \pm 0.82\%$) of offspring were significantly higher ($p < 0.05$) in the PBG diet than in the control. Consequently, early embryonic and larval development was better in PBG treated group than in the control. Therefore, the present study proved that the polyunsaturated fatty acids (PUFAs) and beta glucan enriched experimental diet was more effective for achieving better growth, feed utilization, maturation, immunity, and spawning performances of *O. pabda*.

Keywords: Polyunsaturated fatty acid, Beta Glucan, *Ompok pabda*

MORPHOGENETIC IMPACTS OF CADMIUM ON *Labeo rohita* IN BANGLADESH

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Cadmium is a naturally occurring metal that is linked to metal mining and other industrial processes. This research focused on the determination of 96-hour LC50 value and examined the changes in growth and development including histology parameters, RNA: DNA ratio, and the expression of heavy metal-induced HSP60 & CYP3A genes in a commercially important fish *Labeo rohita* in response to the toxic impact of cadmium chloride ($\text{CdCl}_{2.5/2\text{H}_2\text{O}}$). The LC50 value of cadmium chloride was 75.032 ppm in *Labeo rohita*. Then the fishes were treated with cadmium chloride at the doses of 0.05, 7.5, and 15 ppm for 14 days. In comparison to the control group, 15 and 0.05 ppm had the highest 69.6% and lowest 24.1% length gain reduction, respectively. A similar pattern was also observed in weight gain. Both the control and 0.05 ppm concentration groups had the highest survival rate (100%). No significant difference was observed in the condition factor among the treatments. Cadmium chloride exhibited variability in nucleic acid concentrations in muscle tissues, but those changes were not statistically significant. Cadmium exposure resulted in up-regulation of hsp60, and cyp3a in gill tissue. However, the hsp60 showed down-regulation in muscle tissues. Microscopic examination of the vertical sections of cadmium chloride-treated liver and kidneys revealed significant changes. In liver tissues, hyperplasia, hepatocyte breakdown, expansion of sinusoidal spaces, and severe hemorrhages were observed. Because of cadmium toxicity, congested and shrunken glomeruli and damaged renal tubules were observed in kidney tissues. Finally, this study proved that chronic exposure to cadmium chloride could be a powerful toxic agent for slowing down the growth rate and development of *L. rohita*. As a result of bioaccumulation of cadmium in different tissues, fish consumption can result in economic loss and impairment to human health.

Keywords: *Labeo rohita*, Cadmium, Toxicity

GENETIC DIVERSITY AND POPULATION STRUCTURE OF KAWAKAWA TUNA (*Euthynnus affinis*) IN THE BAY OF BENGAL, BANGLADESH

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Euthynnus affinis is one of the important commercial fish species in Bangladesh. In this study, we have investigated the population genetic structure of *E. affinis* using the mtDNA d-loop region mitochondrial DNA (mtDNA) marker in the Bay of Bengal, Bangladesh and compared them with other seas' populations of the world. Samples were collected from Chittagong-Cox's Bazar coast (CC) and Kuakata-Pathoghata coast (KP) of the northern Bay of Bengal, Bangladesh in 2021. For comparison, DNA sequence data were collected from different populations of other sea areas such as Indian coast of the Bay of Bengal (BoB), Arabian Sea (AS); and Andaman Sea (AnS). The sequences of the d-loop region of *E. affinis* defined 176 haplotypes where 11 haplotypes were found in the BoB population. Among eleven haplotypes of the BoB, eight haplotypes were unique for the Bangladesh coast. The nucleotide diversities (π) were very low in each population estimating from 0.025 to 0.027, while the haplotype diversities (h) were relatively high which was calculated as 0.88 in *E. affinis* populations of Bangladesh. High level of haplotype diversities in contrast with low nucleotide diversity in the BOB population indicates that both fish species has experience population expansion after a period of low effective population. The fixation index (F_{ST}) between the two Bangladeshi populations of *E. affinis* was -0.01 ($p < 0.05$) i.e. no significant deviation from the random mixing. Estimates of F_{ST} between the BOB populations and each of the compared populations of neighboring seas were ranged from 0.06 to 0.12 with significant difference ($P=0.00$). This result indicates a unique population genetic structure of *E. affinis* was established in the Bay of Bengal region compared to other seas. Exact test of the population differentiation also showed significant differentiation between BoB and each of other populations investigated suggesting a non-panmictic population of the BoB compared to other seas.

Keywords: mtDNA Genetic diversity, Population structure, *Euthynnus affinis*, Bay of Bengal

MORPHOLOGICAL VARIATION, REPRODUCTIVE BIOLOGY AND GUT CONTENT ANALYSIS OF PARADISE THREADFIN *Polynemus paradiseus* OF RIVER POPULATIONS IN PATUAKHALI DISTRICT

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The paradise threadfin (*Polynemus paradiseus*) is a valuable catadromous ray-finned fish from the Polynemidae family, that are found in freshwater rivers throughout South and Southeast Asia. A total of 152 samples of *P. paradiseus* were collected from four different coastal river sources such as Andharmanik, Payra, Lohalia, and Biskhali rivers in Patuakhali district to identify phenotypic variation among the four stocks. Morphometric and meristic characteristics of fishes are imperative for both fisheries biology and taxonomy studies. A one-way ANOVA was used to find substantial variation among the four populations through thirty-one morphometric characters. This study has provided meristic characteristics of *P. paradiseus* which includes 7 branchiostegal rays, number of 7 rays in first dorsal fin, 16 rays in the second dorsal fin, 16 pectoral-fin rays, 5 pelvic fin rays, 14 anal fin rays and 18 caudal-fin rays. The disparity of length-length relationships among various length parameters of each sample was found to be highly significant ($p < 0.05$). The length-weight relationships demonstrated that the value of b (allometric coefficient) fluctuated from 2.7955 (Andharmanik) to 3.2465 (Payra). The Fulton's condition factor of this species was found for both sexes as 1.33 (Payra) to 2.40 (Andharmanik). GSI was ranged between 0.441 and 2.135 whereas the highest GSI was found in the Payra population followed by Lohalia, Biskhali, and Andharmanik populations. GLI for both sexes were ranged from 46.142 (Lohalia) to 56.421 (Biskhali), GaSI from 1.465 (Andharmanik) to 3.439 (Biskhali) and his ranged from 0.853 (Andharmanik) to 0.998 (Payra). This study provided some new information on the length-length relationships, length-weight relationships, condition factor, meristic characteristic, and reproductive biology of *P. paradiseus* of the four coastal rivers. Therefore, the results of this study would be very effective for sustainable management, and also further study should be carried out to know the genetic make up for stock identification and better management of *P. paradiseus*.

Key words: Morphology, Reproductive biology, Gut content, *Polynemus paradiseus*

CRISPR/CAS9-MEDIATED KNOCK-IN OF CATHELICIDIN GENE IN NON-CODING REGION OF CATFISH GENOME

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CRISPR/Cas9-based gene knockout in animal cells, particularly in teleosts, has proven to be very efficient with regards to mutation rates, but the precise insertion of exogenous DNA or gene knock-in via the homology-directed repair (HDR) pathway has seldom been achieved outside of the model organisms. Here, we succeeded in integrating with high efficiency an exogenous alligator cathelicidin gene into a targeted non-coding region of channel catfish (*Ictalurus punctatus*) chromosome 1 using two different donor templates (synthesized linear dsDNA and cloned plasmid DNA constructs). We also tested two different promoters for driving the gene, zebrafish ubiquitin promoter and common carp β -actin promoter, harboring a 250-bp homologous region flanking both sides of the genomic target locus. Integration rates were found higher in dead fry than in live fingerlings, indicating either off-target effects or pleiotropic effects. Furthermore, low levels of mosaicism were detected in the tissues of P1 individuals harboring the transgene, and high transgene expression was observed in the blood of some P1 fish. This can be an indication of the localization of cathelicidin in neutrophils and macrophage granules as also observed in most antimicrobial peptides. This study marks the first use of CRISPR/Cas9 HDR for gene integration in channel catfish and may contribute to the generation of a more efficient system for precise gene integration in economically important catfish like stinging and walking catfish of Bangladesh and other aquaculture species, and the development of gene-edited, disease-resistant fish.

Keywords: CRISPR/CAS9, Cathelicidin Gene, Catfish, Genome

16S rRNA GENE DEPENDENT F₁ CROSSBREED DETECTION IN BANGLADESH: POTENTIAL FOR CONSERVATION AND AQUACULTURE

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In aquaculture of Bangladesh, occurrences of hybridization in hatchery populations are a common phenomenon. It creates problems to the fish farmers in farming targeted pure breeds. Substantial admixture of indigenous and exotic species, and crossbreeding between them for gaining more production may negatively affect the native populations. From our previous studies with limited number of samples, we confirmed the crossbreeding of indigenous *Clarias batrachus* with exotic *Clarias gariepinus* through the analysis of mitochondrial COI and Cytochrome b genes. Through the analysis of same genes, we also confirmed the availability of *Anabas testudineus* originated from Bangladesh, Thailand and Vietnam. In this study, attempts were taken for further confirmation of the previous findings with higher number of samples of *Clarias batrachus*, *Clarias gariepinus*, *Anabas testudineus* and their F₁ crossbreed using gene marker, the 16S rRNA. The amplification of 16S rRNA followed by purification, sequencing and analyses showed crossing between exotic and indigenous *A. testudineus* as well as hybridization between indigenous *C. batrachus* × exotic *C. gariepinus*. The study also identifies the parental lineage of F₁ crossbreeds which are originated from the crossing of indigenous and Vietnamese *A. testudineus*. Further studies using the nuclear gene markers are required for proper broodstock management and conservation strategies to protect pure breeds.

Keywords: *Anabas testudineus*, *Clarias batrachus*, *Clarias gariepinus*

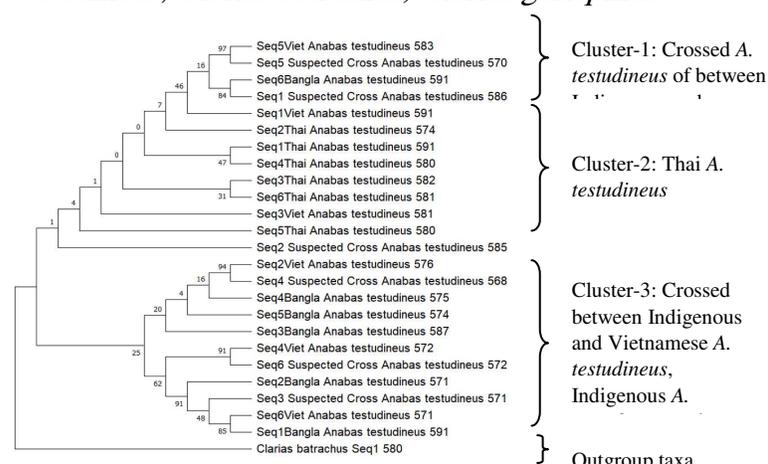


Fig. 1. Rooted Phylogenetic Tree of *Anabas testudineus* constructed based on Maximum likelihood (ML) methods using the 16S rRNA nucleotide sequences.

GENETIC VARIATION IN NATIVE POPULATIONS OF GREAT SNAKEHEAD FISH (*Channa marulius*) REVEALED BY mtDNAGENE

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The Great Snakehead *Channa marulius* is a commercially important freshwater fish and a potential candidate species for aquaculture. It is widely distributed in Bangladesh, India, Pakistan, Nepal, Sri Lanka, Myanmar, Thailand, and China. A study was conducted to investigate the genetic variation in seven populations of great snakehead (*Channa marulius*) by sequence analysis of the mtDNACytochrome b gene. A total of 67 samples were collected from Barishal, Chattogram, Dhaka, Khulna, Mymensingh, Rajshahi, and Sylhet divisions in Bangladesh. At first, samples were used for morphometric and meristic characteristics, then data have been recorded on the basis of several parameters. Subsequently, 67 samples from seven populations were used for amplification of partial Cytb gene using universal primer and the fragment size was around 897bp. Then sequence analysis was conducted after PCR purification, and the edited sequence length was 742 bp, and ten haplotypes were observed from all populations. A single population-specific haplotype was observed in the Barishal population. The highest haplotype diversity (0.80) was found in the Mymensingh population and the lowest haplotype diversity (0.00) was found in the Dhaka population. The highest nucleotide diversity (0.088) was found in the Chattogram population and the lowest nucleotide diversity (0.00) was found in the Dhaka population. The pairwise F_{st} value ranged from 0.114 to 0.911. The highest F_{st} value was found between Dhaka vs. Sylhet (0.911) indicating higher genetic differentiation of those populations. The lowest F_{st} value was found between Khulna vs. Mymensingh (0.114). A Phylogenetic tree was constructed by the mtDNA Cytochrome b gene sequences including gene bank data and haplotypes H3, H4, H7, and H8-H9 produced distinct and separate groups in two clades. Whereas haplotype H2, H5, H6, H10 produced separate clades with distinct Indian groups, and haplotype H1 produced another clade with the Pakistani group that was treated as a nout group during tree formation. However, present findings may be used as a piece of preliminary molecular evidence for further clarification of *C. marulius* in Bangladesh.

Keywords: Genetic variation, Snakehead, *Channa marulius*, mtDNA Gene

REPRODUCTIVE BIOLOGY OF MOLA *Amblypharyngodon mola* IN WILD, CULTURED AND ARTIFICIALLY BRED POPULATIONS IN BANGLADESH

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Reproductive biological characters: sex determination and ratio, gonadosomatic index(GSI), ova diameter, fecundity and condition factor has been carried out for mola using fish from natural sources of open and closed system from Northwest region and using fish produced through induced breeding from September, 2014 to October, 2015. A total of 2,325 mola samples were collected and analyzed. Matured females were found to be larger, swollen abdomen and wholesome; and matured males were smaller, thin and streamlined. March to December was found to be breeding season of mola with more than one peak during April-September. GSI showed significant positive relationship with total length (TL), standard length (SL), body weight (BW) and gonad weight (GW) in all populations except with BW for male in openwater. Mola is a partial breeder. Ova diameter was 0.29 ± 0.20 (0.04–0.75) mm. The immature ova were present in all months in all populations and ripe ova (0.61–0.75 mm) was found in March to December. The absolute fecundity of mola was found to be 1,329 to 14,784 with a mean of $6,117 \pm 3,690$ ($n=64$) and the relative fecundity was 10,17,402 to 31,93,672 eggs kg^{-1} body weight with an average 19,85,501. Females were significantly dominated over the males. The sex ratio of male and female was found to be 1:1.91 ($\chi^2=166.67$, $p<0.001$, $df=1$, $n=1,710$). Induced breeding of mola was carried out successfully through combine with environmental stimuli and hypophysation with pituitary gland (PG). PG at 25mgkg^{-1} body weight of female was found to be effective and resulted a fertilization rate of 84.25%, hatching rate 63% and 678 ± 305 hatchlings per female. Visible and significant mating behavior i.e., forming pair and other courtship was observed for releasing sperm and eggs. Fertilized eggs are sticky in nature. Survival of spent mola after spawning was found to be $67.78 \pm 16.41\%$ for female and $54.44 \pm 10.14\%$ for male. No significant difference was found for reproductive biological characteristics of mola in three different population. The peak spawning season and frequencies varied in different populations which might happen due to habitat, management and environment. The detail information on reproductive biology would be useful to improve the production technology and will eradicate the malnutrition from Bangladesh.

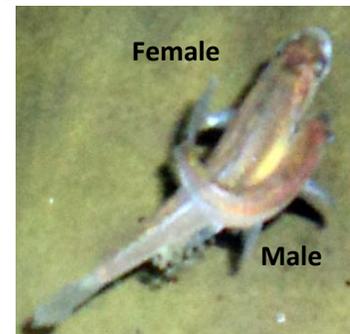


Fig. 1. Spawning of mola

Keywords: *Amblypharyngodon mola*, Reproductive biology, GSI

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

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This study was aimed to evaluate the impact of dietary beta-glucan on the enhanced immunity of Rohu carp, *Labeo rohita* those were collected from Dingapota Haor, Netrokona, and stocked in the earthen ponds. The experimental design was consisted of two groups, the treated group was administered a supplemented diet with 10% mushroom powder as a source of beta-glucan for 120 days in a row, while the control group was provided the same feed excluding beta-glucan. Tests on immunological parameters such as antioxidants, respiratory burst, reactive oxygen species (ROS), alternative complement activity, as well as serum immunoglobulin were analyzed. Results showed significant increases ($p < 0.05$ and $p < 0.01$) in K value for the beta-glucan fed immune primed *L. rohita* compared to control groups, indicating a positive effect of beta-glucan on fish health. Hematological parameters were also determined as among the immunological indices. The total counts of erythrocytes and leukocytes were assessed using standardized methods to elucidate the immunomodulatory effects of beta-glucan on *L. rohita*. Fish were challenged with a 1.92×10^4 CFU/ml intramuscular dose of *Aeromonas veronii*. The disease-defending systems such as serum lysozyme activity and serum total protein level were shown to have significantly higher protection ($p < 0.01$), followed by the control groups. Acetylcholinesterase (AChE) activity and serum enzyme activity were measured to support the stress effect of beta-glucan on *L. rohita*. The stress indicating results did not show any significant differences, indicating the fish's physiology was not harmed in any way. Hence, the supplementation of dietary beta-glucan was found to be significant in enhancing immune responses in *L. rohita*.

Keywords: *Labeo rohita*, beta-glucan, *Aeromonas veronii*

Table 1. Composition of experimental diets

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

Table 2. Immunology after fed with beta-glucan diet

Parameters	Control	Treatment
RBC ($\times 106/\mu\text{l}$)	2.34 ± 0.23	$3.39 \pm 0.35^*$
WBC ($\times 103/\mu\text{l}$)	7.17 ± 0.44	$8.26 \pm 0.63^{**}$
Glucose (mmol/L)	2.12 ± 0.26	2.15 ± 0.24
Serum protein (g/dl)	2.66 ± 0.25	$3.15 \pm 0.32^{**}$
Lysozyme ($\mu\text{g/ml}$)	4.60 ± 0.74	$6.11 \pm 0.74^*$
ACH50 (unit/ml)	84.10 ± 3.2	$112.1 \pm 4.8^{**}$
AChE (nmol/min/mg)	245 ± 14.5	248 ± 13.7
ROS (mmol/l)	0.17 ± 0.02	$0.07 \pm 0.01^{**}$
Respiratory burst (mg/ml)	0.30 ± 0.08	$0.68 \pm 0.11^{**}$

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

MARKER-ASSISTED SELECTIVE ALLELE RESPONSIVE GROWTH OF TILAPIA HYBRIDS (*Oreochromis niloticus* × *O. mossambicus*)

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Alleles of prolactin1 gene are responsible for both growth and survivability of fish on different saline conditions. As coastal zone of Bangladesh facing salinity intrusion leading changes in aquaculture; it is imperative to pave the way for overcoming the salinity stress and sustaining tilapia production. Set of pre-selected (genotypes of specific marker, Pr11) males (m) and females (f) from both *Oreochromis niloticus* (N) and *O. mossambicus* (M) were kept inside hapas with 1:1 ratio for breeding. Four hybrids with interspecific reciprocal cross (Mm_{254/254} × Nf_{281/281}, Mf_{254/254} × Nm_{253/253}, Mf_{254/254} × Nm_{281/253}, Mf_{254/254} × Nm_{281/281}) and two traditional (Nm_{281/281} × Nf_{281/281}, Nm_{XXX/XXX} × Nf_{XXX/XXX}) selection have breed successfully. The offspring of different parental allelic combinations were reared for 45 days in hapa with same stocking densities and applied weight specific feeding regime following manufacturer's guidelines. In all hybrid crosses the genotype for the M were homozygous 254/254 irrespective sexes (f/m). The hybrid cross with Mf_{254/254} × Nm_{281/281} produced progenies demonstrated significantly highest weight gain per day while the hybrid cross with Mf_{254/254} × Nm_{253/253} produced progenies demonstrated significantly lowest ($p < 2e-16^{***}$) weight gain. We found similar growth (weight gain per day) pattern with Mm_{254/254} × Nf_{281/281}, Nm_{281/281} × Nf_{281/281} and Nm_{XXX/XXX} × Nf_{XXX/XXX} progenies. While progenies produced by Mf_{254/254} × Nm_{253/253} showed relatively flatter growth. On the other hand, Mf_{254/254} × Nm_{281/253} and Mf_{254/254} × Nm_{281/281} offspring displayed interaction effect with other groups (Fig. 1). As because the shorter allele is responsible for better survival inside higher salinity and longer is for higher growth; the selection of the parental group depending on marker assistant allelic segregation could be a pertinent protocol in coastal region.

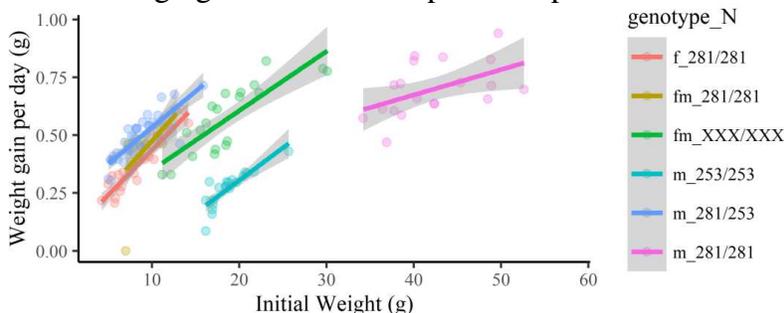


Fig. 1. Interaction plot by genotypes of N (for the absent sex in hybrid cross M carries f_{254/254} or m_{254/254} genotypes)

Keywords: Prolactin, Genetic marker, Interspecific reciprocal cross, Coastal zone

ISOLATION AND MOLECULAR CHARACTERIZATION OF FISH GUT BACTERIA AS POTENTIAL FISH PROBIOTICS

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Probiotics is a promising alternative to synthetic agro-chemicals including growth regulators and have been proven as the positive promoters for fish growth and survival. Probiotics used in aquaculture in Bangladesh are mostly imported and expensive. Considering the above facts, a study was conducted to isolate and characterize (biochemical and molecular) gut bacteria from two different healthy fish such as Nile tilapia (*Oreochromis niloticus*) and Stinging catfish (*Heteropneustes fossilis*) followed by validating in an *in vivo* experiment. A total of 90 gut bacteria were isolated on nutrient broth (NB) agar plates based on their morphological characteristics like colony colour, shape, size etc. Among them nine bacteria were selected for molecular characterization based on their physiological, biochemical and its growth promoting traits. Four bacterial isolates from Nile tilapia and five bacterial isolates from Stinging catfish were selected for probiotic formulation and all the 9 isolates were able to survive and grow from a wide range of pH (2-8) and NaCl concentration (0%-8%) with the highest viability and growth rate at neutral conditions. To evaluate the probiotic properties of five bacteria (HF consortium) isolated from Stinging catfish, an *in vivo* experiment was conducted using Nile tilapia fry as the host species. The HF consortium was tested in 10 days-old Tilapia fry in a mini-biofloc system including a commercial probiotic and a control for comparison. The fry (0.029g Av. weight) were stocked in 15 L aquaria at a density of two fry per liter and were fed three times daily at 5% of their body weight for 60 days. After two months of rearing, weight gain, growth rate and feed utilization were found to be significantly ($p < 0.05$) higher in the fish treated with native probiotic (HF consortium, Av. weight 2.027 ± 0.003 g) than that of Commercial probiotic (Av. weight 1.867 ± 0.002 g) and the control group (Av. weight 1.087 ± 0.002 g). Specific growth rate (SGR) also followed the same pattern where native probiotic (7.093 ± 0.0021 % per day) played a superior role than the commercial probiotic (6.955 ± 0.0018 % per day) and control (6.051 ± 0.0023 % per day). On the other hand, significantly lower feed conversion ratio (FCR) has been observed in the native probiotic treated group than the commercial probiotic and control group. In a nutshell, the native probiotic developed from Stinging catfish showed significant improvement of fish growth and nutrient retention, and can be recommended as potential probiotics in commercial fish production after further trials at field level.

Keywords: Probiotics, *Oreochromis niloticus*, *Heteropneustes fossilis*

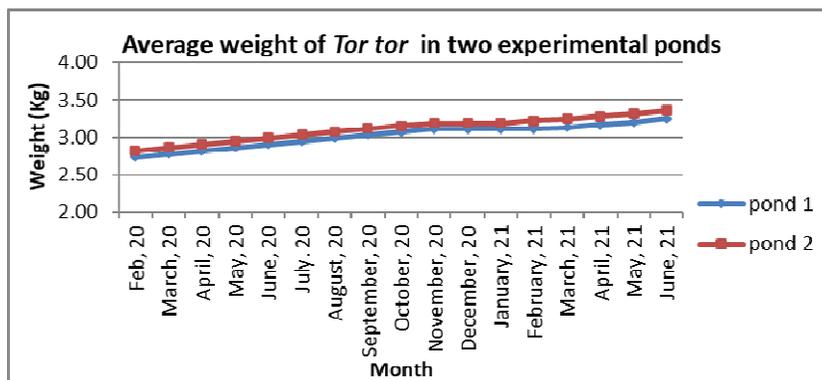
CAPTIVE REARING OF CRITICALLY ENDANGERED INDIGENOUS MOHASHOL (*Tor tor*) FOR GROWTH AND MATURITY ENHANCEMENT

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Red fin Mahseer *Tor tor* is one of the most attractive, high demand cyprinid fishes in Bangladesh, but now-a-days it is recognized as critically endangered. This research focused on captive rearing of *T. tor* with supplementary feeds containing different protein percentages for growth and maturity enhancement. Two formulated feeds having protein content of 37.65% and 44.02% were used for observing the growth performance of *T. tor* in two ponds and were considered as Treatment 1 and Treatment 2, respectively. The length-weight relationship was also observed and it was $W=0.04111L^{2.70}$ and $W=0.03848L^{2.72}$ in Treatment 1 and Treatment 2, respectively. It exhibited negative allometric growth in the fish having “b” values of 2.70 and 2.72, respectively in Treatment 1 and Treatment 2. After seventeen months (February 2020 to June 2021) of rearing, a significantly ($p<0.05$) higher growth in terms of weight gain (g), percent (%) weight gain and specific growth rate (SGR), were observed in Treatment 2 compared to Treatment 1. The mean weight gain was 1435.63 ± 91.94 g and 2296.75 ± 116.18 g, percent (%) weight gain was 56.40 ± 3.41 and 92.70 ± 9.76 , and specific growth rate was 0.09 ± 0.005 and 0.13 ± 0.006 , respectively in Treatment 1 and Treatment 2 which showed a significantly ($p<0.05$) higher values in Treatment 2. The survival rate of fish was found to be 100% in both treatments. During administering the feed, 5 ml of each of Vitamin-E, Vitamin-C, Zinc and Selenium and an egg were mixed to per kg feed for maturity and gonadal development of fish. Some progresses in gonadal maturation were observed in male and female fish. Few males produced good quality sperm but no ovulated eggs were obtained though bulky and swollen abdomens were observed in few females. Temperature, DO, and pH of water in both the experimental ponds were regularly measured and found suitable and within the range of fish culture. Overall, this slow-growing cold water species demonstrated an impressive growth performance in the captivity with supplementary feeds and sign of gonadal maturity.

Key words: Captive rearing, *Tor tor*, Supplementary feeds



EFFICACY OF DIFFERENT PROBIOTICS ON GROWTH PERFORMANCE, SURVIVAL, BODY PROXIMATE COMPOSITION AND HAEMATOLOGICAL PARAMETERS OF ASIAN CATFISH (*Clarias batrachus*) JUVENILES

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This study aimed to determine the effects of different probiotics gut probiotic bacteria (GPA), pond care and navio plus on the growth performance, survival, body proximate composition and hematological parameters of Asian catfish (*Clarius batrachus*, Linnaeus, 1758) juveniles. Four experimental diets were formulated to contain 0 (control), 0.2% GPA, 0.2% pond care and 0.2% navio plus. A number of 180 fishes with an average body weight of 11.14 ± 0.50 g were equally divided and distributed randomly at twelve tanks (124cm×72cm×84cm) where fishes were fed twice daily at a rate of 3% of body weight. Water temperature, pH, dissolved oxygen, NH₃ and hardness (CaCO₃) were monitored every two weeks for a 12 weeks period, which was ranged between 16.46-16.56°C, 6.92-7.13, 6.74-6.94 mg/L⁻¹, 0.31-0.41 mg/L⁻¹, 39-52 mg/L⁻¹ respectively. At the end of twelve weeks of the feeding trial, the growth performance, body indices, proximate composition and hematological parameters were evaluated. The result revealed that the growth performance (weight gain, specific growth rate) and feed utilization parameters (feed conversion ratio, protein efficiency ratio) were significantly improved ($p < 0.05$) in all of the groups fed with 0.2% probiotics than the control group with the highest value in the 0.2% navio plus fed group. The survival was not significantly influence ($p > 0.05$) when Asian catfish fed with probiotics supplemented diets. Among the body indices, only intra peritoneal fat showed a significant reduction in the navio plus supplied group compared to the control group. Significantly highest protein and lowest lipid content were noted in Asian catfish fed with navio plus supplemented diet compared to those fish fed with the control diet. Hematological parameters such as packed cell volume and white blood cell were improved in the navio plus and GPA supplied groups compared to the control. Mean corpuscular volume was found significantly lower in GPA and pond care supplemented groups compared to the control group. Based on the result of growth performance, proximate composition and hematological parameters, it can be concluded that 0.2% navio plus was more effective for *C. batrachus* juvenile farming.

Keywords: Probiotics, Proximate composition, Hematological parameters, *Clarius batrachus*

EVALUATION OF PROXIMATE COMPOSITION, ACTIVE COMPOUNDS AND ANTIOXIDANT ACTIVITY OF FERMENTED & NON-FERMENTED WHEAT BRAN

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Fermentation is an environmental friendly, easy and cost-effective method that needs less energy and produces less waste. Solid state fermentation is the most convenient method for fish feed ingredients. Utilization of non-conventional resources for animal feed has been made possible by the process known as fermentation. Then their proximate composition was analyzed. Total phenolic and total flavonoid content were also analyzed. The antioxidant activities of non-fermented and fermented wheat bran were evaluated by the DPPH radical scavenging assay and the ABTS radical scavenging assay. The protein percentage was increased from 16.29% to 19.25% after 72 hours of fermentation. The carbohydrate percentage was also increased from 74.40% to 78.60%. Among the ethanol, methanol, and water-extracted solutions of fermented and non-fermented wheat bran, methanolic extract showed the highest results for active components and antioxidant activity. In case of Total Phenol Content(TPC) the non-fermented and fermented wheat bran contain 4.90 and 7.80mg of gallic acid/g respectively. For Total Flavonoid Content(TFC) the quantitative value of non-fermented and fermented samples was 10.77 and 15.10mg of quercetin/g, respectively. In case of DPPH and ABTS % radical scavenging activity it was found that the difference between non-fermented and fermented maize was 20.91 to 53.12 % DPPH and 15.30 to 40.40% ABTS, respectively. The process of fermentation has been reported to improve the nutritional quality of agro-industrial products that can be used in aquafeed and animal feed industries.

Keywords: Wheat bran, Anti-oxidant, Proximate composition

SUPPLEMENTATION OF CHICKEN EGG SHELL STIMULATES GROWTH AND MOLTING IN FRESHWATER PRAWN (*Macrobrachium rosenbergii*)

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Calcium is an essential nutrient that is recognized for its fundamental importance during the molting of Arthropods. Global production of chicken eggs leads to waste like eggshell which is a great source of calcium. Therefore, an experiment was conducted to investigate the effect of chicken eggshell supplementation on the growth and molting performance of freshwater prawns (*Macrobrachium rosenbergii*). Chicken eggshell was used as a replacement for DCP (1.2% in the total feedstuffs) in the formulated diet of *M. rosenbergii* and three different diets were prepared using different eggshell inclusion levels; diet 1- 100% DCP (no eggshell), diet 2- 50% DCP + 50% eggshell, and diet 3- 100% eggshell (no DCP) with a fixed rate of protein percentage (34%). Ninety *M. rosenbergii* (6.13 ± 0.54 cm in length and 1.77 ± 0.37 g body weight) were fed at varying inclusion levels of 0%, 50%, and 100% eggshell for a period of 30 days, and growth performance and the number of molted prawns were recorded. Results showed that *M. rosenbergii* fed with diet 3 demonstrated significantly higher mean weight gain (MWG), specific growth rate (SGR), and relative growth rate (RGR), compared to diet 1, whereas feed conversion ratio (FCR) showed a significantly lower value in diet 2 and 3 compared to diet 1. Principal component analysis (PCA) using different lengths and weight revealed that body weight (BW), standard length (SL), partial carapace length (PCL), carapace diameter (CD), highest body depth (HBD), and lowest body depth (LBD) were the major components that contribute the growth in prawns fed with diet 3. The molting percentage was 45%, 35%, and 13% in the diets 3, 2, and 1, respectively during the culture period. The findings of the present study may be useful in utilizing the chicken eggshell waste as a feed supplement, which could also help to reduce environmental pollution.

Keywords: Eggshell, *Macrobrachium rosenbergii*, Moulting

ANALYSIS OF PROXIMATE COMPOSITION, ACTIVE COMPOUNDS, ANTIOXIDANT ACTIVITY OF NON-FERMENTED AND FERMENTED MAIZE

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Fermentation ensures the utilization of non-conventional resources for fish feed. It decomposes complex organic substances into simpler compounds by the action of microorganisms. The aim of the current study was to evaluate the changes in proximate composition, active components, and antioxidant activity of non-fermented and fermented maize. Sample was collected from a local market and fermented with protease producing bacteria. Then their proximate composition was analyzed. Total phenolic and total flavonoid content was also analyzed. The antioxidant activities of non-fermented and fermented maize were evaluated by the DPPH radical scavenging assay and the ABTS radical scavenging assay. The protein percentage was increased from 8.04 to 10.55% after 72 hours of fermentation. The carbohydrate percentage was also increased from 63.63 to 85.66%. Among the ethanol, methanol and water extracted solutions of fermented and non-fermented maize ethanolic extract showed the highest results for active components and antioxidant activity. In case of Total Phenol Content (TPC) the non-fermented and fermented maize contain 2.50 and 7.03 mg of gallic acid/g, respectively. For Total Flavonoid Content (TFC) the quantitative value of non-fermented and fermented samples was 6.10 and 11.17 mg of quercetin/g respectively. In case of DPPH and ABTS % radical scavenging activity, it was found that the difference between non-fermented and fermented maize was 44.46 to 53.87 % DPPH and 53.60 to 63.90% ABTS respectively. The above results indicate that fermentation can be a very effective biological method to use maize by enhancing its active compounds, antioxidants, and protein for the formulation of cost-effective fish feed.

Keywords: Maize bran, Anti-oxidant, Proximate composition

EVALUATION OF THE NUTRITIONAL QUALITY OF FEED OF SOME INDIGENOUS FISH SPECIES IN BANGLADESH

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A study was conducted to investigate the nutritional status of indigenous fish feed available in Bangladesh. Nursery, starter 1, starter 2, and grower feed were collected from ACI Godrej, Agata Feed, C.P. Bangladesh Co. Ltd., ChhuyaAgro, KNB Feed, Quality Feed, Tongwei, New Hope, Paragon Feeds, and Nourish Feed for the proximate chemical composition, gross energy, and total calcium and phosphorus. The indigenous fish species were categorized as koi, pabda, gulsa, shing, magur and shol (snakehead). For example, shol (snakehead) 7.4-9.8%, climbing perch (koi) 5.30-12.0%, pabda, gulsa, shing and magur 5.30-12.0%. Protein (dry matter – DM basis) concentration in the feed of shol (snakehead) 43.8-46.1%, climbing perch (koi) 33.7%-48.4%, pabda, gulsa, shing, magur 33.7%-48.4% were also within the label declared by the feed companies. The crude lipid (DM basis) content in the feed for shol, climbing perch, pabda, gulsa, shing and magur was between 7.3 - 9.2%, 5.6 - 10.5%, and 5.6 -10.5%, respectively, and was not found within the label mentioned by the feed companies. The fiber value for shol (snakehead), climbing perch (koi), and catfish was varied between 0.2 - 1.7%, 1.0-5.4%, and 0.8-5.4%, respectively and within the declared label of companies. The concentration of phosphorus varied largely among the feed companies and was between 1.0-1.7% for all three species groups. It can be concluded from the present study that the concentration of moisture, crude protein, crude fiber, crude ash, calcium in nursery, starter 1, starter 2, grower feed were found within the amount labeled by companies.

Keywords: Nutrient requirement, Small Indigenous Fish, Fish feed

ISOLATION AND CHARACTERIZATION OF BACTERIA FROM SOIL AND WATER AND THEIR EFFECT ON NUTRIENT COMPOSITION OF SOYBEAN MEAL UPON SOLID-STATE FERMENTATION

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Beneficial microorganisms, known to confer positive health benefits and enhance the nutritional quality and shelf-life of food ingredients through fermentation, have been used in various dimensions from time immemorial. Being more specifically classified as probiotics, these microbes have been used in aquaculture in Bangladesh for the last decades. Therefore, this study was carried out to isolate the bacterial strains from the natural native sources, characterize their biochemical and probiotic properties, perform screening for exogenous enzymes, and use the combination of isolates in the fermentation of soybean meal. From soil and water samples, a total of five isolates (SB-1, SB-2, SB-3, SB-4, and SB-5) were collected. The preliminary identification was carried out based on morphological and biochemical tests. Most of the five isolates have been observed to have the ability to break down different types of carbohydrates and proteins. In the case of probiotic properties (in-vitro assay), most isolates showed moderate to low tolerance in acidic pH, whereas all were highly bile salt resistant. SB-1 and SB-2 showed medium auto-aggregation capacity. Three of the tested isolates (SB-3, SB-4, and SB-5) showed no hemolysis, and the others had partial hemolytic features. All the isolates were cellulolytic, with three of those being protease-producing bacteria. When used as a combination, these isolates in solid-state fermentation of soybean meal showed the best nutritional enhancement (Dry Matter basis) with the highest protein content ($58.64\% \pm 1.61$) after four days. From this study, we have found out that the isolated bacteria can be used for feed development. It could also be vital to utilize plant-protein as an alternative to animal-protein sources for aquafeed preparation.

Keywords: Probiotics, Bacteria, Soil, Water

**ASSESSMENT OF *Salmonella* and *Escherichia coli* CONTAMINATION IN
COMMERCIAL FISH FEEDS AND LOCAL FISH FEED INGREDIENTS
AVAILABLE IN NORTHERN PART OF BANGLADESH**

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The study was conducted for the assessment of *Salmonella* and *Escherichia coli* (*E. coli*) contamination in five different commercial fish feed brands, including ACI, Aman, Teer, A-One, and New Hope, and three different local fish feed ingredients, including rice bran, mustard oil cake, and dry fish powder in northern part of Bangladesh for a period of seven months from July, 2019 to January, 2020. The results indicated that all of the samples were contaminated with *Salmonella* and *E. coli* bacteria, and the percentages were 31.69% and 54.73%, respectively. The incidence of *E. coli* was higher than that of *Salmonella* spp. The highest number of *Salmonella* and *E. coli* contaminations were found in rice bran (64.28%) and mustard oil cake (83.33%), respectively in feed ingredients. The presence of a high concentration of *E. coli* and *Salmonella* spp. in fish feeds and feed ingredients ultimately indicates a lack of proper hygienic practices during product manufacturing, afterward product maintenance, and proper transportation.

Keywords: *Salmonella*, *E.coli*; Fish feeds, Fish Feed ingredients

SURVIVABILITY, GROWTH, IMMUNITY AND DISEASE RESISTANCE OF ROHU (*Labeo rohita*) LARVAE REARED WITH MULTI-SPECIES PROBIOTICS

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Probiotics is one of the most reliable approaches to combat fish disease for sustainable aquaculture. Multi-strain probiotics (MSP) provide more benefits to aquatic organisms as it provides synergistic effect in contrast to the use of a single-strain probiotics (SSP). This research was carried out to evaluate the effects of the multi-species probiotics on the survival, growth performance, immunity and disease resistance in *Labeo rohita* larvae. Newly hatched *L. rohita* larvae (average weight 0.003g) from the day of first feeding were reared in small aquaria with multi-species probiotics supplied in the water for 90 days. Multi-species probiotics containing *Bacillus* spp. (1×10^9 cfu/mL) and *Lactobacillus* spp. (1×10^{11} cfu/mL) were supplemented with raising water at doses of 0 (control), 0.5, and 1.0 ml/L in triplicates. The results showed that growth performance [weight gain and specific growth rate (SGR) and survival] were significantly higher in fish maintained in the probiotic-supplemented water compared to control. Immune response indicators of histological gut of *L. rohita* (fattening of mucosal fold, abundance of goblet cell, width of lamina propria, enterocyte width) and total viable count were also significantly better in fish reared in probiotic-supplemented water than the control. Further, probiotics treated fishes had highest post challenge survival rate (100%), followed by control against *Aeromonas veronii* infection. Considering these promising results, we suggest that a multi-species probiotics supplementation for 90 days can effectively improve fish survival, health welfare, better immune response and growth performance.

Keywords: Probiotics, *Labeo rohita*, Bacteria

GROWTH PERFORMANCE OF NILE TILAPIA REARED WITH MULTI-SPECIES PROBIOTICS

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Application of probiotics in aquaculture is growing due to its miraculous results as an ecologically sound agent. A study was done in the laboratory using multi-species probiotics containing *Bacillus* spp. (1×10^9 cfu/mL) and *Lactobacillus* spp. (1×10^{11} cfu/mL) to assess the growth performance of Nile tilapia (*Oreochromis niloticus*). Tilapia fingerlings (5.95 ± 0.07 g) were stocked and evenly distributed into three replicates, each separated into three treatment groups, each providing probiotics at concentrations of 0, 0.5, and 1.0 ml /L in water for eight weeks. After completion of the trial, growth factors (weight gain, % weight gain, specific growth rate, hepato-somatic index, and viscera somatic index), feed utilization parameter (feed conversion ratio), gut microbiota, and intestinal, liver, and muscle morphology were examined. The experiment revealed dramatic growth and feed utilization in the fish reared with multi-species probiotics compared to the control group. The total viable count (TVC) and total lactic acid bacteria (LAB) count increased substantially in the fish gut provided with multi-species probiotics. The morphological improvement of intestine includes increased intestinal length, width, and area of the villi, lamina propria, and abundance of goblet cells were observed in the probiotic treated fish. The livers of treated fish showed irregular shaped nucleuses turned into regular shaped and reduced spaces between liver tissues. Increased number of nucleus, diameter of muscle fiber, and hyperplastic muscle fiber were also found from morphological observation of the multi-species probiotics applied to the fish compared to the control group. The study indicates administration of multi-species probiotics can be an important growth promoter for Nile tilapia.

Keywords: Probiotics, Tilapia, Bacteria

SEASONAL VARIATION OF PROXIMATE COMPOSITION OF HILSHA (*Tenualosa ilisha*) IN THREE CHANNELS OF BARISAL REGION

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Hilsa is one of the most important tropical fishes in the indo-pecific region. Hilsa from Kirtonkhola river (Barisal), Payra river (Patuakhali) and Rabnabad channel (Patuakhali) were analyzed which showed that proximate compositions varied among different size in different season. In Kirtonkhola river, Payra river and Rabnabad channel, moisture content in summer season the small size of hilsa fish were 70.26%, 67.62%, 69.21%; in rainy season the medium size fishes were 65.51%, 63.41%, 65.37%, and in winter season the large size flesh fishes were 60.05%, 58.18%, 55.63%; For ash content in summer season the small size hilsa fish were 1.37%, 1.19%, 1.25% respectively; in rainy season the medium size fishes were 2.15%, 2.09%, 2.11%, respectively and in winter season the large size flesh fishes were 3.05%, 3.08%, 3.03% respectively; For lipid content in summer season the small size hilsa fish were 7.72%, 8.1%, 7.92% respectively; in rainy season the medium size fishes were 12.17%, 13.51%, 12.28% respectively and in winter season the large size flesh fishes were 18.93%, 20.65%, 23.39% respectively, For protein content, in the summer season the small sized hilsa fish were 19.12%, 20.13%, and 19.25% respectively; in the rainy season the medium sized fish were 17.59%, 18.17%, and 17.72% respectively; and in the winter season the large sized flesh fish were 15.7%, 17.46%, 14.61% respectively. The study revealed that the large proximate composition of hilsa species varies with the stages of maturity in different seasons.

Keywords: Hilsa, Proximate composition, Seasonal variation, Proximate composition

**SEASONAL VARIATION OF WATER QUALITY PARAMETERS IN RIVER,
LAKES AND WATERFALLS IN RANGAMATI AND KHAGRACHARI
HILL TRACTS OF BANGLADESH**

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The present study was conducted to investigate the seasonal variation of water quality parameters from river, lake and waterfalls in Rangamati and Khagrachari hill tracts of Bangladesh. The study conducted from March 2021 to January 2022. Results showed that the temperature, EC, TDS, DO, BOD, pH, total alkalinity and total hardness were 16 to 32.5^oC, 90 to 180 μ S/cm, 53 to 75 mg/L, 5.4 to 7.5 mg/L, 0.95 to 1.8 mg/L, 6.0 to 7.9, 83 to 140 mg/L and 45 to 135 mg/L, respectively in the Kaptai Lake. In Chengi River, the results showed the temperature, EC, TDS, DO, BOD, pH, total alkalinity and total hardness were 15 to 29.7^oC, 90 to 170 μ S/cm, 40 to 88 mg/L, 4.4 to 7.2 mg/L, 0.98 to 1.76 mg/L, 5.9 to 8.01, 85 to 190 mg/L and 45 to 139 mg/L, respectively. In the Shuvolong and Risang Waterfall the temperature, EC, TDS, DO, BOD, pH, total alkalinity and total hardness were 12 to 22.01^oC, 150 to 200 μ S/cm, 74 to 114 mg/L, 5.4 to 9.5 mg/L, 0.63 to 1.7 mg/L, 6.5 to 8.2, 120 to 223 mg/L and 75 to 200 mg/L, respectively. The study revealed that the temperature, EC, TDS, BOD, pH was higher in pre-monsoon season than monsoon and post-monsoon season. On the other hand, total alkalinity and total hardness was higher in post monsoon season than monsoon and pre-monsoon season. In the waterfalls transparency was higher in post monsoon season than monsoon season and DO was higher in monsoon season compared to pre monsoon and post monsoon season. The current study provides baseline data on physiochemical parameter fluctuation in the Chittagong Hill Tracts lake, river, and waterfalls, which will contribute in the long-term management and protection of those ecosystems.

Keywords: Water quality, Hilly District, Water falls

PRESENT STATUS OF FISH HATCHERIES AND BROODSTOCK FEEDS IN DINAJPUR DISTRICT

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A year-long study was conducted to investigate the present status of fish hatcheries and brood stock feeds used in the hatcheries of Dinajpur district. A total of twelve hatcheries were found in Dinajpur district. Data was collected by using a well-structured questionnaire. The study revealed that the average age of the most respondents (44%) was in the age group of 41-55 years; all of them were male and Muslim and used ground water in the hatchery activities. Most of the hatchery owners were qualified at a higher secondary level (34%) and 56% of the respondents were trained by different organizations. It was found that 75% hatcheries were operated privately, 50% were large (area above 6 acres), and the annual productivity of fish seed of 67% of hatcheries were low (less than 1000 kg/year). Most of the respondents (67%) used both commercial and on-farm feeds. Commercial feeds were collected from various reputed feed companies, e.g., Mega Feed, Provita Feeds Limited, Quality Feeds Limited, Aftab Feed Production Limited, AG Agro Feeds Limited, Lili Feeds Limited etc., and 42% of the respondents applied feeds at 1-2% of body weight, 67% of the respondents fed twice daily in the morning and evening. Feeds were applied manually in all the hatcheries.

Keywords: Fish feed, Brood stock, Dinajpur

EFFECTS OF *Spirulina platensis* MEAL AS A FEED ADDITIVE ON GROWTH AND IMMUNE RESPONSE OF GULSHA, *Mystus cavasius*

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An experiment was conducted to observe the effect of *Spirulina platensis* on growth performance, body composition, and immune response of gulsha (*Mystus cavasius*). The experiment was conducted with five treatments, each with three replications. The gulshas were fed with diets where fish meal was replaced by *S. platensis* at five graded levels (0, 2.5, 5.0, 7.5, and 10%). Fish were reared in rectangular-shaped glass aquaria, each with a water capacity of 180 L and fed two times in a day near satiation. The stocking density of fish was 50 per aquarium. At the end of the feeding trial, 10 fish of each treatment were challenged by pathogenic *Aeromonas hydrophila*, given by an intra-peritoneal injection, and were kept under observation for 10 days to record the symptoms and daily mortality rate. At the end of the experiment, growth performance, whole-body composition, blood parameters, and serum lysozyme values were investigated. Replacement of 7.5% fish meal in the diet with *S. platensis* meal resulted in higher body weight, protein efficiency ratio (PER), and lower feed conversion ratio (FCR) than the control diet ($p < 0.05$). The treatment, where 10% dietary fish meal was replaced with *S. platensis*, had higher whole-body protein and ash content than control ($p < 0.05$), whereas a higher level of moisture and lipid content were observed in the control diet. Feeding fish with 7.5-10% *S. platensis* increased the red blood cell, white blood cell, haemoglobin, lymphocytes, monocytes, hematocrit, mean corpuscular haemoglobin than control ($p < 0.05$). The treatment with 7.5% replacement of fish meal with *S. platensis* has a higher serum lysozyme value than control ($p < 0.05$). The addition of *S. platensis* in the fish diet decreased the total mortality challenged with *A. hydrophila*. Therefore, a dietary replacement of 7.5% fish meal with *S. Platensis* can be recommended for gulsha.

Keywords: *Spirulina platensis*, Feed additives, *Mystus cavasius*

IDENTIFICATION AND CHARACTERIZATION OF CELLULASE PRODUCING BACTERIA ISOLATED FROM FERMENTED BAMBOO

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Cellulose is one of the most abundant polysaccharides in plant ingredients but hinders its potential as feed. Cellulases are the enzymes that hydrolyze cellulosic biomass and are produced by the microorganisms grown over cellulosic substrates. Therefore, this study was conducted to isolate the cellulase producing bacteria from the fermented bamboo and characterize their biochemical and probiotic properties. Fermented bamboo sample was collected from Khagrachhari as a source of cellulose degrading bacteria. Nutrient media were used for bacterial isolation followed by screening using Carboxymethylcellulose (CMC) agar plates to identify cellulolytic isolates where three (3) identified bacteria were FB-1, FB-2 and FB-3. The preliminary identification of the isolates was carried out based on morphological and biochemical tests such as gram test, catalase test, oxidase test, Methyl red-VogesProskauer test, Indole test, Gelatinase test, etc. In biochemical characterization, three isolates were gram and catalase positive (+) and two isolates were oxidase positive. In the Methyl red-VogesProskauer test, two were MR positive and one was VP positive. In glucose and sucrose fermentation, all isolates showed positive results whereas two out of three were positive in starch and dextrose fermentation. Moreover, pH tolerance, bile tolerance, hemolytic activity, and auto-aggregation were performed as in-vitro assays of probiotic properties. A bile test with one bile concentration of 0.3% and a pH test with three pH values (pH 3 pH 4 and pH 7) was evaluated to know its potential as a probiotic. The tested isolates showed moderate tolerance in acidic conditions whereas they were highly resistant to bile salt. In the case of auto-aggregation, FB-3 isolates showed low auto-aggregation capacity, and whereas FB-1 and FB-3 showed medium auto-aggregation capacity. In addition to that, the antibiotic susceptibilities and hemolytic assay of three isolates were tested. A total of three isolates were screened for antibiotic susceptibilities and showed different levels of susceptibilities in response to different antibiotics. To determine the pathogenicity of isolates, a total of three isolates were screened out by hemolytic assay and found that three isolates showed gamma hemolysis, which indicates no lysis of blood cells. From this study, it has been found that isolates do not exist for secret H₂S or Urease. The tested isolates showed nonpathogenic characteristics and good probiotic features. The three isolates also have the ability to break down the carbohydrates (CMC) containing media, and these bacteria have shown cellulase producing capability. The isolated bacteria could be utilized for pre-treating plant feed ingredients to improve the nutritional quality and digestibility, reducing anti-nutritional factors.

Keywords: Cellulase, Probiotics, Bamboo

**EFFECT OF DIFFERENT NITROGEN CONCENTRATION ON THE GROWTH,
PIGMENT AND PROXIMATE COMPOSITION OF FRESHWATER MICROALGAE
*Monoraphidium contortum***

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The objective of this study was to examine the effects of different nitrogen concentrations on the growth, pigments, and proximate composition of the freshwater microalgae *Monoraphidium contortum*. It was observed that higher nitrogen concentrations had a significant ($p < 0.05$) impact on enhancing microalgal growth, photosynthetic activity, protein and carbohydrate content. Maximum cell density (7.19×10^7 cells/ml), dry biomass (0.61g/L), total chlorophyll (17.42 mg/L) were obtained in the highest concentration of (18.5g/500ml NaNO₃), on the contrary, minimum values were found in 6.5g/500ml NaNO₃. Carotenoid (6.14 mg/L) and total phycobiliprotein (4.11 mg/g) were maximum in control concentration (12.5g/500ml) of NaNO₃. Proximate composition also varied significantly ($p < 0.05$) among all the treatments, where maximum protein (23.77% dry weight) and carbohydrate (22.79% dry weight) were produced in the highest nitrogen concentration (18.5g/500ml NaNO₃) and minimum protein (16.36% dry weight) and carbohydrate (14.08% dry weight) were found in the lowest nitrogen concentration (6.5g/500ml NaNO₃). Moreover, the highest lipid accumulation (20.07% dry weight) was obtained at the concentration of 6.5g/500ml NaNO₃, whereas the lowest 15.88% dry weight lipid was in 12.5g/500ml NaNO₃. This study stated that higher nitrogen concentration boosts the growth and nutritional profile of *M. contortum*, but lower nitrogen concentration enriches the lipid production, which will be economical in commercial microalgae culture.

Keywords: Microalgae, *Monoraphidium contortum*

EVALUATION OF THE NUTRITIONAL QUALITY OF TILAPIA (*Oreochromis niloticus*) FEED AVAILABLE IN BANGLADESH MARKET

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A study was conducted to investigate the nutritional status of Tilapia feed available in Bangladesh market. Nursery, Starter 1, Starter 2, and grower feed was collected from Quality feed, Mega feed, Nourish feed, Rupushi Bangla, Tongwei, KNB Feed, Agata feed, AIT feed, New Hope, Paragon feeds, Nahar feed, C.P. Bangladesh Co. Ltd for the proximate chemical analysis. In the present study, the moisture content in the feed of Tilapia was recorded at 7.04-11.54%. The protein concentration in the feed was found 27.04-43.94%. The estimated crude lipid value of the feed companies was ranged from 2.11% to 11.54%. Ash content of the tested feeds of Tilapia was recorded between 5.69-10.16%. Fiber value of the tested feeds of Tilapia varied ranged 0.75-7.05%. The concentration of carbohydrates in the feed was recorded in the range of 32.01-52.70%. The estimated amount of calcium of the tested feeds of Tilapia ranged from 0.75% to 1.95%. The concentration of phosphorus was recorded between 0.40-1.13%. Moisture, Protein, Ash, Fiber, Calcium and Phosphorus content of the tested feed were within the level declared by feed companies and DoF standard. While carbohydrate and crude lipid content were less deviation from standard limit of DoF. The result of the present study demonstrated Carbohydrate and Lipid were not found within the label declaration by feed companies and DoF.

Keywords: Tilapia, Fish feed, Proximate composition

ISOLATION, SCREENING AND PRODUCTION OF CELLULASE ENZYME FROM INDIGENOUS BACTERIA AS A POTENTIAL FEED SUPPLEMENT FOR ENHANCING FISH AND SHRIMP PRODUCTIVITY

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Aquaculture is one of the agro-industrial activities that has the highest growth retain last decades and provide sustainable benefits for providing feed as well as contributing to economic development. The majority of aquaculture feed is plant-based feed and contains a high amount of fiber. Thus, exogenous cellulose enzymes are now extensively used throughout the world as additives in fish diets. Also, supplementation with enzymes can help to degrade the cellulose in plant feedstuffs, resulting in improved performance of fish and shrimp productivity. This present study was conducted to isolate extracellular cellulase-producing bacteria from indigenous sources like soil from a different region of Bangladesh for enhancing fish and shrimp productivity. In this study, samples were collected contained in sterilized bags and transported immediately to the laboratory at -80°C . Then serially diluted and an aliquot of the suspension was streaked on different nutrient agar media and incubated at a different range of temperature 25°C - 37°C for 24 hr for pure colony separation. A total of fourteen (14) bacteria were isolated and purified using different levels of screening based on colony morphology and biochemical characterization (such as gram test, hemolytic test, catalase test, oxidase test, starch hydrolysis test, MR test, and gelatinase test). Among isolates, three (3) isolates were screened for the cellulolytic enzyme. The colonies which show discoloration of Congo-Red medium were identified as cellulose bacterial colonies. Crude enzymes were prepared and activity was assessed. Among isolates, SB2 gave maximum activity (OD_{600} 0.94) at 30°C temperature, pH 6, and 72-hours fermentation. SB2 was purified through ammonium sulfate precipitation and maximum activity (0.28 U/ml) was determined using glucose standard curve through cellulase activity assay. Besides, to conduct molecular characterization, amplified 16SrRNA and got a band size of about 1465bp, respectively on agar osegelectrophoresis. The above results indicate that this bacterial isolate can be used as a biotechnological tool and a potential feed supplement for enhancing fish and shrimp productivity.

Keywords: Cellulase-producing bacteria, Shrimp feed, Biotechnology

ISOLATION, SCREENING, AND PRODUCTION OF PHYTASE AS POTENTIAL FISH FEED SUPPLEMENT FROM INDIGENOUS BACTERIA FOR ENHANCING FISH AND SHRIMP PRODUCTIVITY

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Phytate is an antinutritional factor widely found in plant-based feed raw materials. Dietary supplementation of phytases, essential for the digestion of plant-derived phytates, increases the bioavailability of phosphorus and other minerals and improves overall growth performance. The use of exogenous phytase in feed is substantially efficient in reducing phosphorus excretion by converting phytate phosphorus into bioavailable free inorganic. The objective of the present study was to isolate phytase-producing bacteria as a potential fish feed supplement from indigenous bacteria for enhancing fish and shrimp productivity. Total of five samples were collected from indigenous sources like gut intestine of grass carp gut bought from local market. Samples were serially diluted and streaked on nutrient agar plates for pure colony separation. Among the isolates, two (2) isolates were screened for the phytase enzyme. For phytase, the colonies that show clear hydrolytic zone forming bacterial strains in calcium phytate media were taken as phytase-producing bacteria. Crude enzymes were prepared by infusion into broth media and activity was assessed by the phytase enzyme assay procedure. Among isolates, maximum activity of GCG-7 was (OD_{700} 0.87) at 35^o C temperature, pH 7, and day-4 fermentation. The crude enzyme (GCG-7) was purified through ammonium sulfate precipitation and comparative activity (0.20 U/ml) was determined. Also conducted molecular characterization, amplified 16SrRNA and got a band size of about 1465bp, respectively on agarose gel electrophoresis. The above results indicate that this bacterial isolate can be used as a potential feed supplement for enhancing fish productivity in the fish feed industry.

Keywords: Phytase-producing bacteria, Shrimp feed, Biotechnology

ISOLATION, SCREENING, AND PRODUCTION OF PROTEASE AS POTENTIAL FISH FEED SUPPLEMENT FROM BACTERIA COLLECTED FROM SOIL AND WATER OF COX'S BAZAR

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A dietary protease is an effective tool in improving feed utilization and growth performance of aquaculture species. The current study aimed to isolate extracellular protease-producing bacteria from indigenous sources like soil and water in different parts of Cox's Bazar. Samples were serially diluted and streaked on an agar plate for pure colony separation. A total of 14 bacteria were isolated and purified based on colony morphology and biochemical characterization. Among them, 8 isolates produced clear zone on casein media indicated having proteolytic activity and were chosen for further procedure based on clear zone diameter. Crude enzymes were prepared in casein broth and activity was assessed by the Lowry method (total protein estimation). Isolate UCW-1 gave maximum activity (OD_{750} 3.52) at 35^o C temperature, pH 7, and 36-hours fermentation. UCW-1 crude enzyme was purified through ammonium sulfate precipitation and comparative activity (U/mg) with Sigma protease enzyme (P2143-5G) was determined using a tyrosine standard curve through a universal protease activity assay. The activity of UCW-1 protease was found to be 0.37 U/mg whereas Sigma protease activity was 0.493 U/mg. The above results indicate that this bacterial isolate can be used as a biotechnological tool for the fish feed industry.

Keywords: Protease-producing bacteria from, Shrimp feed, Biotechnology

**EFFECT OF DIETARY LIPID ON GROWTH PERFORMANCE
AND BODY COMPOSITION OF THAI KOI, *Anabas testudineus***

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An experiment was conducted to investigate the effect of dietary lipid in practical diet on the growth performance, body composition, and production of climbing perch (*Anabas testudineus*) for a period of 100 days in ponds. Six experimental ponds were prepared for the rearing of Thai Koi (mean area of 0.0020 ha and water depth of 1.5m) by the Department of Fisheries, University of Rajshahi. Feed formulation was performed with lipid (soybean oil) considering the nutritional balance of the diets. Thai koi were fed with three different experimental diets containing soybean oil:0% (T₁), 5% (T₂) and 10% (T₃). Water quality parameters were monitored fortnightly and the growth parameters were monitored monthly. All the water quality parameters were found at suitable limit. The final weight, weight gain, SGR of fish were found significantly highest in the treatment in T₃ T₂ were higher ($p < 0.05$) than that of T₂ and T₁. The FCR value was significantly lower in the T₃ (1.83±0.02) diet-fed fish group than in the T₁ (2.43±0.13) diet-fed fish group. The mean values of SGR were found to be significantly higher in T₃ (5.86±0.27) than in T₁ (5.39±0.32). The yield was highest in T₃ (7046.48±25.57 kg/ha). The body composition of whole fish was significantly different among the treatments. Lipid content was found to be higher with T₃ (6.01±0.19) than with T₂ (5.78±0.17) and T₁ (5.05±0.14). Findings suggest that 10% soybean oil was in the practical diet, which is suitable for pond based Thai koi culture.

Keywords: *Anabas testudineus* , Fish feed, Dietary level

EFFECTS OF CARBON-NITROGEN RATIO MANIPULATION ON THE GROWTH PERFORMANCE, BODY COMPOSITION AND IMMUNITY OF STINGING CATFISH *Heteropneustes fossilis* IN A BIOFLOC BASED CULTURE SYSTEM

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A 10-week indoor culture trial was conducted to evaluate the effect of varying C/N ratios on growth performance, body composition, immunity, and hematology of *Heteropneustes fossilis* (locally known as shing) cultured in a biofloc system. Organic carbon in the form of molasses was added daily to the culture tanks to maintain carbon to nitrogen (C/N) ratios of 12:1 (CN12), 15:1 (CN15), 18:1 (CN18), and 21:1 (CN21) based on the carbon-nitrogen content of the feed and the carbon content of the molasses. No molasses was added in the control group, which had a C/N ratio of 10:1 (CN10). The higher C/N ratios shifted the predominately autotrophic biofloc to heterotrophic, simultaneously displaying higher levels of suspended solids. The water quality parameters (pH, temperature, total ammonia nitrogen, nitrite nitrogen, dissolve oxygen, total suspended solids, and total dissolved solids) were monitored throughout the experiment, which were found to be within permissible limits for shing culture. At the end of the experiment, it was observed that, there were significant differences between the treatment groups and the control regarding weight gain, weight gain %, specific growth rate %/day, feed conversion ratio, and protein efficiency ratio. Better final weight and specific growth rate with significantly higher protein efficiency ratio and lower feed conversion ratio value, were found in treatments CN15-CN21 than in the control treatment. Higher protein and ash content were found with increasing C/N ratio than control ($p < 0.05$) whereas higher levels of moisture and lipid content were observed in control. In the serum lysozyme test, values increased with a gradually increasing C/N ratio and a better result was found in CN15-CN21 treatments. At the end of the experiment, a challenge test was done to determine the mortality rate where mortality was lowest in CN15 (15:1) treatment. Furthermore, increasing the C/N ratio from CN15-21:1 showed better results for hemoglobin, white blood cell, red blood cell, and hematocrit%. Overall, the manipulation of C/N ratio from 15-21:1 revealed suitable for the feed utilization, growth performance, body composition, and immunity of shing. Therefore, maintaining a C/N ratio of 15:1 can be recommended for the culture of shing in a biofloc system.

Keywords: *Heteropneustes fossilis*, Biofloc, Feed

EFFECTS OF INOSINE MONOPHOSPHATE ON GROWTH AND GUT MORPHOLOGY OF JUVENILE GOLDEN MAHSEER *Tor putitora*

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Inosine monophosphate (IMP), a well-studied individual nucleotide, is recently being harnessed as a functional nutrient to ameliorate the health and growth status of aquatic species. To determine its effect as a functional nutrient on growth, feed utilization, and intestinal morphology of juvenile golden mahseer (*Tor putitora*), a feeding trial for 10-weeks was carried out in laboratory conditions. A casein and fishmeal based partially purified basal diet was prepared, which was composed of 40% protein, 10% lipid and without any IMP supplementation (Control). Four separate degrees of IMP nucleotide (0.05, 0.1, 0.2, and 0.4%) were combined with the previously prepared basal diet to prepare the experimental diets, named IMP-0.05, IMP-0.1, IMP-0.2, and IMP-0.4, respectively. Each diet was randomly assigned to three groups of fish (n = 10), the initial average weights of which were 9.1 g. It was discerned from the results that, the dietary IMP significantly enhanced ($p < 0.05$) the growth performance of fish, and fish fed diets IMP-0.05 and IMP-0.1 showed significantly higher growth performance. In comparison to IMP-0 (control), the IMP-0.05 diet group showed a significantly lower feed conversion ratio (FCR). The protein efficiency ratio (PER) was also considerably ameliorated in the IMP-0.05 diet group along with the IMP-0.1 diet group, followed by the IMP-0.2 fish diet group. Quadratic regression analysis of percent weight gain (%WG) indicated that 0.15% IMP supplementation was optimum for juvenile golden mahseer. IMP supplementation between 0.05%-0.15% showed significant improvement in fold height (hF), enterocyte height (hE), and microvillus height (hMV) of anterior intestine compared to the control diet group. This level of IMP supplementation brought significant improvement in posterior hE and hMV, while hF in posterior intestine was numerically increased by IMP supplementation except in the IMP-0.05 diet group. Hence, 0.05%-0.15% IMP supplementation was optimum for improving growth-related indices and gut morphological features in juvenile *T. putitora*.

Keywords: *Tor putitora*, Inosine monophosphate, Feed

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

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Evaluation of using housefly maggot meal (MM), a protein sources ingredient from housefly *Musca domestica*, as a potential substitute of fishmeal (FM) in practical diets of rainbow trout *Oncorhynchus mykiss* was undertaken to develop low FM practical diets. Among four isonitrogenous and isocaloric diets, diet MM0 was the control, containing 15% FM without MM. Diets MM6, MM12, and MM18 were obtained by including graded levels of MM (6%, 12% and 18%) replacing FM (33%, 66% and 100%, respectively) from the control. Triplicate groups of 25 rainbow trout (initial average weight of 14.60 ± 0.13 g) were reared in 60-liter glass tanks for 12 weeks. Insignificant differences ($p > 0.05$) in growth and feed performance among all treatments were observed except for MM6. The growth decreased slightly as MM was included. The N and P retention values (35.10 ~ 38.48% and 39.91 ~ 44.08%) in fish fed experimental diets showed an insignificant difference. The total amino acid composition of rainbow trout showed no significant difference between the control and experimental groups. The fatty acids 16:0 and 16:1 of fish whole bodies increased significantly ($p < 0.01$) with the inclusion levels of MM in test diets, while 18:2n-6 decreased. Phagocytic activity of head kidney leucocytes of rainbow trout and phagocytic index were not affected with FM substitution by MM, except for the MM6 group. There was no difference in superoxide production in phagocytes among all groups. Thus, MM being able to completely replace FM in the diet of rainbow trout, can meet its nutrient requirements as a potential substitute for fish meal.

Keywords: Fish meal, Maggot, *Oncorhynchus mykiss*

EVALUATION OF DIFFERENT STOCKING DENSITY OF SMALL INDIGENOUS FISH PABDA WITH CARP POLYCULTURE SYSTEM AT JHENAIDAH DISTRICT

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An experiment on the polyculture of carps with high valued small indigenous fish species (SIS) Pabda (*Ompok pabda*) was carried out for 152 days to evaluate the production performances of carp and pabda in some on-farm pond conditions in three Upazila of Jhenaidah district. Three stocking densities of Pabda were T₁500, T₂600, and T₃700 fish per decimal where released, carp density was the same among the treatments at 246 nos./33 decimal. Fish was fed with commercial (sprectahexa, mega) pelleted feed at the same rate at the different stages of Pabda (0.66-50 gm BW @ 20%-4% twice a day respectively). The weight gain of Pabda was 40.965±0.04, 35.17±0.11 and 30.99±1.17 g in T₁, T₂, and T₃ treatments, respectively. The production levels showed significant difference (p<0.05) among the treatments. The SGR (%) of Pabda was 2.76±0.0006, 2.66±0.002 and 2.58±0.024 in T₁, T₂, and T₃, respectively that showed a significant difference (p<0.05) among the treatments. The weight gain of carp was 1177.24±30.87, 1150±0.001, 1154.85±3.43 in T₁, T₂, and T₃, respectively, which was also significantly different (p<0.05) when ANOVA was performed. The water quality parameters like transparency and dissolved oxygen in the treatments showed significant differences (P<0.05) except temperature, pH, and ammonia nitrogen. The results of the present study demonstrated that the fishes showed better growth, survival, and production in the low stocking density of Pabda in T₁ treatment.

Keywords: Polyculture, *Ompok pabda*, Stocking density

MODULATION OF GROWTH, BIOCHEMICAL AND HISTOLOGICAL CHARACTERISTICS OF STINGING CATFISH AND NILE TILAPIA USING NATIVE FISH PROBIOTICS

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Feed supplementation with probiotics are gaining importance in the aquaculture systems, and those probiotic bacteria are mostly isolated from land animals and non-native fish sources. These probiotics are mostly imported to Bangladesh and sometimes show a negative impact on fish and the surrounding environment. In that case, development of probiotics from native sources are expected to adapt better to the aquatic environment and improve the physiology of fish species. A study has been conducted with the native probiotic (HF consortium) prepared by combining 5 bacterial isolates collected from the intestine of Stinging catfish (*Heteropneustes fossilis*). The HF probiotic consortium was used in the mini-biofloc culture system and in the traditional culture system as a feed supplement where fingerlings of Stinging catfish (22 days old) and Nile tilapia (45 days old) were used as test subjects. All the fishes were fed three times daily at 5% of their body weight and reared for 60 days. Growth performance, feed utilization, hematology, liver and intestine morphology and gonadal development of fishes in all the experimental groups were examined. Results suggested that significantly ($p < 0.05$) higher body weight has been observed in HF consortium treated group (average body weight 6.52 ± 0.10 g) than commercial probiotics (6.22 ± 0.39 g) and control (4.79 ± 0.08 g). Similar results have been found in the traditional feeding systems for Stinging catfish and Nile tilapia. The HF consortium treated fish showed significant changes in the morphology of their intestine by the presence of a higher number of goblet cells, high value of microvillus length, width of enterocyte, greater thickness of intestinal wall and villi area than the control. In case of liver, a lower number of cells with irregular nucleolus was found in all the treatment groups. Histological analysis and a high value of GSI compared to the control indicated early gonadal development of the ovary. In case of hematological parameters, a significant increase of RBC has been observed in biofloc ($2.70 \pm 0.45 \times 10^6/\text{mm}^3$) and feeding system ($2.36 \pm 0.35 \times 10^6/\text{mm}^3$ and $2.82 \pm 0.48 \times 10^6/\text{mm}^3$ for Stinging catfish and Nile tilapia respectively) treated with HF consortium than the control ($2.05 \pm 0.33 \times 10^6/\text{mm}^3$). On the other hand, WBC showed the opposite results. Glucose and Hb also showed significantly higher values in all the treated groups compared to the control. The HF consortium proved to be an effective probiotics for increasing the growth and physiology of the same species and of cross species like Nile tilapia. Therefore, HF consortium can be recommended as an effective native fish probiotics for commercial aquaculture production.

Keywords: Probiotics, Tilapia, *Heteropneustes fossilis*

EFFECT OF NATIVE PROBIOTICS ON THE ENHANCEMENT OF GROWTH AND HISTO-BIOCHEMICAL PARAMETERS OF NILE TILAPIA

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Probiotics as an eco-friendly alternative to such chemicals are being used worldwide, mostly isolated from terrestrial hosts and non-native fish sources. Such probiotics are expensive, imported to Bangladesh, and have failed to show their consistent efficiency. In this study, a probiotic formulation (ON consortium) was prepared by combining 4 potential bacterial isolates collected from the gut of Nile tilapia (*Oreochromis niloticus*) and was tested in vivo in traditional feed supplements and mini-biofloc culture systems. For the feeding experiment, 10 day old fry and 45 day old fingerlings of Nile tilapia and for the mini-biofloc culture system, 10 day old Nile tilapia fry were used as test subjects. All the fishes were fed three times daily at 5% of their body weight for 60 days. After the experiment, growth performance, feed utilization, hematology, liver and intestine morphology, and gonadal development of fishes in all the groups were evaluated. In case of mini-biofloc system, significantly higher ($p < 0.05$) body weight (Av. weight $2.468 \pm 1.18g$) has been observed in case of native probiotics than commercial probiotics ($1.86 \pm 1.46g$) than control ($1.46 \pm 1.37g$). In case of feeding system of fry and fingerling, the treated group with ON consortium showed significantly higher body weight ($2.46 \pm 1.47g$ and $11.94 \pm 4.55g$ respectively) than the control ($1.54 \pm 0.67g$ and $8.40 \pm 3.61g$ respectively). Significant changes in intestinal morphology have been detected by the presence of an increased number of goblet cells, higher microvillus length, width of enterocyte, greater thickness of intestinal wall and greater villi area in the treated groups than controls. In case of liver, a lower number of cells with irregular nucleolus was found in all the treatment groups. Consequently, histological analysis and the high value of GSI compared to control indicated early gonadal development of the ovary. In case of blood biochemical parameters, a significant increase in RBC treated with ON consortium ($2.54 \pm 0.09 \times 10^6/mm^3$) has been observed than the commercial ($1.89 \pm 0.101 \times 10^6/mm^3$) and control ($1.31 \pm 0.173 \times 10^6/mm^3$) in biofloc system, and the results of RBC from feeding systems also showed the same pattern. Similarly the increased number of WBC, Hb and glucose has been observed in all the system groups treated with ON consortium than the control. Results from these study proved that ON consortium isolated from gut of Nile tilapia is an effective probiotic for enhancement of growth and other physiological parameters in both conventional feeding and biofloc systems of Nile tilapia. This is the first study to use fish fry in the biofloc system where fish probiotics were used as growth enhancers.

Keywords: Probiotics, Biofloc, *Oreochromis niloticus*

EFFECTS OF DIETARY REPLACEMENT OF FISH MEAL BY SOYBEAN MEAL ON GROWTH, FEED UTILIZATION, AND HEALTH STATUS OF STINGING CATFISH, *Heteropneustes fossilis*

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The stinging catfish (*Heteropneustes fossilis*) is a highly valued and popular fish owing to its high protein and iron content. It is one of the promising species for aquaculture, mainly due to its long time survival in oxygen-depleted water. In addition, *H. fossilis* grows well on artificial diets at high temperatures, and can tolerate salinity fluctuation, and has high fecundity. The increasing cost and irregular supply of fish meal (FM) demand the search for its replacement with cheaply and abundantly available plant protein feedstuffs. Among all plant protein sources, soybean meal (SBM) represents the highest content of effective protein, the most balanced amino acid profile, stable supply, and realistic price. However, there is a limit to using SBM as a fish feed due to its lower methionine content and higher anti-nutrients. Therefore, the present study was designed to investigate the effect of the replacement of FM by SBM on growth, feed utilization, and health status of stinging catfish. A 14-week feeding trial was conducted to evaluate the effect of replacement of FM by SBM on growth and feed utilization of stinging catfish, *H. fossilis* (mean initial weight of 1.55). The experiment was performed in twelve (12) plastic tanks. Each tank was stocked with 50 fries of *H. fossilis*. Water quality parameters were maintained at a suitable range for fish culture. Four isonitrogenous (35%) diets were formulated. In the four diets, 0%, 25%, 50%, and 75% of fish meal were substituted by SBM (SBM₀, SBM₂₅, SBM₅₀, and SBM₇₅, respectively). After 14 weeks, significantly higher mean final weight (g), weight gain (g), and specific growth rate (%/day) of stinging catfish were obtained in the SBM₅₀ group than in the others. Consequently, a significantly lower feed conversion ratio (FCR) was obtained with a diet having 50% SBM. The survival rate (%) did not differ significantly among different fish groups. The hemato-biochemical parameters such as Hb, RBCs, WBCs, and Glu were high in fish fed 50% soybean meal-containing diet. A considerable morphological improvement of the intestine was observed in a 50% SBM containing diet. Therefore, the results suggest that SBM could replace up to 50% of fish meal in diets of stinging catfish, *H. fossilis* without negative effects on growth, feed utilization, and health condition.

Keywords: Soyabean meal, Fish meal, *Heteropneustes fossilis*

COMPARATIVE STUDY OF GROWTH PERFORMANCE, FEED UTILIZATION, PROXIMATE COMPOSITION AND HEMATOLOGICAL PARAMETERS OF VIETNAMESE KOI (*Anabas testudineus*) FINGERLINGS FEEDING WITH EARTHWORM-BRED VERMI AND COMMERCIAL FEED

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Fish feeds play a crucial role in aquaculture production. But, they also pose a great challenge to fish farming as they account for up to 70% of total aquaculture costs. Vermicomposting biotechnology is an environmentally friendly technology to convert organic wastes into by-products that would provide nutritionally enriched compost for sustainable aqua food production. Earthworm, *Eisenia fetida*, has been considered a suitable candidate for fish feed due to its superior nutritional attributes, higher growth rate, and ability to tolerate a wide range of climate conditions. Hence, the present study was designed to evaluate the potential impact of vermi on the overall growth performance, feed utilization, and blood hematology of Vietnamese koi (*Anabas testudineus*) over commercial feed. A four month feeding trial was conducted in 20 L ($50 \times 25 \times 25 \text{cm}^3$) fibre glass aquaria with fingerlings of (mean individual weight, 1.015 ± 0.10 g) Vietnamese koi, which was categorized into two treatments, each having three replicates. Fish were hand-fed with a commercial diet (CP 30%) in control group and cultured chopped vermi in the treatment group at 15-5% body weight. Water temperature, pH, dissolved oxygen, and ammonia were measured every week. Growth, feed utilization, proximate analysis, and blood hematology were measured to determine the comparative effects of vermi and commercial feed on Vietnamese Koi. After four months of feeding, fish fed with vermi showed significantly higher ($p < 0.05$) weight gain, SGR, and lower FCR. A considerably higher ($p < 0.05$) crude protein and moisture content were found in vermi treated fishes. An improved level of ($p < 0.05$) Hb, RBCs and HCT were found in vermi fed fish indicating vermi had a progressive influence on the overall growth, body composition and hematology of Vietnamese koi, which indicated that vermin would be an alternative source of fish feed for sustainable aquaculture production of (*A. testudineus*).

Keywords: *Heteropneustes fossilis*, Vermi compost, Fish feed

SUITABILITY OF *Spirulina platensis* AS A FEED ADDITIVE ON GROWTH PERFORMANCE, BODY COMPOSITION, HEMATOLOGY AND IMMUNE RESPONSE OF STINGING CATFISH *Heteropneustes fossilis*

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A 60 days experiment was conducted to determine the effect of spirulina (*Spirulina platensis*) on growth performance, body composition, hematology, and immune response of stinging catfish (*Heteropneustes fossilis*). The experiment was conducted in a completely randomized design (CRD) with five treatments and three replications. A total of 15 glass aquaria of 180 L water capacity were used for rearing fish, and the stocking density was 50 fish per aquarium. Diets were prepared by replacing fish meal with *S. platensis* at a rate of 0 %, 2.5 %, 5 %, 7.5 %, and 10 %. At the end of the experiment, weight gain (WG), weight gain %, specific growth rate (SGR % per day) revealed significantly higher value at 7.5 % dietary supplementation of *S. platensis*. *S. platensis* did not significantly affect the hepatosomatic index (HSI) of *H. fossilis*. Lower feed conversion ratio (FCR) and higher protein efficiency ratio (PER) values were obtained at 7.5- 10 % inclusion level of dietary *S. platensis*. The high content of protein and ash and low content of lipid and moisture were found at 7.5-10 % inclusion level of dietary *S. platensis*. Better white blood cell (WBC), red blood cell (RBC), and hemoglobin (Hg) content were recorded at 7.5-10% inclusion levels of *S. platensis*. Better lymphocytes (LYMPH), hematocrit (HCT), hemoglobin (Hg), procalcitonin (PCT), mean corpuscular hemoglobin (MCH), mean corpuscular volume (MCV), and mean corpuscular hemoglobin concentration (MCHC) were recorded at 5-10% inclusion level of dietary *S. platensis* than control. Maximum lysozyme value was obtained at 7.5-10 % *S. platensis* inclusion level. At the end of the experiment, a challenge test was done with *Aeromonas hydrophila* and low mortality was found at a 7.5 % inclusion level of dietary *S. platensis*. In case of the most of the growth, body composition, hematological, and immunological parameters of *H. fossilis*, there was no significant difference between 7.5- 10% inclusion levels of dietary *S. platensis*. It can be concluded that, considering the culture cost of *S. platensis*, replacement of 7.5% dietary fish meal with *S. platensis* can be recommended as an ideal alternative protein source and immune-stimulants for better growth performance and immunity of *H. fossilis*.

Keywords: *Spirulina platensis*, *Heteropneustes fossilis*, Fish feed

MOLECULAR CHARACTERIZATION OF THE CAUSATIVE AGENT OF VIBRIOSIS DISEASE IN CULTURED SHRIMP *Penaeus monodon* OF BANGLADESH

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The present study was focused to diagnose the pathogenic bacteria causing vibriosis diseases in shrimp post larvae (PL), adult and hatchery water samples as well as to investigate their antimicrobial resistance patterns. To conduct this work, 49 shrimp samples were collected from the southeast region (Khulna, Bagerhat) and shrimp hatchery of Cox's Bazar. Classical agar plate technique, 16S rRNA gene sequencing, species-specific gene *viz.* *toxR* and *vhh* amplification were performed to identify the vibriosis disease causing bacteria in cultured shrimp.

Seventy-one representative strains were isolated using agar plates- Thiosulphate citrate bile salt sucrose agar (TCBS), *Vibrio harveyi* agar (VHA) and Tryptone soya agar (TSA)). Among them, 27 isolates were selected and further used for molecular identification. Among those, 26 isolates were amplified and sequenced, and then identified as *Vibrio parahaemolyticus*, *V. alginolyticus*, *V. mediterranei*, *V. brasiliensis*, *V. proteolyticus*, *V. vulnificus*, *V. navarrensis*, *Photobacterium damsela*, *Shewanella algae* and *Pseudomonas guguanensis* using NCBI GenBank BLAST search. Except for *S. algae* and *P. guguanensis*, the rest of the bacterial isolates are from the Vibrionaceae family. From 26 representative isolates, seven isolates TV6, TV7, TV10, TV17, TV21, TV23 and TV24 showed positive result for *toxR* gene amplification which were identified as *V. parahaemolyticus*. On the other hand, all the isolates showed a negative result for *vhh* gene amplification. Antibiotic resistance patterns of the studied strains revealed that the MAR index value exceeds 0.2 for 75% of the strains. The

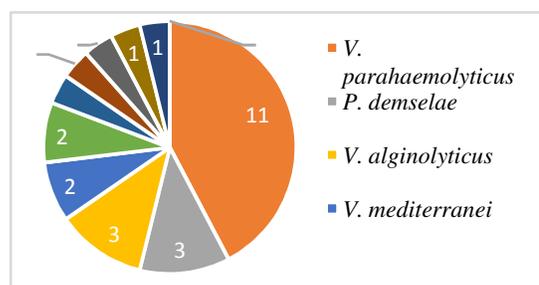


Fig. 1. Diversity of bacterial strains identified in the shrimp industry of Bangladesh.

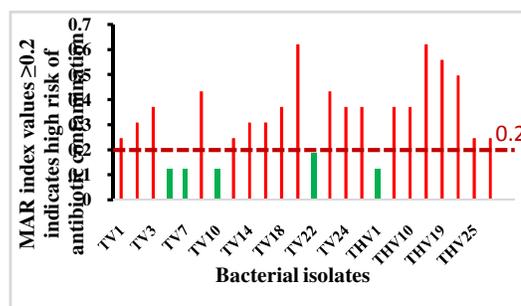


Fig. 2. MAR index values of diverse bacteria identified in the present study.

present study reveals the existence of different pathogenic bacterial strains in shrimp farms and hatcheries with the risk of high antibiotic contamination.

STUDY ON FISH DISEASE STATUS AND PRODUCTS OF DIFFERENT AQUA DRUG COMPANIES IN MYMENSINGH DISTRICT

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The research was conducted to determine the fish disease status and to examine the products of different aqua drug companies used in commercial aquaculture in Mymensingh. Total 150 stakeholders related to aquaculture activity were interviewed through questionnaire and focus group discussions (how many??) were conducted to collect baseline primary data. Study found approximately 50 aqua drug companies supply their products in the Mymensingh district. Among the manufacturers, Fishtech (BD) Ltd. (12%), ACI Animal Health Ltd. (10%), Eon Animal Health Products Ltd. (10%), SK&F Pharmaceuticals Ltd. (6%) and Square Pharmaceuticals (6%) have captured the highest market share in Mymensingh. The commonly used aqua drugs have been divided in to ten groups: antibiotics, disinfectants, gas reducers, oxygen suppliers, feed additives, pesticides, piscicides, oxidants & coagulants, parasiticides, and probiotics. The most frequent fish diseases observed among cultured areas include dropsy (23%), epizootic ulcerative syndrome (20%), red and white spot (10%), edwardsiellosis (27%), fin and tail rot (13%) and argulosis (7%). In the antibiotic category, Renamycin, Levaquin, Eraprim, Enroflox DS captured 32%, 17%, 12%, and 6% of the market, respectively. In the gas reducer drugs category, Bio Aqua 50%, Mega Zeo Plus, Ammonil, Zeolite gold are captured 10%, 10%, 10%, and 8% of the market, respectively. Farmers also used various calcium oxide and calcium carbonate and sodium chloride to treat their culture pond water. The disease prevalence was more frequent in the month of March-April (27%) and November-December (23%) in the study area. The study recommends implementing good aquaculture practices recommend a dosage for sustainable aquaculture production.

Keywords: Aquadrugs, Fish disease, Mymensingh

PATHOGENIC BACTERIA IDENTIFIED IN MUD CRAB (*Scylla olivacea*) FARMS FROM SOUTHWEST COASTAL REGION OF BANGLADESH

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Mud crab is considered as one of the most important aquaculture species in climatically stressed southwest coastal part of Bangladesh. In recent time frequent mortality of mud crab in farming condition is being reported from various parts where mud crab is fattened for short time or cultured the juveniles to exportable size. A number of bacteria pathogenic to mud crab were investigated year round. Total bacterial load as well as pathogenic bacterial load and types associated with crab, water, and sediment were investigated. Samples were collected from four different locations where each location corresponded two neighboring sub-districts. Series of biochemical tests and selective bacteria isolation kits were used for identification of bacteria. In mud crab sample both total bacterial load ($8.25 \log_{10} \text{cfu g}^{-1}$), concentration of pathogenic *Vibrio* spp. ($5.34 \log_{10} \text{cfu g}^{-1}$) and *Aeromonas* spp. ($4.98 \log_{10} \text{cfu g}^{-1}$) were calculated highest in the summer, while highest concentration of *Pseudomonas* spp. ($4.81 \log_{10} \text{cfu g}^{-1}$) was recorded in late autumn to early winter period. Mostly isolated *Vibrio* spp. were *V. parahaemolyticus* (20%), *V. harveyi* (16%), *V. alginolyticus* (10%), *V. vulnificus* (8%), *V. fluvialis* (12%), *V. mimicus* (20%), and rest of the isolates remained unidentified. Among *Aeromonas* spp. about 60% were identified as *A. hydrophilla*, 15% as *A. caviae*, 15% *A. veroni* and rest 10% left unidentified. Almost 100% *Pseudomonas* spp. was identified as *P. aeruginosa*. Like to that of mud crab sample, highest concentration of *Vibrio* spp. ($4.53 \log_{10} \text{cfu ml}^{-1}$) in water sample was identified in the summer but concentration of *Vibrio* spp. was found almost similar in sediment samples all the year round. However, both total bacterial load ($8.41 \pm 0.132 \log_{10} \text{cfu g}^{-1}$) and total pathogenic *Vibrio* spp. concentration ($6.08 \pm 0.021 \log_{10} \text{cfu g}^{-1}$) was found significantly higher in sediment samples compare to that of crab samples and water samples. As pathogenic bacteria can insert potential health hazard in crab aquaculture system, the present study was carried out for profiling of selected pathogenic bacteria and this study confirms that mud crab carry significant number of bacteria highly pathogenic to it.

Keywords: Pathogenic bacteria, *Vibrio* spp., *Aeromonas* spp., *Pseudomonas* spp.

EFFECT OF *Clostridium* sp. AGAINST *Vibrio parahaemolyticus* CAUSING DISEASE SYMPTOMS AND SURVIVAL OF *Macrobrachium rosenbergii*

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The present study conducted to determine the effect of *Clostridium* sp. (probiotic) against *Vibrio parahaemolyticus* (pathogen) on its disease symptoms and survivability of freshwater prawn (*Macrobrachium rosenbergii*).

The experiments were carried out in the wet laboratory of Fisheries and Marine Resources Technology Discipline, using 12 plastic tanks (20L each) with four treatments namely negative control (NC- prawn + feed), positive control (PC- prawn + feed + pathogen), T₁ (prawn feed + probiotic) and T₂ (prawn + feed + pathogen + probiotic). PC treated with pathogenic

Vibrio parahaemolyticus at a level of 4ml/20L water, whereas T₁ treated with probiotic at the level 2ml/20L water. In T₂ both pathogen and probiotic present at a level of 4ml/20L and 2ml/20L respectively. Ten juvenile prawn were used in each treatment which was replicated thrice and cultured for 18 days. Feed application was same in all the treatment. This experiment showed that the survival rate of prawn in NC, PC, T₁ and T₂ were 75%, 50%, 75% and 75% respectively (Fig. 1.) Survival rate of prawn was higher in probiotic treated tank rather than pathogenic tank. Probiotic *Clostridium* sp. might reduce pathogenic effect of *Vibrio parahaemolyticus*. Loss of appetite, melanisation, loss of appendages, lethargy, black and yellow spots were found in pathogenic *V. parahaemolyticus* treated prawn. Those symptoms were not found where both pathogen and probiotic (T₂) was applied. Therefore, *Vibrioparahaemolyticus* might have virulence activity to *Macrobrachium rosenbergii* but the probiotic *Clostridium*

sp. could provide protection against *V. parahaemolyticus* infections in *M. rosenbergii* and will be able to increase immunity of *M. rosenbergii*.

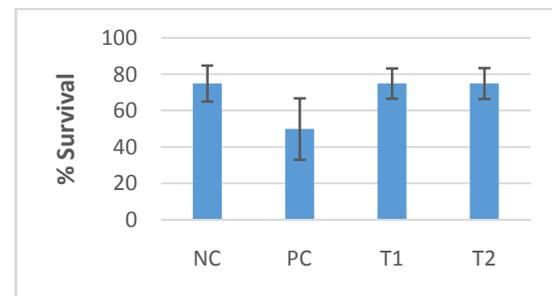


Fig. 1. Survival of *M. rosenbergii* challenged with *V. parahaemolyticus* and under *Clostridium* sp. treatment.

Keywords: Probiotic, Pathogen, Shrimp

EFFECT OF *Lactobacillus* sp. ON THE PATHOGENIC *Vibrio parahaemolyticus* CAUSING DISEASE SYMPTOMS AND SURVIVAL OF *Macrobrachium rosenbergii*

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The present study aimed to analyze the effect of probiotics (*Lactobacillus* sp.) on disease symptoms and the survival of *Macrobrachium rosenbergii*. The experiment was conducted for 18 days in plastic tanks (20L) with 10 juvenile prawns fed on protein (32%) containing feed at a rate of 10% body weight twice a day. The four treatments were are- negative control (NC- prawn and feed), positive control (PC- prawn, feed, pathogen), T₁ (prawn, feed, probiotic) and T₂ (prawn, feed, pathogen, probiotic). Each treatment was replicated thrice.

Positive control (PC) treated with pathogenic *Vibrio parahaemolyticus* at a level of 4ml/20L water, whereas T₁ treated with probiotic at the level 2ml/20L water. In T₂ both pathogen and probiotic present at a level of 4ml/20L and 2ml/20L respectively. The results of this experiment represented that the survival of *M. rosenbergii* was found highest (80%) in T₂ compared to T₁ (73.33%) and NC (70%), which was lowest in PC (40%) (Figure1). Survival duration length was found highest in T₂ and lowest in PC. Loss of appetite, lethargy, melanisation, loss of appendages, black and yellow spot on body found in PC where pathogenic *V. parahaemolyticus* was added. Those symptoms are not found where both pathogen and probiotic (T₂) was applied. Hence, *V. parahaemolyticus* might have putative virulence activity to *M. rosenbergii*, and probiotic might have an impact on reducing their virulence activity and increasing the immunity of *M. rosenbergii*.

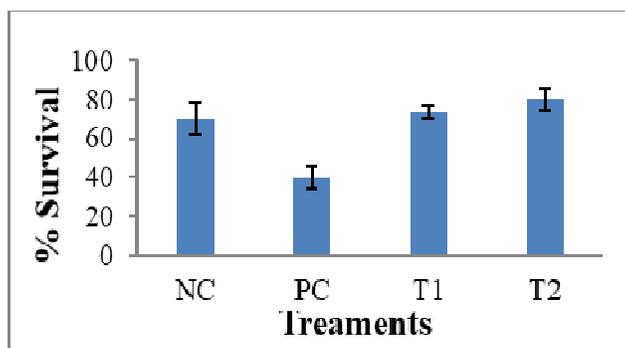


Fig.1. Survival of *M. rosenbergii* challenged with *V. parahaemolyticus* and under probiotic (*Lactobacillus* sp.) treatment. The error bars represent the standard deviation of three replicates.

Keywords: Probiotic, *Lactobacillus* sp, *Vibrio parahaemolyticus*, Pathogen

A LARGE-SCALE OCCURRENCE OF *Chilodonella* IN OLIVE BARB (*Puntius sarana* HAMILTON, 1822) AND ITS MEDICAL MANAGEMENT BY VARIOUS CHEMICAL SUBSTANCES

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Puntius sarana, also known as the olive barb, is a popular choice for both food and ornamental fisheries. In the current study, 200 juvenile olive barbs were collected from Keane Bridge, Surma river, Sylhet and reared in FRP (Fibre-reinforced plastic) tank for breeding purposes. After few days, we observed a severe outbreak of pox-like white opaque raised lesions on skin. *Chilodonella*, a protozoan parasite was identified as the causal agent through the assessment of clinical signs. These were confirmed by wet mount and histopathological observations of gill and skin scrape from infected *P. sarana*. A total of 150 fishes with a mean length (8.89 ± 1.21 cm) and weight (10.72 ± 1.21 g) were examined with severe infection of *Chilodonella* (Prevalence 75%). The infected fishes were transferred equally to the glass aquaria ($90 \times 60 \times 1$ cm) having 70 L water. Four treatments including one control (C 1) with triplicates were assigned with different concentration of therapeutic agents *viz.*, T 1 (Methylene blue, 1 ppm + Sodium chloride, 1 ppt); T 2 (Potassium Permanganate, 1 ppm + Sodium chloride, 1 ppt); T 3 (Aquarium heater, 32 °C + Sodium chloride, 1 ppt) and T 4 (Hydrogen Peroxide, 0.4 ppm + Sodium chloride, 1 ppt). No mortality were recorded during the experimental period. The highest recovery rate was noted in T 3 where complete disappearance of white opaque raised lesions within 7 days of treatment. **Table 1.** Therapeutic agents and their dosages in different treatment trials

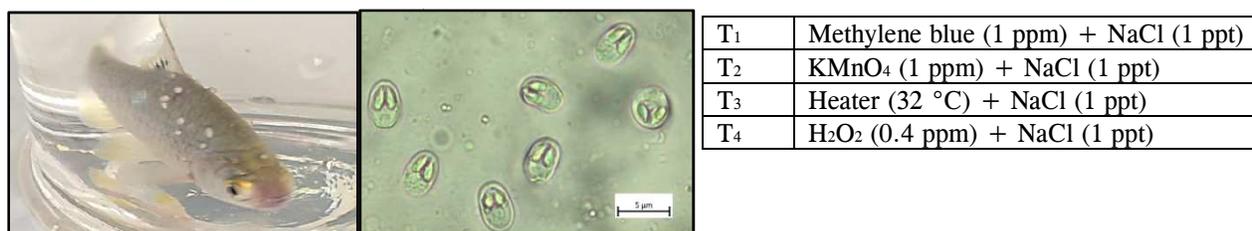


Fig. 1. (A) Severe infection on skin characterized with white pox like oval spots. Wet mount of skin showing numerous *Chilodonella*.

Keywords: *Puntius sarana*, *Chilodonella*, Disease

EXPRESSION PROFILING OF INNATE IMMUNE GENES OF HEALTHY AND SICK BLACK TIGER SHRIMP *Penaeus monodon* OF DIFFERENT SOURCES

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Shrimp sector, globally, is in threat of diseases as there is no suitable therapeutics against the pathogens causing loss to shrimp production. *Penaeus monodon* is one of the economically important culturable shrimp species contributing to global economy. Because of being invertebrate, shrimp does not acquire adaptive immunity and totally depends on innate immune defense. The profiling of innate immune genes especially the antimicrobial peptides (AMPs) are not well documented. The present study was thus conducted to investigate the expression of different antimicrobial peptides including antiviral and antibacterial molecules in different organs of black tiger shrimp from wild and farmed environments using semi-quantitative and quantitative RT-PCR (qRT-PCR). High level of expression of antiviral gene PMAV, antilipopolysaccharide factor ALFPM, peroxinectin (PeroX) and penaeidin (PEN-3) in hepatopancreas, pleopod and muscle of wild shrimp was observed while shrimp from pond gher had variable levels of expression in all the organs. Higher expression of prophenoloxidase (ProPO) and astakine was also observed in wild shrimp than that of pond cultured shrimp. Expression of crustin was low in wild and pond cultured shrimp while higher expression was observed in healthy *gher* shrimp. Comparing organ-wise expression of different genes, similar pattern of expression was observed while comparing source-wise expression in different organs, wild shrimp had higher level of expression. The evolutionary relationship of the tested genes of *P. monodon* was established where PMAV of *P. monodon* was closely related to *P. indicus*, ALFPM to *P. chinensis*, Peroxinectin to *Scyllaserata*, penaeidin to *P. paulensis*, ProPo to *P. vannamei* and crustin to red swamp crayfish *Procambarus clarkia*. The findings of the present study suggest that wild black tiger shrimp have higher level of innate immune response than that of farmed shrimp. The gene expression pattern along with the evolutionary relationship of these genes will facilitate further research on designing therapeutic agents against the pathogens of shrimp and related organisms.

Keywords: Immune gene, Black tiger shrimp, *Penaeus monodon*

CHARACTERIZATION OF PATHOGENIC MICROBIOTA OF GILL AND GUT IN FARMED NILE TILAPIA (*Oreochromis niloticus*) THROUGH CLASSICAL AND MOLECULAR APPROACHES

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Nile tilapia (*Oreochromis niloticus*) is one of the most popular food fish among the fish consumers and producers in Bangladesh. Identification and characterization of pathogenic gill and gut microbiota is essential for good production quality and reducing economical losses. So, the focus of this work was to identify and characterize the pathogenic gill and gut microbiotain farmed Nile tilapia, as well as to investigate their antimicrobial resistance patterns.

To conduct this work, 36 Nile tilapia samples were collected from 12 different farms of Cumilla, Khulna and Mymensingh district in Bangladesh. The samples were processed to isolate and identify pathogenic gill and gut bacteria via classical agar plate technique and molecular approaches. 16S rRNA gene sequencing was performed to identify bacteria. Moreover, antibiotic susceptibility was observed against 16 antibacterial agents.

Representative bacterial isolates (104 from gill and 82 from gut) were selected using agar plates (Thiosulphate citrate bile salt sucrose (TCBS) agar, Mannitol salt (MSA) agar, *Salmonella-Shigella* (SS) agar, eosin methylene blue (EMB) agar and tryptone soya agar (TSA). Among them, 8 from gill and 8 from gut isolates (Fig 1 and Fig 2) were selected and further used for molecular identification by 16S rRNA gene sequencing using NCBI GenBank BLAST.

Isolates were identified as *Aeromonas caviae*, *A. hydrophilla*, *Escherichia coli*, *Citrobacter sp.*, *Macrococcus caseolyticus*, *Enterobacter sp.*, *Staphylococcus sp.*, *Klebsiella aerogenes*, *Priestia aryabhatai* (Figs. 1 and 2). Among 16 representative bacterial isolates, all isolates showed resistance to penicillin G, whereas 13 isolates showed resistance to amoxicillin and 7 isolates showed resistance to the erythromycin. These results may help the farmers to control the pathogenic bacteria in Nile tilapia farm and also to improve fish health quality.

Keywords: Microbiota, Nile Tilapia, *Oreochromis niloticus*

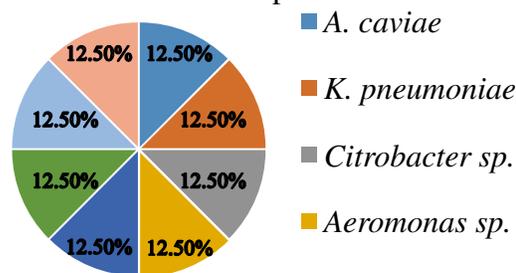


Fig 1. Gill bacteria of Nile tilapia.

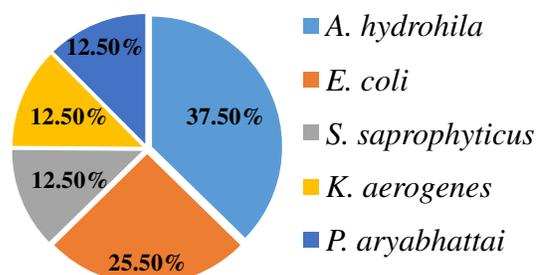


Fig. 2. Gut bacteria of Nile tilapia.

MOLECULAR IDENTIFICATION AND CHARACTERIZATION OF STREPTOCOCCOSIS DISEASE CAUSING AGENTS IN TILAPIA FARMING IN BANGLADESH

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The aim of this study was to identify and characterize streptococcosis disease causing agents especially gram-positive bacterial species *Streptococcus agalactiae* and *S. iniae* in Bangladesh tilapia (*Oreochromis niloticus*) farming. Both diseased and apparently healthy Nile tilapia were sampled from Khulna and Mymensingh districts. Exophthalmia, corneal opacity, lethargy, erratic swimming, discoloration, falling scale, hemorrhages were observed as clinical signs. A total of 6 organs *viz.* brain, liver, spleen, kidney, intestine, gut samples were collected from 27 tilapia from 9 different farms from October to December 2021.



Fig 1. Body discoloration in sample-fish



Fig 2. Beta hemolysis in sheep blood agar

Both classical and molecular method were performed to identify and characterize the target bacterial species. The selective media 5% sheep blood agar showed hemolysis. Species-specific primers (SP1 and SP2 for *S. iniae* while cfb (H1) and cfb (H2) for *S. agalactiae*) and universal primers (27F, 1492R) for 16S rRNA were used in PCR for identifying the target species. A total of 13 types of antibiotics were used for susceptibility test via disc diffusion method. A total of 56 isolates were primarily screened for further study where 2 isolates (MS13, MS14) were identified as *S. iniae* and 13 isolates (MS1, MS4, MS5A, MS5B, MS6, MS11, MS16, MS21, MS25, MS26, MS30, MS32, MS34) as *S. agalactiae* while 10 isolates showed as *Peribacillus huizhouensis*, *Bacillus cereus*, *Pseudomonas oryzae*, *Acinetobacter junii*, *Vibrio cholerae*, *Aeromonas veronii*, *A. enteropelogenes*, *A. caviae* in 16S rRNA gene sequencing. All isolates showed resistance against penicillin G while most of the isolates showed sensitivity against amikacin, ceftriaxone and chloramphenicol.

Keywords: Characterization, Streptococcosis, Disease, Tilapia

MORINGA LEAF (*Moringa oleifera*) POWDER IN FISH FEED IMPROVES FISH GROWTH

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In the present experiment, potentiality of moringa leaf as a nutritious dietary source for fish was tested. The moringa leaves were brought, cleaned, dried and finally crushed into powder. Three experimental diets were formulated using the processed moringa leaf powder at the rate of 0% (T1) as control, 10% (T2) and 20% (T3) as treatment mixing with rice bran, wheat bran, mustard oil cake, fish meal, soya oil and vitamin-mineral premix. Fifteen tilapia fingerlings having average initial length 10.88 ± 0.11 cm and initial weight 29.06 ± 0.50 g were stocked in each tank with 90 L water. Sixty days feeding trial was performed with three replications of each treatment. The fishes were fed with formulated feeds twice daily at 9 am and 4 pm at a rate of 3% of their body mass. Sampling of fish and water quality parameters were carried out at twelve days interval. Moreover, the blood glucose and cholesterol of tilapia were measured monthly.

Final length, final weight, weight gain, percent weight gain, feed conversion ratio (FCR), specific growth rate (SGR) and production of tilapia were significantly different among the treatments. The highest FCR (3.17 ± 0.25) and SGR (1.33 ± 0.12 %) values were in T3 and T2, respectively. In the experiment, the highest and the lowest tilapia production were 9.21 ± 0.39 and 7.39 ± 0.35 kg m⁻³ in T2 and T3, respectively. The blood glucose values were significantly different among the treatments ($p < 0.05$) and the highest value was in T1 (48.00 ± 2.00 mg dl⁻¹). Moreover, the highest and the lowest blood cholesterol was found in T1 (177.67 ± 2.52 mg dl⁻¹) and T3 (148.33 ± 1.53 mg dl⁻¹), respectively whereas the values were highly significantly different among the treatments ($p \leq 0.01$). Water quality parameters were statistically similar among the treatments ($p > 0.05$) and the values were within acceptable range for tilapia culture.

Table 1. Growth performance of tilapia feeding with formulated feed in the present study

Traits	T1	T2	T3	<i>p</i> value
Length gain (cm)	$3.72 \pm 0.05a$	$3.83 \pm 0.12a$	$3.77 \pm 0.02a$	0.224
Weight gain (g)	$25.63 \pm 0.42a$	$31.89 \pm 0.57c$	$27.46 \pm 0.76b$	0.000
FCR	$2.73 \pm 0.21a$	$2.60 \pm 0.17a$	$3.17 \pm 0.25b$	0.040
SGR (%)	$1.20 \pm 0.03ab$	$1.33 \pm 0.12b$	$1.07 \pm 0.03a$	0.012
Survival rate (%)	$82.22 \pm 13.61a$	$91.00 \pm 3.46a$	$80.10 \pm 7.51a$	0.120
Yield (kg m ⁻³)	$7.49 \pm 0.63a$	$9.21 \pm 0.39b$	$7.39 \pm 0.35a$	0.005

Table 2. Effect of moringa leaf powder on blood glucose and cholesterol of tilapia

Traits	T1	T2	T3	<i>P</i> value
Glucose (mg dl ⁻¹)	$48.00 \pm 2.00b$	$44.33 \pm 1.53a$	$43.67 \pm 1.53a$	0.042
Cholesterol (mg dl ⁻¹)	$177.67 \pm 2.52c$	$152.67 \pm 2.08b$	$148.33 \pm 1.53a$	0.000

Keywords: Moringa leaf, Feed, Tilapia

MANAGEMENT AND FISH HEALTH ISSUES IN AQUACULTURE: A PRELIMINARY STUDY IN PANCHAGARH, BANGLADESH

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The current study was conducted to determine the existing fish culture systems and health management practices in the selected aquafarms of Boda sub-district, Panchagarh which is a northern district of Bangladesh. Data were collected from fifty fish farmers from February to June, 2021 using questionnaire interview, focus group discussion (FGD), field visit and crosscheck interview. Seventy percent farms were located in 100- 500 m distance from their house and 40% were within 100 m from main transportation route. Dominant portion of aquafarmers had 16 to 30 years' experience of farming. Forty percent pond area was below 100 decimal, 46.67% was between 100-500 decimal and maximum pond depths were more than 5 feet. Only 14% fish farmers stocked single fish species like *Clarias batrachus*, *Heteropneustes fossilis*, *Mystus* sp., whereas other used to practices polyculture. Most of the fish farmers stocked fish seed at high density and rest had least idea of stocking density. Major fish health problems in the study area were infectious and non-infectious diseases occurred due to bacteria, virus, fungus, parasites, unfavorable water quality and malnutrition. Common fish diseases in the study area were exophthalmia, dropsy, tail and fin rot, red spot, fish lice, fungal attack, epizootic ulcerative syndrome and malnutrition. Majority (96%) of the farmers did not have water quality measurement tools. However, the major health problems of fish were ranked by the farmers on the basis of critical condition where fish disease, improper stocking density, nutritional imbalance, no scope of water quality monitoring, easy access of people were ranked as 1st, 2nd, 3rd, 4th and 5th utmost constraints, respectively. Maximum farmers (80%) received the technical support from the Upazila Fisheries Office (UFO) and rest from relatives and culture fellow. The fish farmers were not aware of good aquaculture practice maintaining biosecurity and which results in sudden disease outbreaks in their farms.

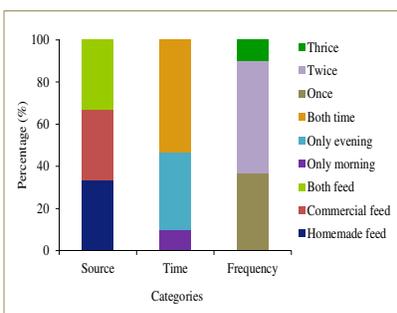


Fig. 1. Feed source, feeding time and feeding.

***Acinetobacter venetianus*: A POTENTIAL THREAT TO SHRIMP AQUACULTURE OF BANGLADESH**

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Acinetobacter venetianus has been reported as a potential pathogen of red leg disease of whiteleg shrimp. Still, there is lack of information on *A. venetianus* as a pathogen in the world shrimp industry. For the first time in Bangladesh, we have detected this potential pathogen in the shrimp PL nurseries of south-west region. Moreover, the antibiotic susceptibility and multiple antibiotic resistance profiles were also investigated for the representative *A. venetianus* isolates.

The sampling covered eight nurseries of south-west region of Bangladesh. To isolate the *A. venetianus*, shrimp PL and three kinds of water *viz.* raw seawater, treated (after filtration and disinfection) water and outlet water were collected. The processed samples were inoculated in TCBS, EMB, SS, MSA agar media. Based on the colony morphology on selective agar plates, representative isolates were cultured on TSA plates for DNA extraction. Detection of the *A. venetianus* strains were performed by 16S rRNA gene sequencing. The Kirby-Bauer disc diffusion technique was performed to determine the sensitivity of the isolates against 12 antibacterial compounds. Multidrug resistance and MAR index of the isolates were calculated.

Among 49 primary isolates, 6 were finally identified as *A. venetianus*. The isolates YPL3-35, YWT4-39, YPL6-75, YWR7-79, YWO7-86 and YWR8-91 showed 100% similarity with *Acinetobacter venetianus*. These isolates were screened mainly on EMB agar plates showing pinkish colored small colonies except YPL6-75, which was isolated from SS agar plate showing cream color. The six isolates were resistant to penicillin G, trimethoprim, tetracycline, and five isolates were resistant to azithromycin, ciprofloxacin and erythromycin. However, no isolate showed resistance against ceftazidime and gentamycin. All the six isolates having MAR index from 0.5 to 0.75. The presence of this pathogen in the raw sea water, treated water, outlet water, and PL samples of five different nurseries is a matter of concern for the shrimp industry of Bangladesh. The findings of this research will help the shrimp farmers and policy makers to take proper biosecurity measures and surveillance program to protect shrimp industry from the potential threat of *A. venetianus* infection.

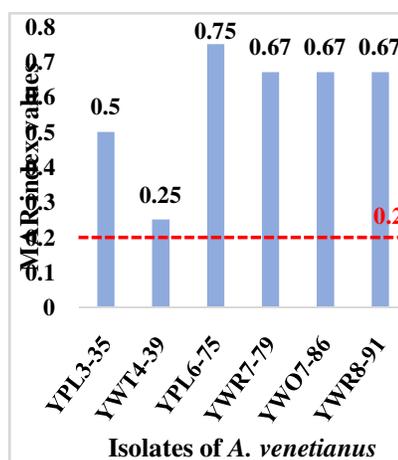


Fig. 1. MAR index values of six studied *Acinetobacter venetianus* isolates.

IDENTIFICATION OF POTENTIAL PROBIOTIC BACTERIA FROM NATIVE SOURCES FOR SUSTAINABLE MANAGEMENT OF MAJOR FISH DISEASES IN BANGLADESH

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The present studies were conducted to identify probiotic candidates from native sources for the prevention and control of the major bacterial diseases of carp and tilapia fishes. Bacteria were aseptically isolated from the guts of healthy carps (*Catla catla*, *Labeo rohita*, *Cirrhinus cirrhosus*) and tilapia (*Oreochromis niloticus*), marine sponges and soil samples. Bacteria were screened for their inhibitory activities against different fish pathogens where, 55 fish gut isolates, 04 sponge isolates, and 04 soil isolates exhibited inhibitory activities against different fish pathogens. Most of the isolates inhibited *Aeromonas veronii* followed by *Enterococcus faecalis*. To find out the disease prevention efficacy of putative probiotic bacteria against motile *Aeromonas septicaemia* (MAS), nine groups of fingerlings of rohu were fed the bacteria incorporated commercial pelleted feeds for 90 days and artificially challenged with *A. veronii* strain B55. In this study, 100%, 83.33%, 93.33%, and 93.33% survival was obtained in the challenged fish fed feed supplemented with WS1A, CR112, CR121 and CR331, respectively while 100% mortality with distinct disease symptoms was noticed in control fish. Similarly, the MAS prevention efficacy of dietary inclusion (for 90 days) of bacterial isolates TP111, TP115, TG523, and TG524 was obtained 96.66±4.71 to 100±0% in Tilapia. The survival was obtained 96.66±0.94, 98.33±2.35, 96.66±2.35, 76.66±2.35, 95.0±4.08 and 3.3±4.71 % for the bacteria CR121, CR112, CR414, SM421, CD223, and control, respectively when tilapia were challenged with *E. faecalis* strain F1B1 (the causative agent of Streptococcosis). The dietary inclusion of these bacteria significantly enhanced the growth of fish. Based on the *16S rRNA* gene sequence homology the potential native probiotic bacteria were identified as *Bacillus subtilis* (CR 331, TP111, WS1A, YBS29), *B. pacificus* (CCI101, CCI201 and CR121), *B. haynesii* (CD223), *Proteus alimenterum* (CR112), *Lysinibacillus macrolides* (CR323), and *Aneurinibacillus migulanus* (TP115). Metagenomics study of the guts of control and probiotic treated fish revealed that dietary inclusion of the native probiotic bacteria modulates the gut microbes by reducing the pathogenic microbes and increasing other probiotic or beneficial microbes. The whole-genome sequence analyses of *B. subtilis* strain WS1A and YBS29 decoded several orthologs to intrinsic genes of potential probiotic bacteria.



Fig 1. Effects of dietary supplementation of native probiotic bacteria WS1A in *L. rohita*. a) No disease symptom in native probiotic fed fish; b) Haemorrhages in the control fish after artificial infection challenge with *A. veronii* strain B55.

Key words: Probiotic bacteria, *Aeromonas Septicaemia*, *E. faecalis* infection

**STUDIES ON *in-vitro* PHAGOCYTOTIC ACTIVITY OF JAPANESE FLOUNDER
Paralichthys olivaceus MACROPHAGES AGAINST VIRULENT
AND AVIRULENT *Edwardsiella tarda* STRAINS AND THEIR ECP**

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The bactericidal activities of glycogen-elicited peritoneal macrophages and head-kidney macrophages of Japanese flounder against two virulent and two avirulent strains of *Edwardsiella tarda* and *Escherichia coli* were studied using MTT (in full) assay method and acridine orange staining. The macrophages showed a greater killing efficiency for the avirulent strains than the virulent strains when macrophages and bacterial cells (ratio, 1:20) were incubated for a period of 9 h. About 50% of cells of the avirulent strains died during this period whereas 90% cells of the virulent strains were alive. The acridine orange staining method gave more reproducible results than the MTT assay method although the former one was a time consuming method. The effects of extracellular products (ECP) of these strains on macrophage activities against *E. tarda* were studied by examining percent phagocytosis and phagocytic index using May-Grünwald-Giemsa staining. The ECPs of the virulent strains were found to affect macrophage activities by decreasing phagocytotic percentages and phagocytic indices. The ECP of the virulent strain NUF251 had a remarkable effect on the phagocytic activity of the macrophages against *E. coli*. Intramuscular injection of the ECP of virulent strains to Japanese flounder gave rise to the death of all the fish whereas that of the avirulent strains could not kill the flounder. It was understood that the toxicity of the ECP was responsible for the inactivation of the macrophages.

Keywords: *Paralichthys olivaceus*, *Edwardsiella tarda*

INVESTIGATION ON FISH HEALTH AND DISEASES IN POND-BASED AQUACULTURE SYSTEMS IN THREE UPAZILAS OF THAKURGAON DISTRICT

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The present investigation was aimed to know the current status of fish health and disease management in various pond based aquaculture system in Thakurgaon district. Data were collected through preset questionnaire and participatory rural appraisal (PRA) tools from three different Upazilas namely Pirganj, Ranisonkail and Haripur. A total of 90 farmers were interviewed from each Upazila and FGD sessions were conducted. Most of the respondents were practiced Carp; Tilapia and Pangas polyculture and encountered severe disease problems in their fish ponds. The prevalence of fish disease varied with cultured species and locations. Percentage of diseased fish varied with Upazila and the size of the farm. The average percentage of fish diseases was highest in Pirganj, Ranisonkail, and Haripur Upazila respectively. Among the diseases reported by the farmers, most of the farmers (76.67%) monitor the health of fish either weekly or monthly. Farmers mentioned several diseases and conditions which they could recognize clinically. The most prevalent clinical signs of disease were EUS (57.78%), Tail and fin rot (55.56%), red spot (40%), haemorrhagic lesion over body surface (28.29%), dropsy (36.67%), gill rot (41.11%) and pop eye (33.33%) other conditions like red spot, scale erosion, argulosis, mouth reddening, haemorrhagic eyes, rectal protrusion, and malnutrition were also mentioned by the farmers but with lower incidences. Most susceptible species to disease was Silver carp (52.22%), followed by Mrigal (30%), Catla (44.4%), Shing (32.22%), Rui (42.22%), Tilapia (12.22%), and Pangas (36.66%). The disease occurred mainly in the winter season. Overall, the knowledge of the farmers on basic fish health management was found very poor. Most of the farmers (87.78%) used treatment measures with respect to particular disease problems. Generally, affected farmers turned to other experienced farmers for advice when for fish health management suggesting and disease treatment. It was found that they applied some traditional treatments. Liming (17.78%) and application of salt (28.89%) in the pond were the most common treatment followed by the use of antibiotics, potassium permanganate, and copper sulphate. This study elicited various issues connected with fish health management problems in rural areas such as lack of technical knowledge, lack of suitable therapeutics and their proper uses lack of assistance from the governmental and non-governmental organization, and financial problems.

Keywords: Fish diseases, Thakurgaon

**PARASITIC INFESTATION ON SPOTTED SNAKEHEAD, *Channa punctatus*
COLLECTED FROM KAWRAN BAZAR FISH MARKET, DHAKA, BANGLADESH**

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Channa punctatus is an indigenous spotted snakehead and one of the most important freshwater fish with high nutritional value and market demand because of its relatively low cost and high availability in the fish market. But parasitic infection pose threat to fish cultivation, as it is a valuable source of food and employment. The parasitic infestation was studied on *C. punctatus*, collected from Kawran Bazar fish market, Dhaka. Total 148 host fish were examined of which 36 fishes were observed to be infested by numerous parasites. A total number of 64 parasites were recorded from the infected fishes. Moderate infestation was observed in the hosts. Majority of the parasites were collected from intestine. The problem caused by parasites is the reduction of weight and length and lack of palatability. In this way, the fish parasites may cause great impact on fish growth and ultimate loss of potential nutrition and economic loss to the fishers. Prevalence, intensity and abundance of infestation with parasites were varied to different length groups of the hosts. In case of length, the medium sized fishes were more infested than the large sized and their prevalence, intensity and abundance were highest. The losses of length and weight were 1.37% and 5.32% respectively. Further study should be proceeded to identify the nature and seasonal variation of parasitism and effects on host.

Keywords: *Channa punctatus*, Disease

SKIN MICROBIOME STRUCTURE AND FUNCTIONAL PREDICTION IN HEALTHY AND DISEASED *Heteropneustes fossilis*

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In this study, we report the mucosal microbiome composition from healthy and diseased stinging catfish (*Heteropneustes fossilis*) comparison of the inhabiting community clusters and the functional annotations of their genes based on 16S rRNA metagenomics. Healthy and diseased fishes were collected from Mymensingh (M), Narsingdi (N), Dinajpur (D) districts of Bangladesh from October 2019 to January 2020. Microbiome community from healthy and diseased fish mucus were compared by both culture dependent method using 16S rRNA gene sequencing and culture independent method (metagenomics). We have found 2174 operational taxonomic units (OTUs) annotated for genus where the healthy fishes had more OTUs than diseased. Proteobacteria, Bacteroidota, Actinobacteriota and Firmicutes were four major phyla found from the OTUs. Bacteroidota and Firmicutes phyla significantly differentiated the healthy and diseased groups. Overlapping and scattering of microbiome communities was observed from principal coordinate analysis (PCoA) and Nonmetric multidimensional scaling plots (NMDS) between two groups. The diversity and abundance of microbiome was found higher in healthy group by different alpha diversity parameters but did not significantly differ from the diseased groups. Two genus *Pseudomonas* and *Flavobacterium* showed the abundance in healthy and diseased groups respectively.

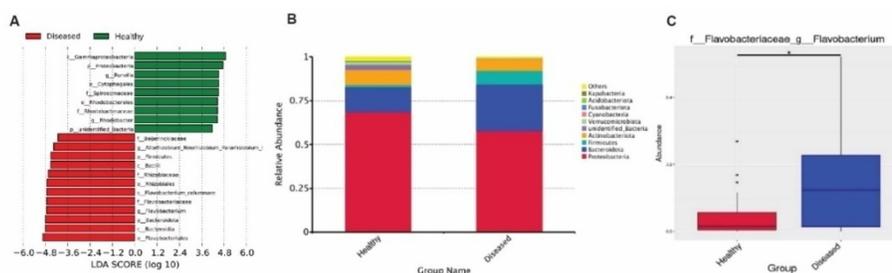


Fig. 1. (A) Abundance of four major phyla in healthy and diseased *Heteropneustes fossilis*, (B) Linear discriminant analysis (LDA) scores represent distinguishing bacterial communities, (C) The genus *Flavobacterium* significantly highest in diseased group than healthy group.

Prediction on important gene functions like metabolism, immune and digestive systems and environmental adaptations were highly observed in diseased fishes. The results of this study showed that the compositions, richness, and functions of the bacterial community have an impact on the health of farmed stinging catfish.

Keywords: *Heteropneustes fossilis*, Microbiome

NATURAL CO-INFECTION OF VARIOUS PATHOGENIC AGENTS IN CULTURED SHRIMP *Penaeus monodon* IN BANGLADESH

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In this study, different pathogenic agents were identified by classical and molecular approaches. To execute the study, 34 shrimp samples were collected from the south-west (Khulna, Satkhira) region of Bangladesh. Samples were processed and cultured in different culture media such as TCBS, EMB, TSB, TSA etc. to isolate bacterial strains. PCR and gel electrophoresis were done with species specific (*ldh*), gene specific (AP3) and 16S rRNA gene sequencing (27F, 1492R) primers. Shrimp tissue samples were taken to identify WSSV using VP28 primers. Samples were also taken to identify pathogenic agents of black gill disease (BGS) and red leg disease (RLS) showing specific symptoms. A total of 75 bacterial strains were selected from the culture media. DNA were extracted from 44 isolates. Among them, 28 representative isolates were selected for PCR analysis with *ldh* primers and 5 isolates (CoVp 1, CoVp 3, CoVp 23, CoVp 31 and CoVp 45) were positive *Vibrio parahaemolyticus*. Among the five *V. parahaemolyticus* strains, two strains (CoVp 31 and CoVp 45) were AHPND positive on AP3 primers. Besides, 16S rRNA gene sequencing were performed for 12 isolates and NCBI BLAST search identify the isolates as *V. parahaemolyticus*, *Photobacterium damsela*, *Acinetobacter baumannii*, *Aeromonas hydrophila*, *Enterobacter hormaechei*, *V. cholerae*, *Klebsiella pneumonia*. Moreover, conventional PCR analysis using VP 28 primers for WSSV detection showed negative results for 12 samples.

Table 1. Identified species of 12 isolates using 16S rRNA gene sequencing & its relevant disease of shrimp

Isolate name	Identified species	Percentage identity (%)	Relevant disease	References
CoVp 1, 2, 23, 31 & 45	<i>Vibrioparahaemolyticus</i>	100.00	Acute hepatopancreatic necrosis disease (AHPND)	Tran et al., 2013
BGS 1	<i>Photobacterium damsela</i>	100.00	Black gill disease (BGS)	Vaseeharan et al., 2007
BGS 3 & 5	<i>Aeromonas hydrophila</i>	100.00	Melanisation, shrinkage of hepatopancreas	Dierckens et al., 2008
BGS 12	<i>Vibrio cholerae</i>	100.00	Intestinal problem	Haldar et al., 2007
RLS 1B	<i>Enterobacter hormaechei</i>	100.00	Respiratory tract infection	Brouwer et al., 2018
RLS 2	<i>Acinetobacter baumannii</i>	100.00	Red leg disease	Huang et al., 2020
RLS 3	<i>Klebsiella pneumonia</i>	100.00	Blood infection, tissue lesion	Nawaz et al., 2012

Antibiogram results showed that, among 10 representative bacterial isolates, all the isolates showed resistance to penicillin G, whereas 4 isolates showed resistance to the amoxicillin & 3 isolates to ampicillin & erythromycin indicating that these antibiotics had become less effective.

ANTIMICROBIAL ACTIVITY OF MICROALGAE AND MEDICINAL PLANT AGAINST COMMON BACTERIA CAUSING DISEASES IN FISH AND SHELLFISH

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Antimicrobial activity of the ethanolic extract of dried marine microalgae *Chlorella* sp. and *Spirulina* sp., and dried medicinal plant *Aloe vera*, *Clinacanthus nutans* were used to against four Gram-negative (*Aeromonas hydrophila*, *Vibrio* sp., *Escherichia coli*, *Salmonella* sp.) and two Gram-positive bacteria (*Staphylococcus aprophyticus*, *Streptococcus* sp.) by using disk diffusion technique. All the treatments revealed antibacterial properties where *Spirulina* sp. showed highest inhibition zone (19.193mm) against *Vibrio* sp. isolated from crab (Table 1). Minimum Inhibitory Concentration (MIC) was performed on the extracts against the test microorganism and lowest concentration revealed by the treatments which was ranged from 6 mg/ml to 10 mg/ml (Table 2). We conclude that, *Spirulina* sp., *Chlorella* sp., *Clinacanthus nutans*, and *Aloe vera* can be good for substituting the antibiotic agents due to presence of the bioactive compounds that have antimicrobial properties.

Table 1. Inhibition zone of test bacterial at concentration of 100 mg/ml of *Aloe vera*, *C. nutans*, *Chlorella* sp., *Spirulina* sp. with antibiotic agents

Diameter zone of inhibition (mm)					
Bacteria	<i>Aloe vera</i>	<i>C. nutans</i>	<i>Chlorella</i>	<i>Spirulina</i>	Control
<i>Vibrio</i> sp. ©	15.363	11.38	11.59	19.193	14.637
<i>Vibrio</i> sp. (s)	12.997	12.317	13.225	11.385	15.1
<i>S. saprophyticus</i>	9.043	14.21	11.41	13.05	10.44
<i>A. hydrophila</i>	11.53	8.783	7.55	8.61	13.375
<i>E. coli</i>	14.037	15.103	11.633	-----	14.027

Treatments	MIC Value (mg/ml)				
	<i>Vibrio</i> sp. (c)	<i>Vibrio</i> sp. (s)	<i>S. saprophyticus</i>	<i>A. hydrophila</i>	<i>E. coli</i>
<i>Aloe vera</i>	30	40	20	20	20
<i>C. nutans</i>	30	40	30	20	20
<i>Chlorella</i> sp.	20	20	20	20	20
<i>Spirulina</i> sp.	20	30	20	20	----

Keywords: Microalgae, Fish & Shellfish disease

REPRODUCTION OF GANGETIC MYSTUS *Mystus cavasius* OF AN INLAND HABITAT IN BANGLADESH

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Reproductive biology of Gangetic mystus *Mystus cavasius* was studied. Fish samples were collected monthly from January to December over a calendar year from Dingaputa hoar of Netrokona district in Bangladesh. Standard length (SL) of male *M. cavasius* individuals collected over the study period ranged from 5.2 to 14.5 cm, and the body weight (BW) varied from 3.1 g to 62.5 g; those of female were from 5.2 to 16.4 cm and 3.1 to 77.7 g respectively. Mean monthly percent GSI of both male and female were high in June, and remained so until September while they were low in other months. GSI observation disclosed that spawning season of *M. cavasius* approximately took place from June to September with the peak in June. External feature and histology of female gonads confirmed the GSI based inference. Scatter plot built with SL and corresponding female percent GSI indicated that GSI triggered higher from 8.5 cm SL and onward, suggesting the minimum SL at maturity of female was 8.5 cm. The BW and fecundity (F) were related linearly, and the equation was $F = 583.9 BW - 371.2$. The calculated fecundity ranged from 5468-28824 in terms of BW (10-50g). Power curve relationship existed between SL and F, and the equation was $F = 5.0587 SL^{3.28}$. The calculated fecundity ranged from 9639-29063 in terms of SL (10-14 cm).

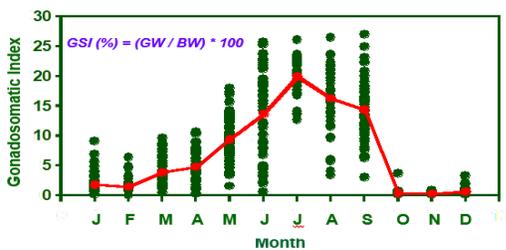


Fig. 1. Monthly changes of GSI of female.

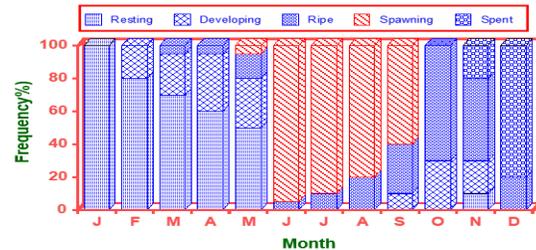


Fig. 2. Monthly frequency of external features.

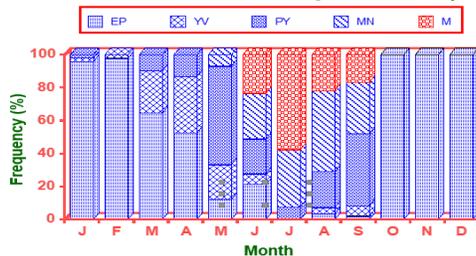


Fig. 3. Monthly frequency of histological stages.

M: Mature, MN: Migratory nucleus, PY: Primary yolk, YV: Yolk vesicle: Early perinucleolus.

PLANKTON ABUNDANCE AND DISTRIBUTION PATTERN ALLIED TO ENVIRONMENTAL PARAMETERS IN THE PADMA AND MEGHNA RIVERS OF BANGLADESH

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These rivers contain major fishes of inland open water, including our national flag fish Ilish (*Tenualosa ilisha*). The physico-chemical parameters of water and plankton samples were collected following the standard methods from July-December 2021. All the sampling was done monthly during the period following standard procedures. The findings revealed that the water quality parameters differed in the two sites but within the standard range. Bacillariophyceae was the most dominant Phytoplankton order in the two sites, which contained 25% in Shabazpur Channel and 23% in Mawa ghat. But in the case of zooplankton Cladocera, Copepoda and Rotifera were almost the same (33%) in Mawa ghat, whereas Cladocera was the most dominant order in Shabazpur Channel. Bacillariophyceae, Chlorophyceae, and Cladocera are the most dominant orders in these rivers, which are similar according to the gut contents analysis and plankton sample analysis by Hasan et.al. 2016 and Hossain et.al. 2020. These findings will be helpful for further research about the food abundance of Ilish and other fishes in these rivers.

Keywords: *Tenualosa ilisha*, Plankton, Padma River, Megna River

Table 1. Physico-chemical parameters of Mawaghat and Shabazpur Channel

Parameters	Mawaghat (Padma)	ShabazpurChannel(Meghna)
Air Temperature (°c)	28.6±2.19	27.8±0.8
Water Temperature (°c)	26.86±2.81	26.1± 0.7
Dissolved Oxygen(mg/l)	4.86±0.19	5.969±0.05
CO ₂ (mg/l)	10.4±2.60	9.94± 0.5
pH	8.24±.23	7.75± 0.01
Transparency (cm)	31.6±2.50	12.61± 0.39
Alkalinity (mg/l)	50.4±2.07	71.2± 0.6
Hardness (mg/l)	72 ± 4.06	96.2± 7.2
Salinity (ppt)	0± 0	0.96± 0.66

REUTILIZATION POTENTIALITIES OF *Gracilaria tenuistipitata* AFTER AGAR EXTRACTION AS A SOURCE OF PHYTOCHEMICALS AND ANTIOXIDANTS

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Gracilaria tenuistipitata is one of the most important widely available red seaweeds for the production of unique sulfated galactans specially agar. In industries significant volume of solid residues are created during agar extraction processes which are not handled and cause wastage of resources. Considering this issue present study was designed to explore the potential reutilization of the agar extraction residues as a source of phytochemicals and antioxidants. Agar was extracted from *Gracilaria tenuistipitata* following different methods: alkali soaking (S_1), alkali heating (S_2) and hot water extraction (S_3) worldwide used by the researchers. Phytochemical screening, fourier transform infrared (FTIR) analysis and antioxidant activity of extracts from agar extraction residues was determined to evaluate the reutilization potentialities with comparison to raw seaweed (S_0). Results showed the presence of different phytochemicals in residues where concentration of total phenols (95.27 mg of GA/g) and flavonoids (57.46 mg of quercetin/g) washighest in methanolicextract of S_3 sample. FTIR results confirmed the presence of functional groups of active components. S_3 sample also showed the highest antioxidant activity measured by different assays such as Phosphomolybdenum (absorbance 8.71 ± 0.13 at 695 nm wavelength), DPPH ($93.10 \pm 1.19\%$), ABTS ($87.68 \pm 0.29\%$) followed by $S_2 > S_0 > S_1$, and reducing power (absorbance 3.51 ± 0.46 at 700 nm wavelengths) followed by $S_2 > S_1 > S_0$. These results indicate that *G. tenuistipitata*residues after agar extraction can be reutilized as a significant source of natural antioxidants which could be a great contributor in circular economy and support sustainable reutilization of natural resources.

Keywords: Reutilization, *Gracilaria tenuistipitata*, Agar, Antioxidants

ASSESSMENT OF WATER QUALITY PARAMETER IN RUPSHA RIVER, BANGLADESH

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Rupsha is the largest riverine system of south-west Bangladesh with a fragile estuarine ecosystem. The present study was undertaken to assess the surface water quality of Rupsha River. Water quality data for 12 physico-chemical parameters from 10 monitoring sites were collected from December, 2018 to May, 2019 and analyzed for this study. Temperature, pH, DO, BOD₅, EC, TDS, Turbidity, Salinity, Nitrate, Alkalinity, Hardness and Chloride concentrations in water samples were found to range within 28.7-33.5°C, 6.5-8.2, 4.4-6.6 mg/L, 1.5-4.7 mg/L, 12.39-21.39 mS/cm, 5965-10846 mg/L, 355-1077 NTU, 6.53-16.43 ppt, 3.31-12.47 mg/L, 121.5-229.1 mg/L, 1131.59-2172.23 mg/L, 4373.05-8311.75 mg/L and 4373.05-8311.75 mg/L, respectively. The result was compared with the WHO and ECR standards of drinking water quality parameters. Multivariate statistical analyses, such as Correlation Matrix (CM) manifested significant relations among water parameters at different stations ($p < 0.01$ and $p < 0.05$). Principal component analysis (PCA) was observed to relate the compositional outlines amongst the examined samples, recognized four features accounting for nearly 89.801% of the total data set which denotes that the dissimilarities in water complexes are primarily associated with pollution from inland and manufacturing wastewater and non-point cause impurity (agronomy activities). Cluster analysis (CA) has directed at tired outcomes of interpreting diverse sets of similarity among sample sites. A strong positive correlation was found with turbidity, pH showed very strong positive correlation with EC ($r = 0.815$, $p < 0.01$), salinity ($r = 0.847$, $p < 0.01$). Strong positive correlation was also observed between pH and hardness. pH had also negative correlation with alkalinity ($r = -0.660$) at the significance level of 0.05. DO showed strong negative correlation with turbidity ($r = -0.820$, $p < 0.01$). Concerning strong positive correlations were also noticed with BOD₅ versus TDS and alkalinity. At the same time, BOD₅ showed negative correlation with Chloride. Strong positive correlation was reported with hardness ($r = 0.648$, $p < 0.05$) and very strong positive correlation with salinity ($r = 0.815$, $p < 0.01$) and chloride ($r = 0.771$, $p < 0.01$), respectively. Salinity, which is the most dominant features of the selected study areas had showed very strong ($r = 0.904$, $p < 0.01$) and strong correlation ($r = 0.685$, $p < 0.05$) with hardness and chloride, respectively. The results also demonstrated that hardness had notably very strong positive relation with chloride ($r = 0.775$, $p < 0.01$), proving their common sources from industrial effluents, municipal wastes and agricultural activities.

Keywords: Water quality, Rupsha river

PROBABILITIES OF NATURAL SPAWNING AND SPAWNING GROUNDS OF CARP SPECIES IN SURMA RIVER SYLHET

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Major carps are the dominant species for aquaculture in Bangladesh due to high market demand, better growth, easy husbandry practices, and a favorable environment for farming. The natural carp spawn supply is decreasing day by day due to natural, man-made, and anthropogenic causes. Recently, poor quality hatchery carp seed and a scarcity of wild carp spawn lowered productivity, resulting in a loss for the farmers. The aim of the study was to find natural spawning and spawning grounds for carp species in the Surma River. The sample of fertilized spawn was collected by setting four Savar nets at Hetimganj point on the Surma River and nursing them in the Mini Hatchery of Sylhet Agricultural University to identify the carp species by microscopic and physical observation. The result showed that 35 species of spawn were found, including 34% carps, 20% barbs and minnows, 5% loaches, 15% clupeids, 1% snakeheads, 10% perches, 6% catfish, 2% eels and mud eels, and 7% miscellaneous (Figure 1). Carp species spawn was found to be 56% Kalibaus, 37% Gonia, and 7% Bata (Figure 2) among themselves. Despite the favorable natural conditions for spawning, the climatic conditions were unsuitable due to untimely rainfall, climate change impacts, and other human factors. However, the presence of several carp species in the research area indicated that carp spawn may be present in the Surma River.

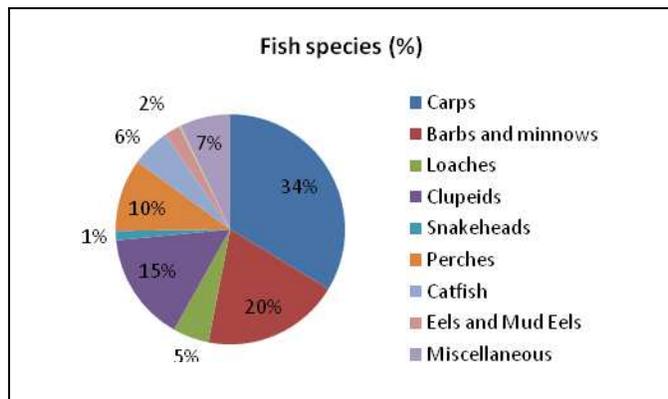


Fig. 1. Fish species composition (%) of collected spawn at the study site

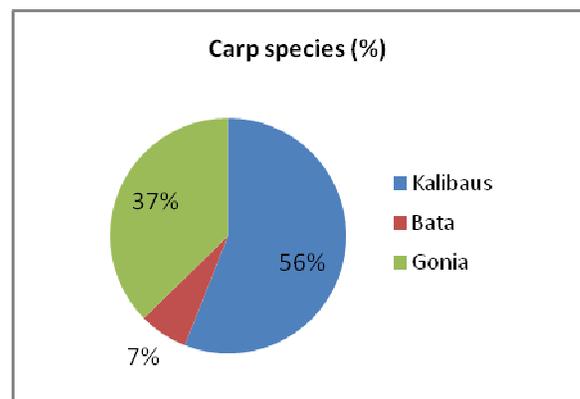


Fig. 2. Carp species composition (%) of collected spawn at the study site

Keywords: Natural spawning, Carp breeding, Surma River

RESEARCH NEEDS FOR MICROPLASTICS IN FISHERIES SECTOR OF BANGLADESH

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Microplastics are small pieces of plastic with less than 5 mm (0.2 inch) in length, that occur in the environment as a consequence of plastic pollution. Unfortunately, microplastics have been found in most of the environments including air, water, sediments and soil. Presence of microplastics in aquatic environment and fish is a critical concern due to their huge negative impacts. Extensive use of Covid-19 safety equipment has further exacerbated the situation. There might also have high risk for human who consumes fish and seafood products. The *objective* of this study is to review the status of research on microplastics in fisheries sector of Bangladesh so as to identify the avenues for future research on this urgent issue. We found that in Bangladesh the study on microplastics in fisheries sector is at a very early stage. Only the types and numbers of some microplastics have been studied in the gut of some freshwater and marine fishes. A recent study has also focused on the microplastic in the dried fish. Most of these studies mainly used microscopic analyses (polarized light, scanning electron microscopy) and Fourier Transform Infrared Analysis for polymers. In these studies, the most common types of microplastics reported include Polyethylene, Polystyrene, Polypropylene and Polyethersulfone. Given the huge concern of microplastics a lot more studies need to be conducted targeting different aquatic ecosystems, water, sediment, planktons, fish and other aquatic animals. Further scientific studies will play a key role in addressing the critical knowledge gaps to support the two-fold objectives of sustained consumption of aquatic foods and safeguarding consumers from possible health risks posed by microplastics. The future studies on microplastic in fisheries should focus on standardized methods to identify and quantify the various types of microplastics; fate, interactions and joint toxicity between microplastics and environmental contaminants as microplastics have a high adsorption capacity to pollutants; adsorption and desorption mechanisms of various chemicals on microplastics; trophic transfer of microplastics in marine food webs; negative effects of microplastics on marine microalgae, zooplankton and organisms from the individual, cellular and genetic levels; ecological risk assessment; ejection microplastics out after ingestion; the potential transfer of microplastics and the related contaminants from fish to human; nanoplastics (smaller than 1 micrometer), and creating a database of microplastics pollution in aquatic environment, aquaculture and fisheries.

Keywords: Microplastic

TOXICITY BIOASSAY OF ORGANOPHOSPHATE AND PYRETHROID OF INDIGENOUS FRESHWATER *Cirrhinus reba*: LC₅₀ CONCENTRATION DETERMINATION

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The study was conducted to observe the lethal effects (LC₅₀) of organophosphate (chlorpyrifos) and pyrethroid (deltamethrin) pesticide on fingerling of *Cirrhinus reba* fish. The indigenous *Cirrhinus reba* was collected from the “RDA matsho hatchery”. The average body length of the collected fingerlings was 6-8 cm and weight 2-3 g. To determine LC₅₀ of organophosphate and pyrethroid 100 ml solution was prepared by simple dilution (Dilution factor method). Four different concentrations with one control were applied of organophosphate (0.102 ppm, 0.105 ppm, 0.108 ppm, 0.111) and pyrethroid (0.0031, 0.0033, 0.0035, 0.0037 ppm) in 96 hours static bioassay method to determine lethal concentration. Each concentration was trialed with three replications. The experiment was conducted in equal size (25 cm × 45 cm × 27 cm) glass tank. The collected fingerling fish was acclimatized for two months in laboratory condition. Approximately 8 fishes (2 gm) were stocked in 10-liter water in every tank. During the experiment, some water quality parameters such as temperature, pH, dissolved oxygen, total dissolved solids and alkalinity were also analyzed. One-way analysis of variance (ANOVA) was used to determine any significant differences in measured variables between control and experimental groups. Probit analysis was used for the estimation of LC₅₀ value. The variability between control and experimental groups was determined by Dunnett's test. In organophosphate, the water quality parameters values remained within the ranges of 16-18°C, pH 7.5-7.9, dissolved oxygen 4.40-4.80 mg/L, alkalinity 70-78 mg/L and total dissolved solid 121-128 mg/L. No significant difference (>0.05) was found among the water quality parameters. In pyrethroid, the pH was found between 7.4-7.8, temperature 16-18°C, dissolved oxygen 4.30-4.90 mg/L, alkalinity 84-98 mg/L and total dissolved solid 125-133 mg/L. These ranges of parameters are suitable for fish. So, the mortality of fish was not influenced by the physical parameters. The 96 hrs LC₅₀ value of organophosphate was 0.108 ppm and pyrethroid was 0.0033 ppm. The mortality was found to increase with exposure and increase in concentration. The result of the study suggested that both organophosphate and pyrethroid pesticide were highly toxic to *Cirrhinus reba* fingerlings.

Keywords: Toxicity, Pesticide, *Cirrhinus reba*

INVASIVE FISH *Pterygoplichthys* spp.: A POTENTIAL THREAT TO AQUATIC ECOSYSTEMS OF BANGLADESH

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Pterygoplichthys spp. is an invasive fish species native to the Amazon River basin and figured out as one of the most effectual invasive taxa due to its global distributions. Being familiar as an aquarium fish species, it has been first reported during 2007 in the native ecosystem of Bangladesh. Recently, this exotic fish is a matter of increasing concern in both scientific and fishers' community due to its availability in the different water bodies across the country. This study is conducted by surveying all available scientific literature on *Pterygoplichthys* spp. which highlights its typical features and invasive biology, global distribution, impacts of distribution in different regions worldwide, present scenario in Bangladesh and it's a control mechanism to wising up government and proper stakeholders. The findings of this review are that this opportunistic invader can reproduce rapidly, consume large amounts of food which disrupt aquatic food chain, keep impact on the native species and also on the surrounding environments. It may cause the greatest threats to native commercial fishery ecosystems and unique indigenous aquatic biodiversity. Due to this terror fish species fishermen's economic loss also has been reported. However, the effects of this introduced fish have not yet been properly assessed. Further research is needed to record the number of this species existing in the country's environment and finding out their impact on the native ecosystem. This study suggested that creating awareness among people, government surveillance, transboundary river management with neighboring countries are important for lessening the risk of this alien species.

Keywords: *Pterygoplichthys* spp., Sucker mouth catfish, Invasive species

DIATOM ASSEMBLAGES AND THEIR INTERRELATIONSHIPS BETWEEN DIFFERENT WATER QUALITY PARAMETERS IN A RIVERINE ECOSYSTEM

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An assemblage of diatom community of a riverine environment was assessed through forthrightly sampling for a period of seven months during September, 2019 to March, 2020. Gorveshwari River located in the northwest part of Bangladesh was chosen for research purpose. Three sites from the downstream, mid-stream and upstream part of study river were selected for water quality analysis. A variety of multivariate data analyses were done to evaluate the environmental and biological data as well as to observe their interrelationships. A total of 7 genus of Diatom namely *Nitzschia*, *Diatoma*, *Melosira*, *Synedra*, *Tabillaria*, *Navicula* and *Fragillaria* were recorded at three sampling sites. *Nitzschia* was the most dominant genus compared to the other genus in downstream with the abundance of 1.92×10^3 cells/L while *Tabillaria* sp. was noted as rare one with lowest abundance of 0.37×10^3 cells/L at midstream site. From the interrelationship analysis it was observed that water temperature positively altered the distribution of *Melosira*, *Navicula* and *Tabillaria* but its abundance less dependent on dissolved oxygen and pH. The results from a two -dimensional NMDS revealed that abundance of diatom in downstream was statistically higher compared with upstream and midstream. Our study concluded that the diatom composition was very sensitive to the physico-chemical parameters and could be used as a bioindicator to assess the quality of surface water.

Table 1. One -way ANOSIM (uncorrected significant) among the three sites

Sites	Overall p -value = 0.002 (R -value = 0.144)		
	Upstream	Midstream	Downstream
Upstream		0.7661	0.0019
Midstream	0.7661		0.0012
Downstream	0.0019	0.0012	

Keywords: Diatom, Water quality, River

WATER QUALITY AND TROPHIC STATUS IN TERMS OF WATER QUALITY INDEX (WQI), TROPHIC STATE INDEX (TSI) AND TROPHIC LEVEL INDEX (TLI) IN GULSHAN AND DHANMONDI LAKES, DHAKA, BANGLADESH

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The study was conducted to investigate the water quality parameters through investigating water quality index (WQI), trophic state index (TSI) and trophic level index (TLI) of Dhanmondi and Gulshan lakes of Dhaka City in order to depict the scenario of water pollution and to determine the present status of water quality and trophic status and also their suitability. Water samples were collected from six different locations of both lakes during September and October in 2021 where these months are considered as monsoon and post-monsoon seasons, respectively. This study has been done based on the essential water quality of physico-chemical parameters (temperature, transparency, pH, DO, BOD, TDS, EC, TSS, total hardness and total alkalinity), major ions (Cl⁻, Ca²⁺, Mg²⁺, NH₃, SO₄²⁻, PO₄-P, NO₃⁻ and NO₂⁻) and biological parameter (chlorophyll-a). The study showed that during the monsoon season the values of TDS, DO, total hardness, chloride, and sulphate contents in Gulshan Lake were 218 mg/l, 1.59 mg/l, 94.6 mg/l, 24.82 mg/l, and 8.0 mg/l, respectively and 253 mg/l, 1.43 mg/l, 101.53 mg/l, 26.47 mg/l, and 37.3 mg/l, respectively, in post-monsoon period. On the other hand, in Dhanmondi Lake these values were 132.67 mg/l, 3.29 mg/l, 82.73 mg/l, 19.86 mg/l, and 10.0 mg/l, respectively in the monsoon season and 134 mg/l, 3.15 mg/l, 85.13 mg/l, 20.68 mg/l, and 42.67 mg/l respectively in the post-monsoon season. Despite the fact that these values were lower than the Environmental Conservation Rules (ECR) standard limit, in both lakes during the both seasons. The correlation coefficient analysis revealed statistically significant ($p < 0.05$) (DO, total hardness, and chloride) and strongly significant ($p < 0.01$) (TDS and sulphate) variations in both lakes during the monsoon and post-monsoon periods. The trophic state index (TSI), trophic level index (TLI), and water quality index (WQI) were used in this study to quantify the water quality of Gulshan and Dhanmondi lakes. Using the both indices (TSI & TLI), it was revealed that both lakes are eutrophic (> 80) and hypereutrophic (> 7), respectively. Both indices indicated that eutrophication is a major threat in Gulshan and Dhanmondi Lakes. The TSI and TLI values have considered both lakes unsafe for drinking, bathing, and even fish culture. On the other hand, the WQI (namely Weighted Arithmetic WQI, Bascaron WQI and WQI model) calculated for the both lakes during the present study and demonstrated that the water of the Gulshan Lake is unfit, very bad and unsuitable for drinking condition. The Dhanmondi lake is also unfit, bad and unsuitable for drinking condition according to the investigated various WQI indices.

Keywords: Dhanmondi Lake, Gulshan Lake, Water quality, Trophic state index (TSI)

SUSTAINABLE ECOSYSTEM BASED PRAWN FARMING SYSTEM IN SOUTHWEST COASTAL BANGLADESH

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A good pond ecosystem deals with the balanced interactions of different organisms using all trophic levels maintaining healthy environment. Pond ecosystem is usually polluted through foreign materials, uneaten food, faces those cause many diseases and deformities of aquatic species. This study aims to make the ecosystem healthy with the application of organic and inorganic extractor. The experiment is being conducted in FMRT Pond complex, Khulna University where only prawn (2 Juvenile/m²) in control pond and in treated pond multi trophic organisms [prawn juvenile (2/m²), rohu (0.1/m²), mola (2 /m²), apple snail (0.25/m²) and floating bed vegetables] are being cultured. Here, prawn is supplementary fed animal whereas snail, mola and rohu are organic pollutant extractor and vegetables are inorganic pollutant extractor. This practice ultimately creates a balanced ecosystem for environmental sustainability (bio mitigation) with economic stability reducing cultivable land use.

It is found that pollutant parameters are within the prawn cultivable range in both control and treated pond, but treated pond showing less pollutants parameters compare to control. It might be due to application of organic and inorganic extractor in treated pond (Table 1). Till now the growth of main crop prawn was found higher in treated pond (29.80g) than the control (25.16g). This study revealed that multi trophic aquaculture with vegetables might keep the pond environment healthy thus higher production and health safe products could be obtained.

Table 1. Comparative water and soil quality of control and treated pond

Parameters	Control pond	Treated pond
NH ₃ (mg/l)	0.14	0.03
NO ₂ (mg/l)	0.24	0.11
PO ₄ (mg/l)	0.06	0.05
Organic matter(%)	3.54	2.79
Nitrogen in soil (%)	0.19	0.16
Phosphorous in soil (ug/g)	9.23	9.25
Prawn weight till now		
prawn weight (g)	25.16	29.80

Keywords: Ecosystem, Multitrophic, Bio mitigation, sustainable

TOXIC EFFECTS OF CADMIUM ON MORPHOLOGY, HISTOPATHOLOGY OF *Ompok pabda*

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The present study was conducted to investigate the morphological, behavioral, growth and histopathological effect of cadmium on *Ompok pabda*. Initially, the fishes were divided into six groups and were treated with different concentrations (20mg/L, 40mg/L, 80mg/L, 160mg/L, 320mg/L, 400mg/L) of CdCl₂. After 96 hours of exposure, the median lethal concentration of CdCl₂ was calculated as 198.61mg/L. Water quality parameters and fish behaviors were observed daily. Finally, on the basis of LC₅₀, three concentrations of CdCl₂ viz., 100 mg/L, 199mg/L and 300 mg/L respectively with three replica and control groups were used to observe morphological, behavioral and histopathological changes of fish. No behavioral changes or death occurred in the control group at any time during the experiment. All control fish were active and swam normally. At the same time, the behavioral abnormalities of the CdCl₂ treated fish was increased as the dose increased. The behavioral abnormalities included loss of balance, respiratory difficulty, slowness of motion, frequent surfacing activity and increased mucus secretion were observed.

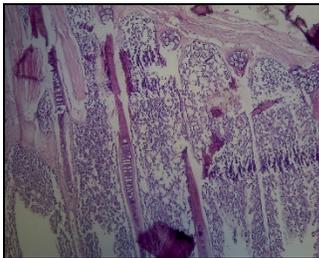


Fig. 1. Gill tissue of Control.

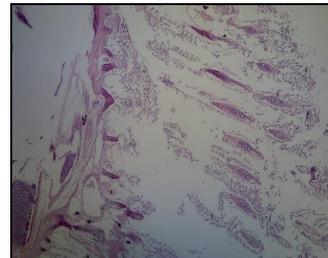


Fig. 2. Gill tissue of treatment 2
(treated by 199 mg/L of CdCl₂).

After 96 hours of exposure of final treatment, growth parameters (weight gain, length gain and condition factors) were calculated and tissue sample (gill and intestine) were collected. Histopathological evidence showed clear and distinct changes in the gill and intestine tissues. The changes in gill were characterized by epithelial hyperplasia, epithelial lifting and edema, lamellar fusion, aneurism, desquamation and necrosis, whereas, the intestine were characterized by intactness of serosa, less organized mucosa, consequent fusion of mucosa, edema between the intestinal sub mucosa and lamina propria. Compared with the control group, *Ompok pabda* of treatment groups showed severe intestinal and gill tissues injury. The result showed that acute cadmium toxicity severely affects the normal behavior and vital organs which is deleterious for the exposed fish.

Keywords: *Ompok pabda*, Cadmium, Histopathology

LENGTH-WEIGHT AND LENGTH-LENGTH RELATIONSHIPS AND CONDITION FACTORS OF *Xenentodon cancila*, *Anabas testudineus* AND *Heteropneustes fossilis* FROM ARIAL BEEL, BANGLADESH

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Length-length relationships (LLRs), Length-weight relationships (LWRs) and relative condition factor (Kn) are of great importance in fishery assessment studies since it provides information about the growth of the fish, its general wellbeing, and fitness in a habitat. This study, therefore, was conducted to evaluate the biometric status (LLRs, LWRs and Kn) of three indigenous fish species in the Arial beel, a significant freshwater wetland of Bangladesh. A total of 603 fishes of *Xenentodon cancila*, *Anabas testudineus* and *Heteropneustes fossilis* were collected on weekly basis from the Arial beel, Munshiganj, Bangladesh over the period of six months. The results showed that total length (TL) was significantly and positively related with the weight (*X.cancila*: $r^2 = 0.9396$, $p = < 0.001$; *A.testudineus*: $r^2 = 0.972$, $p = < 0.001$, *H.fossilis*: $r^2 = 0.9807$, $p = < 0.001$). Growth pattern analysis based on b value indicated that the growth behavior of *X. cancila* is isometry, where the value of b was 3.497. On the other hand, the growth behavior of *A. testudineus* and *H. fossilis* was negative allometry (b value 2.792 and 2.927, respectively). The relative condition factors (Kn) for all the three species from the Arial beel were above 1 (*X.cancila* 1.02, *A.testudineus* 1.01 and *H.fossilis* 1.02), suggesting a fairly sound physiological condition of these three species in the beel. Thus, the present study provided the first baseline data about LWRs and relative condition factor of the fishes in the Arial beel of the Munshiganj, Bangladesh. Further study is needed to establish the fish stocks of the Arial beel as the founder stocks for monitoring and management of these fishes of the beel.

Keywords: Length-Weight relationship, *Xenentodon cancila*, *Anabas testudineus*, *Heteropneustes fossilis*

AN OVERVIEW OF CURRENT STATUS OF FISH BIODIVERSITY AT PADMA RIVER, RAJSHAHI: FROM THE ENTRANCE OF BANGLADESH TO THE SHAMPUR NAGAR GHAT, RAJSHAHI

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The Padma is one of the major rivers of Bangladesh which is the main branch of the Ganges i.e. originates from the Himalayas. It enters into Bangladesh through Chapai Nawabganj district. The Farakka Dam, built by India, has brought about a momentous change in the biodiversity of the Padma river fish. Due to poor access, there is less information about the current status of fish in this transit point of the Padma. Therefore, we have studied the Padma river from the Bangladesh-India transit point to Shampur Nagar Ghat in Katakali, Rajshahi. In recent times, a large portion of total freshwater fish species are facing threat to extinction. Eventually, assessment is essential to detect the key drivers for the loss and to develop an appropriate management technique for both the biota and their habitat. From the current study, we obtained a total of 38 species of fish from 9 orders and 17 families. Of which 8 species are endangered, 3 species are vulnerable, 1 species is critically endangered nationally. This survey was carried out from December 01 to 31, 2020. The achieved result gives us the idea and recommended few policies for sustainable management and conservation of fishes in the Padma river.



Fig A: Rajshahi District Map



Fig B: Bangladesh Map

AN ASSESSMENT OF ABUNDANCE, CHARACTERIZATION, POLYMER TYPE OF MICROPLASTIC CONTAMINATION IN WATER AND SEDIMENT IN KUAKATA (DAUGHTER OF THE SEA), PATUAKHALI, BANGLADESH

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Microplastics (MPs) are an emerging pollutant and are highly abundant in almost all ecosystems where tourist spots could be considered as the host or parent of plastic debris. People may throw plastics everywhere unconsciously and pollute the ecosystem; consequently, the ecosystem health might be degraded, and ultimately human being might be affected. In this study, the second most important tourist spot in Cox's Bazar was selected, named Kuakata for assessing the MPs in surface water and bottom sediment in February 2022. A 45 μm plankton net and an Ekman grab sampler were used for collecting the water and sediment samples, respectively. Samples were analyzed by following the standard procedures like floatation/density separation, digestion, sieving, filtration, and visual identification by electron microscope with camera, and further polymer type MPs was identified using micro FTIR analysis. In terms of the shape of MPs, fiber (22-47%) was found maximum in water samples whereas fragments (27-43%) in sediment recorded in a total of six shapes. A clear significant difference ($p < 0.001$) was observed between the two samples. Furthermore, the blue (14-32%) colored particles were highly abundant in water and sediment, whereas green colored showed least percentage (0-9%). Besides, there is no significant difference among the five stations regarding the MPs. The highest percentage of MPs are 201-600 μm size while the lowest percentage detected in 50 μm size. The present study revealed that MPs particles percentage and size are very high in water and sediments samples; hence, necessary actions should be needed urgently to eliminate harmful MPs contamination. Further study is recommended to identify MPs contamination level in seafood samples to ensure consumer safety.

Keywords: Microplastic, Kuakata

SEASONAL VARIATION OF WATER QUALITY PARAMETERS IN RIVER, LAKES AND WATERFALLS IN RANGAMATI AND KHAGRACHARI HILL TRACTS OF BANGLADESH

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The present study was conducted to investigate the seasonal variation of water quality parameters from river, lake and waterfalls in Rangamati and Khagrachari hill tracts of Bangladesh. The study conducted from March 2021 to January 2022. Results showed that the temperature, EC, TDS, DO, BOD, pH, total alkalinity and total hardness were 16 to 32.5°C, 90 to 180 $\mu\text{S}/\text{cm}$, 53 to 75 mg/L, 5.4 to 7.5 mg/L, 0.95 to 1.8 mg/L, 6.0 to 7.9, 83 to 140 mg/L and 45 to 135 mg/L, respectively in the Kaptai Lake. In Chengi River, the results showed the temperature, EC, TDS, DO, BOD, pH, total alkalinity and total hardness were 15 to 29.7°C, 90 to 170 $\mu\text{S}/\text{cm}$, 40 to 88 mg/L, 4.4 to 7.2 mg/L, 0.98 to 1.76 mg/L, 5.9 to 8.01, 85 to 190 mg/L and 45 to 139 mg/L, respectively. In the Shuvolong and Risang Waterfall the temperature, EC, TDS, DO, BOD, pH, total alkalinity and total hardness were 12 to 22.01°C, 150 to 200 $\mu\text{S}/\text{cm}$, 74 to 114 mg/L, 5.4 to 9.5 mg/L, 0.63 to 1.7 mg/L, 6.5 to 8.2, 120 to 223 mg/L and 75 to 200 mg/L, respectively.

Table 1. The mean of water quality parameters of Kaptai Lake, Chengi River, and Waterfalls

Parameters	Kaptai Lake	Chengi River	Waterfalls
Temp. (°C)	25.17	23.28	18.16
EC ($\mu\text{S}/\text{cm}$)	128.89	127.67	181.5
TDS (mg/L)	61.23	66.77	93.02
DO (mg/L)	6.47	6.16	7.66
BOD (mg/L)	1.2	1.28	0.79
pH	7.00	7.00	7.47
TA (mg/L)	113.25	126.82	168.6
TH (mg/L)	94.06	97.78	135.59

The study revealed that the temperature, EC, TDS, BOD, pH was higher in pre-monsoon season than monsoon and post-monsoon season. On the other hand, total alkalinity and total hardness was higher in post monsoon season than monsoon and pre-monsoon season. In the waterfalls transparency was higher in post monsoon season than monsoon season and DO was higher in monsoon season compared to pre monsoon and post monsoon season.

Keywords: Kaptai Lake, Water quality, Hilly Districts

SPATIO-TEMPORAL DEVIATION, SPECIES VARIETY AND PERIODIC ABUNDANCE OF AVAILABLE FRESHWATER MOLLUSCS IN BANGLADESH

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The diversity and distribution pattern of the available freshwater mollusc population in major inland open water bodies of Bangladesh were assessed for three consecutive years from 2018 to 2020. More than five thousand molluscs were collected from the three major inland water bodies and nearby wetlands of Bangladesh i.e. *Haor* areas (Sunamgaj, Netrokona and Kishoreganj), Chalan *beel* (Rajshahi-Natore) and Kaptai Lake belonging to 49 genera under twelve families were recorded. Among the genera, 15 species were most commercially viable in where 7 genera were under Gastropoda group and the rest 8 were Bivalvia (Unionoida) group. The Pilidae family was reported to be the most common, followed by the Unionidae and Viviparidae, with Planorbidae members being few. The analysis of diversity indices revealed a diversified mollusk population dominated by a few species that was heterogeneously dispersed in the studied area. Some variation in species abundance, richness, and diversity was identified among the sampling locations in this study. However, out of 15 commercial species, 5 were found dominant, 3 were frequent, and the rest were less abundant. The maximum species abundance (27.87%) was observed during the post-monsoon, while the minimum (15.38%) was observed during the monsoon period. Haor areas showed a greater abundance in all seasons than the Chalan *beel* and Kaptai Lake. The most abundant species was *Pila globosa* (31.14%) followed by *Lamellidans marginalis* (22.93%) and *L. corrianus* (8.83%). No significant difference was found in the mean value of Shannon-Weaver diversity, Pielou's evenness and Margalef's richness index among the seasons, but significant difference was observed among the locations indicated the environmental variation of those areas. *Bellamy acrassa* was determined to be the most important species responsible for seasonal differences, and water transparency was shown to be the best explanation for the dispersion of the gastropod population.

Keywords: Molluscs, *Lamellidans marginalis*,

ECOLOGICAL IMPACTS OF A HILSA FISH SANCTUARY IN BANGLADESH

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To conserve and sustain its production, the government has established six hilsa sanctuaries across the country. Among the six sanctuaries, Hizla-Mehendiganj hilsa sanctuary was established in 2018 on which no ecological outcomes have been assessed so far. This study aims to fill in the gaps by assessing the physicochemical (e.g., Dissolved Oxygen - DO, temperature, pH, EC, TDS and transparency) and fish biodiversity from within and outside sites of the sanctuary region. The results of this study have found that the mean DO, temperature, pH, and transparency inside the sanctuary are 5.6 mg/L, 29.1°C, 8.3 and 20.5 cm, respectively (Table 1) which are nearly similar with the values of water quality parameters of different sites outside the sanctuary region. This study reports a total of 374 individuals of 21 fish species in 14 families under 6 orders. Within the sanctuary, the Shannon's, Simpson's, Margalef's and Buzas, and Gibson's indices are 1.881, 0.214, 1.881 and 1.156, respectively (Table 1) which indicate comparatively moderate fish diversity. Two endangered species, *Clupisoma garua* and *Pangasius pangasius* and one vulnerable species, *Gudusia chapra*, are found inside the sanctuary. Fish biodiversity is higher in the outside site of the sanctuary at Rukundi than the sampling sites within the sanctuary. This can happen due to the availability of more fishes and more fishing gear in the area and better ecological conditions which have an impact on the distribution of the fish species.

Table 1. Physicochemical parameters of water and fish biodiversity indices within and outside different sampling sites of the Hizla-Mehendiganj hilsa sanctuary

Site name	Waterbody	Water quality parameters						Biodiversity indices				
		DO (mg/L)	Temp (°C)	pH	EC (μS/cm)	TDS (mg/L)	Transparency (cm)	H	D	D'	d	E
Hizla-Mehendiganj: Inside sanctuary	Gozariya river, near Lalkharabad	5.6	29	8.2	120	50	17.5	1.423	0.362	0.638	1.60	1.195
	Meghna river, near Moulvirhat	5.8	28.4	8.3	130	50	23	1.234	0.333	0.667	1.08	1.280
	Meghna river, near Char Killa	5.5	30	8.3	130	50	21	1.181	0.46	0.54	1.40	1.184
Mean±SD		5.6	29.1	8.3	127	50	20.5	1.881	0.214	0.786	1.88	1.156
Hizla-Mehendiganj: Outside sanctuary	Meghna river, near Ulania	5.5	28.8	7.8	220	100	18	0.633	0.632	0.368	1.28	1.235
	Ilisha river, near Rukundi	5.4	28.9	8.3	110	40	19.3	1.836	0.24	0.76	2.44	1.189
	Meghna river, near Thandarbazar	5.3	29.9	8.4	120	50	13	-	1	-	0.85	1
Mean±SD		5.4	29.2	8.2±0.3	150±49.6	63.3	16.8±2.7	1.94	0.21	0.80	2.47	1.16

Here, H= Shannon-Weiner diversity index, D= Simpson index, D'= Simpson's index of diversity, d= Margalef richness index, and E= Buzas and Gibson's evenness index

Keywords: Hilsa santuary, Ecology, Water quality

**SPATIOTEMPORAL DISTRIBUTION AND ASSEMBLAGES PATTERN OF
PLANKTONIC COMMUNITIES: A CASE STUDY OF RAMSAGAR LAKE IN
DINAJPUR DISTRICT**

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The research was set to assess the spatiotemporal distribution of planktonic communities along with different water quality parameters of Ramsagar lake of Dinajpur district. Water samples were collected fortnightly from four different sampling sites from September 2018 and August 2019 by dividing the time frame as autumn, winter, spring and summer for research purpose. The findings from the present investigation revealed significant differences of plankton populations among with the seasons and sites. A total of 30 genera of plankton belonging to nine groups were identified. Among them 23 species of phytoplankton belonging 5 groups such as Euglenophyceae, Cyanophyceae, Bacillariophyceae, Charophyceae and Chlorophyceae. Whereas, seven genus of zooplanktons were identified belonging to the groups of Copepoda, Rotifera, Cladocera and Crustacean. Among different phytoplankton groups, the euglenophyceae was found as a leading group during summer season, while cyanophyceae, bacillariophyceae, charophyceae and chlorophyceae were dominant during winter season. On the other hand, highest cell densities of four groups of zooplankton were recorded during spring season. The study also revealed that maximum mean value of water temperature ($31.63 \pm 0.26^{\circ}\text{C}$) during summer and the lowest in winter season ($15.78 \pm 0.51^{\circ}\text{C}$). Almost similar observations were reported in cases of transparency and DO with maximum values in summer season followed by winter season. While, highest pH value was recorded in winter season with a minimum pH value during spring season. The study concluded that the water quality of Ramsagar lake was in suitable ranges though, it should be kept in an optimum range so that the biological aspects may flourish.

Keywords: Plankton, Ramsagar, Water quality

POST-HARVEST NUTRITIONAL LOSSES OF MAJOR FISH AND CRUSTACEAN SPECIES IN BANGLADESH: A CIRCULAR ECONOMY ADOPTION FOR SUSTAINABLE AQUACULTURE

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Worldwide, fish and crustacean (FAC) species provide great percentage of macro- and micro-nutrients as diet for consumers. In general, FAC generates considerable volume of by-products. Hence, the present study evaluated both quantitative and qualitative of by-products originate from 14 fish and 2 crustaceans' species in local fish markets of Bangladesh. Furthermore, investigated nutritive content (protein, lipid, Ca, Fe, Zn, and Se) of edible yields and by-products (fish: fin, scale, gill, and viscera; shrimp and prawn: head, shell, brain, and claw) of FAC as future indication in industrial sectors for potential applications. The results showed 9.34 ± 3.57 - 18.78 ± 7.61 % by-products, and 3.68 ± 0.53 - 19.75 ± 7.28 % plate waste detected from fish species whereas shrimp and prawn generated 50-66% byproduct and of plate waste. Among the by-products shrimp and prawn head (36.33 ± 1.41 - 38 ± 3.12 %), and fish viscera (2.77 ± 1.02 - 10.74 ± 2.21 %) contributed large volume followed by fish gill, fin, and scale. Additionally, significant difference was demonstrated among the edible yields and by-products nutritional components of FAC. The by-products were rich in protein (1.53 ± 0.05 - 28.8 ± 1.24 g/100g), fat (0.78 ± 0.17 - 47 ± 2 g/100g), and minerals (Ca: 16 ± 2 - 5247 ± 434 mg/100g; Fe: 0.4 ± 0.08 - 8916.85 ± 209.76 mg/100g; Zn: 24.93 ± 1.98 - 2095.84 ± 489.12 mg/100g; Se: 0.03 ± 0.01 - 138 ± 13.32 μ g/100g). Our findings revealed that FAC by-products are good sources valuable nutrients and can be applied as direct food, develop animal feed, agriculture, pharmaceutical and cosmetic industries. Furthermore, the total amount of 14 fish species by-products can be contributed fish meal and fish oil development for sustainable aquaculture in Bangladesh that render to help in circular economy. Therefore, more attention is needed for the strategically managing of underused by-products for sustainable aquaculture.

Keywords: Post-harvest loss, Fish & Crustacean

FISH BIODIVERSITY OF KAPOTAKSHMA RIVER UPSTREAM, JASHORE, BANGLADESH

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Riverine fisheries play an important role in assessing fisheries resources, fish biodiversity and in evaluating various impacts on the aquatic environment of a river. Fish biodiversity of rivers is an indicator of conservation status, ecosystem services and distribution pattern of diversified aquatic species in inland open water fisheries. Kapotakshma is one of the major rivers in southwestern Bangladesh. However, any study regarding fish biodiversity is unheard of and this is the inaugural study in this river. The present study was conducted to assess the fish biodiversity, distribution and abundance of fishes upstream of Kapotakshma. The sampling was done at day time and night time from five stations from January to December 2021 on monthly basis. Four fishing gears including cast net, seine net, drag net and one fishing trap were used to collect fish. A total of 84 finfish species including 73 indigenous and 11 exotic species belonging to 25 families were documented during the study period. Cyprinidae was the most dominating family of native fishes having 17,331 individuals (33%). *Puntiusticto*, *Colisa fasciata*, *Guducia chapra*, *Amblypharyngodon microlepis* were the most abundant fish species. Among them, 12 native fish species were critically endangered to vulnerable according to the red book of IUCN (2000). The diversity indices (Shannon, Simpson and Margalef) indicated richness of species in all sampling sites throughout the study period with higher values in monsoon. The study result illustrates the present fish diversity in Kapotakshma river which will facilitate further studies and management of the riverine fisheries in the country.

Keywords: Biodiversity, Kapotakshma river

FISH MORTALITY INCIDENCES IN THE TRANSBOUNDARY RIVER, SHARI-GOYAIN ECOSYSTEM OF BANGLADESH

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Mass mortality incidents of fishes now-a-days are becoming very common in many parts of the world as a result of sudden natural and/or human-induced changes to aquatic ecosystems, especially in riverine ecosystems. During the pre-monsoon season in 2019, two mass mortality incidents of fish occurred in the Shari-Goyain River, one of the important trans-boundary rivers at the north-eastern region Bangladesh which comes from the hilly areas of the Meghalaya State of India. Those mass fish mortality incidents occurred along an 80-kilometer stretch of this river. A considerable amount of fishes died which lasted for around three days, and thus caused commotion and worry among the local people and government officials. For the purpose of this study, data were collected from six sampling sites by direct catch assessment during those fish kill incidences as well as by personal interviews, focus group discussions, and key informant interviews from March to May 2019. During the investigation, a total of 38 species of fish were recorded and categorized into three groups, where 14% of fish were dead, 56% were moribund, and the remaining 30% were less affected. It was observed that bottom dwelling *Mastacembelus armatus* showed highest mortality indicating the most sensitive species for those events. Local fishers and other inhabitants perceived that coal mine pollutants from upstream are the main cause of water quality deterioration and sudden fish mortality in the Shari-Goyain River as they have experienced during the last few years before that events coincided by visible flush of coals with flash flood water coming from upstreaming. According to the local fishers, within three decades, many indigenous fish species of the river have disappeared, mainly due to coal mine drainage pollution. To support the findings, six water quality parameters (water temperature, dissolved oxygen, conductivity, total dissolved solids, pH, and transparency) were measured throughout the affected river. The parameters of the river water were found to be fluctuating and some of them especially pH (3.87-6.61) were badly crossing the suitable limits for the survival of aquatic flora and fauna. Therefore, a few continuous water quality monitoring sites throughout the river should be put up, along with comprehensive ecological observations, to notice any repeat incidents and to precisely determine the source of such fish mortality outbreaks in the future. Finally, immediate steps should be taken to find a solution for conserving the Shari-Goyain River ecosystem by creating a joint team with the combination of researchers and administrators from both Bangladesh and India.

Keywords: Fish mortality, Shari-Goyain River

DIVERSITY OF PLANKTON AND THEIR SEASONAL VARIATION IN THE RAMSAGAR LAKE, DINAJPUR

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Ramsagar, a man-made lake in Dinajpur is considered important aquatic resource owing to have great diversity of fish and recreational value. The diversity of plankton and their seasonal variation in this lake was studied in the period of January 2017 to December 2017. Three sampling sites (site1,site 2 and site 3) inside the Ramsagar and four seasons (Summer, Autumn, Winter and Spring) were selected for sample collection. All water quality parameters and plankton samplings were done monthly. All water quality parameters (temperature, transparency, P^H, Dissolved oxygen) showed no significant differences among the three different sampling sites but varied significantly in different seasons. Study of Physico-chemical parameter suggested that all water quality parameters of the water body were in suitable range for fish culture. Plankton variations were characterized with high dominance of phytoplankton (80%), while zooplankton represented only 20% in the plankton community. A total of 4 groups and 31 genera of phytoplankton were observed in the lake. Chlorophyceae was the dominant group of phytoplankton. Among the genera 15 genera of Chlorophyceae, 8 genera of Bacillariophyceae, 7 genera of Cynophyceae and 1 genera of Euglenophyceae were found during the study period. In terms of seasonal variation, highest abundance was found in summer and lowest in winter. On the other hand, 4 groups and 7 genera of zooplankton were found during the study period. Among them 3 genera of Rotifera, 2 genera of Copepoda, 1 genera of cladocera and 1 genera of crustacean were found. The outcomes of this study improve our understanding of the variability in plankton community and regulating environmental drivers in this lake system. Therefore, the findings of the present study would be helpful as baseline information for further plankton related research.

Keywords: Plankton, Ramsagar

COVID-19 IMPACTS ON BASIC NEEDS OF WOMEN WORKERS OF FISH AND SHELLFISH PROCESSING PLANTS IN BANGLADESH

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The contribution of women workers in the FSPPs (Fish and Shellfish Processing P) is immense because in every step from sorting to packing and labeling, they are active participants. However, their contribution remains behind the scenes. Among many sectors, the FSPP sector has been affected by the covid-19 which has created adverse impacts on the women workers. To assess the impacts of covid-19 on women workers, this study conducted questionnaire surveys and FGDs in 9FSPPs located in Khulna and Bagerhatin 2021. Results report that covid-19 posed adverse impacts on households' food consumption, economic condition, monthly payment status from the FSPPs and healthcare facilities (Table 1). This study finds that daily food consumption of 32% and 17% of the respondents' households are decreased to some extent and decreased a lot, respectively (Table 1). Around 35% female members' daily food intake is decreased to some extent due to the covid-19 impacts. Study reports that 32% and 23% of the respondents' households' total monthly income have decreased to some extent and decreased a lot, respectively. However, women workers' regular monthly payment from the FSPP (96%) and healthcare facilities (83%) remain mostly unchanged during the covid-19 period (Table 1).

Table 1. Covid-19 impacts on basic needs of women workers of fish and shellfish processing plants

Factors	Impacts (respondent's responses in %)				
	Increased a lot	Increased to some extent	No change	Decreased to some extent	Decreased a lot
Household' daily food consumption	1	3	47	32	17
Household female members' daily food consumption	0	2	56	35	7
Households' total monthly income	1	5	39	32	23
Respondent's monthly income	0	5	87	6	2
Regular payment status from the processing plant	0	1	96	3	0
Households' basic healthcare facilities	0	22	67	10	1
Women healthcare facilities	0	1	83	14	2

Keywords: Covid-19 impacts, Women worker, Gender

ANALYSES OF PROTECTION AND CONSERVATION ACCORDING TO THE "FISH ACT 1950" IN KAPTAL LAKE FISHERIES MANAGEMENT OF BANGLADESH

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Kaptai Lake (KL), the largest man-made inland watershed in Bangladesh (ca. 700 km²) features an abundant variety of indigenous fish species. Moreover, it provides a plethora of ecological benefits to local communities. Nevertheless, the KL is suffering from multidimensional natural and anthropogenic stressors that threaten these wetlands' sustainability. Though the legal framework assures sustainable conservation of fisheries resources, the implementation scenarios of fisheries laws, regulations, and policies in the KL wetland are insufficient. This study aimed at assessing the fisher's perception of the regulation implementation efficiency of the Protection and Conservation Fish Act of 1950, while analyzing the effectiveness of the legal framework in the context of biodiversity conservation and the management sustainability of KL. By integrating qualitative and quantitative data collected through participatory Rural Appraisal (PRA) tools *viz.* 225 interviews with fishers, four focus group discussions, and 12 key informant interviews, the investigation was performed in four selected areas in KL. The findings show that fishers routinely disregard laws and restrictions of the Fish Act 1950 due to various socioeconomic and political forces. Although the annual fish harvest rate from KL appears to be increasing, the lake is losing its charismatic biological diversity primarily due to inappropriate and ineffective enforcement of fishing regulations. Many fishers believe that they still follow the act's significant laws and regulations while being involved in several destructive and prohibited fishing practices. There is a link between community awareness, the scope of the act's provisions, the effectiveness of its enforcement, and the strength of its execution. One of the leading causes of biodiversity loss in the KL is inadequate and ineffective fishing regulations. Improvement in the enforcement of the fishing act may be the prominent option to ensure better biodiversity conservation and sustainable management of this wetland. This study also highlights the urgent need for transdisciplinary collaboration initiatives and synchronous cooperation among the agencies in order to effectively implement the fishing laws and contribute to better conservation and sustainability of the Kaptai lake fisheries resources.

Keywords: Kaptai Lake, Biodiversity conservation, Legal framework, Fish Act

**POPULATION BIOLOGY OF *Apocryptes bato* (GOBIIDAE)
IN THE PAYRA RIVER, SOUTHERN BANGLADESH**

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The gobioid fish *Apocryptes bato* is a species of mudskipper native to India, Bangladesh, and Myanmar. This study for the first time is documenting the wide-ranging information on the population biology of *A. bato* including- sex ratio, length-weight relationships (*LWRs*), size at sexual maturity, breeding season, fecundity, condition factor and natural mortality (M_w) in the Payra River, southern Bangladesh. A total of 1,028 specimens (303 males and 725 females) were collected from the set bag net (mesh size < 2 mm) fishers during May 2016 to April 2017. For each individual, total length (TL) and standard length (SL) were measured to the nearest 0.01 cm using digital slide caliper, while body weight (BW) was taken by an electronic balance with 0.01 g accuracy. The overall sex ratio was significantly different from the expected value of 1:1 (male: female = 1:2.39; $\chi^2 = 173.23$; and $p < 0.05$). The allometric coefficient (b) of *LWRs* (SL vs. BW) indicated negative allometric growth in male, female, and combined sexes ($b < 3.00$; $p < 0.001$). Size at sexual maturity was estimated as 4.9 cm SL. Monthly variations in gonadosomatic index specify that the main breeding season is from May to December. There was a significant positive correlation of body length and body weight with fecundity. Fulton's condition factor varied in both sexes and was attributed to variations in GSI with maturity. Breeding season was significantly associated with rainfall, but not air temperature. The M_w for the population of *A. bato* was 1.37 year⁻¹ in the Payra River. Additionally, the M_w value was very high when the species was <4.0 cm SL, while it decreased with larger body sizes. The findings of this study will be helpful for management and conservation of *A. bato* populations in the Payra River, as well as for connecting ecosystems.

Keywords: *Apocryptes bato*, Payra River, Population estimation

COMPARISON OF TAXONOMIC CHARACTERISTICS, LENGTH-WEIGHT RELATIONSHIPS, AND GROWTH PATTERN OF WALKING SNAKEHEAD, *Channa orientalis* FROM THREE REGIONS OF BANGLADESH

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This study was aimed to reveal the morphometric and meristic variations, length-weight relationships and condition factor of *Channa orientalis* collected from three regions (Kurigram, Rangpur and Lalmonirhat) of Bangladesh for a period of one year from July 2019 to June 2020, collecting 75 samples from each location. Fifteen morphometric and six meristic characteristics were estimated. Result showed that eight (08) morphometric characteristics were significantly ($p < 0.05$) different among the regions; three characteristics (03) were highly significant ($p < 0.001$) in Kurigram ($PrOD = 0.59 \pm 0.022$, $LJL = 1.26 \pm 0.04$, $UJL = 1.2 \pm 0.038$). These results indicated that the *C. orientalis* population of Kurigram was significantly different ($p < 0.001$) from the other two locations. On the other hand, among six meristic characteristics, DFR, PFR, AFR, and BR were found significant among three sampling locations. The values of PFR varied significantly ($p < 0.05$) in Kurigram, which distinguishes the other two regions. Likewise, DFR (34.23 ± 0.124) and BR (4.23 ± 0.079) showed significant variations ($p < 0.001$) in Rangpur region, which proved the population of Rangpur was unique from the others. On the other hand, AFR value significantly ($p < 0.001$) separated Lalmonirhat population from the others. In length-weight relationships, the generalized relationship between total length (TL) and body weight (BW) were $BW = 0.007TL^{3.147}$ ($r^2 = 0.945$), $BW = 0.03TL^{2.573}$ ($r^2 = 0.916$) and $BW = 0.008TL^{3.084}$ ($r^2 = 0.899$) for Kurigram, Rangpur and Lalmonirhat, respectively. The growth pattern showed positive allometric in Kurigram ($b = 3.14$) and Lalmonirhat ($b = 3.08$), whereas, negative allometric was observed in Rangpur ($b = 2.57$). The study exhibited a higher condition factor (K) value in Kurigram (1.068) and Rangpur (1.049) and the lowest in Lalmonirhat (0.978). Therefore, the findings of the study reveal that the population structure as well as growth of *C. orientalis* population was comparatively better in Kurigram.

Keywords: *Channa orientalis*, Length-weight relationship

STATUS OF THREATENED FRESHWATER FISH SPECIES IN FRESHWATER WETLANDS OF SUNAMGANJ

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Wetlands of northeastern Bangladesh comprised of extensive floodplains and rivers supports productive inland capture fisheries and rich freshwater fish biodiversity. However, the diversity of indigenous freshwater fish species is rapidly declining due to overexploitation, anthropogenic factors, inadequate management and lack of policy and law enforcement. This study aimed to assess the availability of threatened fish diversity in selected wetlands in Sunamganj. Data were collected from different fishing communities, and nearby fish markets and fish landing centers at a regular schedule of 4 visits per month from August 2020 to April 2021 to identify the presence and diversity of threatened species available in Haors of Sunamganj district. Total 37 out of 64 threatened freshwater fish species of Bangladesh have been documented during the period. Among the identified species, 8% have been categorized as critically endangered, 51% as endangered and 41% as vulnerable in IUCN red list of freshwater fishes of Bangladesh. Critically endangered fish species found are *Bagarius bagarius*, *Ompok pabo* and *Tor tor*. Recorded 19 endangered fish species are *Barilius bendelisis*, *Barilius tileo*, *Batasio tengana*, *Bengala elanga*, *Botia dario*, *Botia dayii*, *Channa marulius*, *Chaca chaca*, *Chitala chitala*, *Clupisoma garua*, *Crossocheilus latius*, *Labeo pangusia*, *Mastacembelus armatus*, *Ompok bimaculatus*, *Ompok pabda*, *Oreochthyscosu atis*, *Pangasius pangasius*, *Raiamas bola* and *Rita rita*. Fifteen vulnerable species: *Anguilla bengalensis*, *Chagunius chagunio*, *Chela cachius*, *Danio dangila*, *Gudusia chapra*, *Glyptothorax telchitta*, *Labeo ariza*, *Lepidocephalichthysan nandalei*, *Microphis deocata*, *Monopterus cuchia*, *Notopterus notopterus*, *Pethia ticto*, *Sperata aor*, *Sperata seenghala* and *Wallago attu* have been recorded. Along with 37 threatened species, 18 near threatened fish species were also recorded including *Batasio batasio*, *Canthophrys gongota*, *Cirrhinus reba*, *Gagata youssoufi*, *Macragnathus aculeatus*, *Mystus cavasius*, *Pseudambassis baculis*, *Pethiagelius*, *Plotosus canius*, *Salmostoma phulo*, *Securicul agora* and *Systemus sarana* which are facing a high risk of extinction and likely to fall under a threatened category in near future. This study shows that, at least 58% of the country's total threatened freshwater fish species are available only in the Haors of Sunamganj; which indicates that Haor ecosystems provide suitable breeding and nursing grounds for threatened fish species. But, indiscriminate overexploitation, habitat degradation, decreasing swamp forest size, fishing during breeding season, fishing by dewatering, invasion by alien species, revenue based leasing systems are some of the major threats to sustain the small indigenous fish species in Haors of Bangladesh.

Keywords: Haor, Biodiversity, Endangered spp.

CURRENT STATUS AND DECLINE CAUSES OF FISH DIVERSITY OF BHAWAL BEEL, BANGLADESH

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Bhawal *beel* is one of the ancient types and obviously a fascinating one due to its biodiversity and ecological importance. It provides excellent habitat for small indigenous species (SIS). The present study was carried out from March 2016 to February 2017 by conducting Questionnaire Interviews (QI), Focus Group Discussions (FGDs) and Key Informant Interviews (KII) with the fishermen and resource persons. A total of 56 species of fish, including prawns, under 10 orders and 23 families were recorded from the *beel*. Cypriniformes (33.93%) were the most dominant order, followed by Siluriformes (21.43%), Perciformes (19.65%), Channiformes (7.14%), Synbranchiformes (7.14%) and so on. Among the recorded families, Cyprinidae was the most dominant, contributing 17 species. The availability status of recorded species were classified as available (44.64%), seasonal (19.64%), rare (16.08%), and very rare (19.64%). Overfishing, use of illegal fishing gear, siltation, katha fishing, abstraction of water for irrigation, catching of fry and brood fishes, lack of connection of *beel* with the Banar River and absence of proper *beel* management policy were identified as major threats to the fish diversity of Bhawal *beel*. About 13 species were found threatened (1 critically endangered, 5 endangered, and 7 vulnerable), which may go extinct in the near future due to a lack of proper management of the *beel* fishery. The study recommends minimizing all the above impediments and establishing community-based fisheries management (CBFM) and a *beel* nursery to save the valuable fish diversity of Bhawal *beel* on which local livelihood depends.

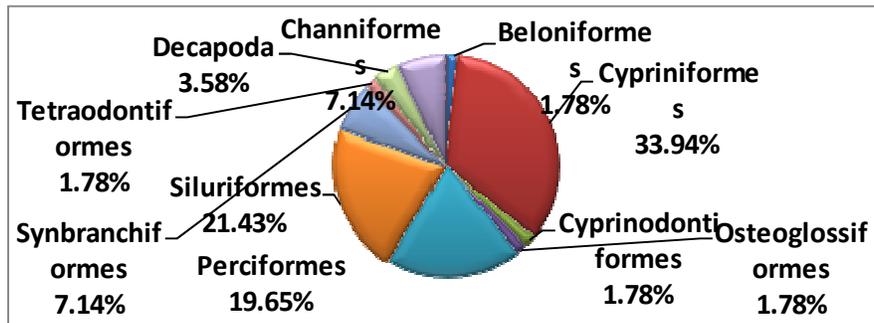


Fig. 1. Order based percentage of recorded fish species from study area.

Keywords: Bhawal beel, Biodiversity

REPRODUCTION AND GROWTH OF *Penaeus indicus* (CRUSTACEA: PENAEIDAE) IN THE ANDHARMANIK RIVER, SOUTHERN BANGLADESH

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Penaeus indicus is one of the major commercial penaeid shrimps distributed in the Indo-West Pacific from eastern and south-eastern Africa, through India, Malaysia, and Indonesia to southern China and northern Australia. Several works concerning the biology and fishery of this species have been undertaken in almost all of its major distribution areas except Bangladesh. Therefore, the present study was conducted to estimate reproduction (size at sexual maturity, spawning season) and growth of this species in the Andharmanik River, during July 2019 to June 2020. Samples were collected monthly. For each individual, carapace length (CL) was measured from the posterior margin of the orbit to the mid-dorsal posterior edge of the carapace using a digital slide caliper. Body weight (BW) was recorded using a digital balance. Sex was determined by the presence of petasma and the lycum as male and female respectively. Ovary weight was recorded and gonadosomatic index (GSI) was calculated as $GSI (\%) = (GW/BW) \times 100$. Size at first sexual maturity was estimated from the relationship between CL and GSI. Spawning season was estimated based on the monthly variation of GSI. Growth was estimated using the time series of length-frequency distributions followed by Pauly and Gaschütz growth model. Size at first sexual maturity of *P. indicus* was estimated at 15.5 mm CL. Growth was described by Pauly & Gaschütz's growth equation as: $L_t = 19.86 [1 - \exp \{-0.711 (t/12 - 0.635) - (1.308/2\pi) \sin (2\pi (t/12 - 0.486))\}]$ for males and $L_t = 22.75 [1 - \exp \{-0.636 (t/12 - 0.647) - (1.515/2\pi) \sin (2\pi (t/12 - 0.174))\}]$ for females. Females grew faster than males and there was sexual dimorphism with larger size in females than males. Longevity was estimated to be around 4.2 years in males and 4.7 years in females. The main spawning season was estimated to be from August to December.

Keywords: *Penaeus indicus*, Reproduction, Andharmanik River, Spawning season

LENGTH BASED SPAWNING POTENTIAL RATIO (LBSPR) OF HILSA, *Tenualosa ilisha* IN THE BAY OF BENGAL, BANGLADESH

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Length-Based Spawning Potential Ratio (LB-SPR) model was deployed to assess the status of Hilsa, *Tenualosa ilisha* in the Bay of Bengal, Bangladesh. About 20,610 specimen's data were collected from January 2019 to December 2021 from commercial fish landing sites on monthly basis, and their total length (TL) and weight were measured. The results revealed that gill net captured most of the *T. ilisha* before first spawning time. The maximum-recorded total length (TL) for this species in the study was 58.9 cm with a mean length of 38.0 ± 10.73 cm. The M/K value corresponds to the maturation of *T. ilisha* was 1.1. On the basis of LB-SPR assessment model, it could be concluded that *T. ilisha* become vulnerable to fishing at its maturation' size of 31.75 cm. The range of annual SPR of *T. ilisha* was estimated between 0.2 to 0.21 in the Bay of Bengal, Bangladesh, meet the threshold value of 0.2. This indicate that the exploitation level of *T. ilisha* is maintained to reach the maximum sustainable yield with the concurrent recruitment and juvenile survival. The Spawning Potential Ratio of *T. ilisha* based on time series data analysis, as a biological reference point was estimated near about 0.2, which comply the SPR for sustainable fisheries. However; the rate of fishing mortality should be reduced constantly.

Keywords: Length-Based Spawning Potential Ratio, First spawning time, Maximum Sustainable Yield, Recruitment

MARKETING CHANNEL AND VALUE CHAIN ANALYSIS OF COMMERCIALY IMPORTANT MARINE FISHES IN BANGLADESH

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Involvement of the working personnel in fish market channel is common in most of the fish markets of Bangladesh whereas the length of chain varies in accordance with region, location of the market and availability of water bodies. Therefore, the study was conducted to know the marine fish marketing channels, market margin, market profit and compare marine fish prices between long distance retail market and short distance retail market in Dhaka and Cox's Bazar over the period of six months (June 2021 – December 2021). Data was collected from 35 fish traders from primary marine fish market at Cox`s Bazar fish landing center, secondary marine fish market at Kawran Bazar wholesale marine fish market, consumer market at Cox's Bazar retail marine fish market as a short distance retail market and Mohammadpur Townhall retail fish market as a long distance fish market. Four marine fish marketing channels were observed at the Cox's Bazar fish landing center, including hilsa, pomfret, jaw fish and tuna fish marketing channel. Marketing cost in both primary and secondary marine fish market was comparatively higher in case of large sized fishes. Transportation and icing costs were comparatively higher than others in primary market. *Aratdar* commission was higher in secondary market at approximately 25% of total marketing cost. Market profit was same in long distance and short distance primary market. In short distance retail market, the market profit of pomfrat was higher compared to large sized Hilsa and seabass. The study revealed that market margin as well as market profit both were relatively higher in consumer markets followed by primary and secondary markets where *Beparies* and *Aratdars* were involved.

Keyword: Fish landing center, Marketing, Marine fishes

STUDY ON MORPHOLOGICAL CHARACTERISTICS OF AVAILABLE GOBIIDAE FISHES AT CHATTOGRAM COAST, BANGLAESH

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A fundamental external morphological study has been conducted to reveal the existence of the available species number under Gobiidae family at Chattogram coast, Bangladesh. Three sampling stations with their transects decided to gather sample, covering coastal zone Chattogram districts (Patenga, Kattoli in Chattogram metropolitan city) including Cox's Bazar. A total 150 samples have been collected during one year (February, 2019- January, 2020) of sampling period excluding ban period (May-July). The study has been shown the evidence of presence of eight goby species in Chattogram, Bangladesh. Three species are locally known as Chiring (*Pseudapocryptes elongates*, *Apocryptes bato*, *Parapocryptes batoides*) and three species are regarded as Chewa (*Taenioides buchani*, *Odontamblyopus rubicundus*, *Trypauchen vagina*). Rest of one is known as Baila (*Glossogobius guiris*) and another is a colorful species of goby (*Boliophthalmas boddarti*) may have quality of being ornamental species in control environment. Difference regarding "Chewa" and "Chiring" have been confirmed by statistical analysis Independent T-test.

Table 1. Differentiation between "Chewa" and "Chiring"

Parameters of comparison	Species with significance ($p < 0.05$) and mean difference (MD) of T-test									
	<i>T. buchani</i>		<i>A. bato</i>		<i>T. vagina</i>		<i>O. rubicundus</i>		<i>P. batoides</i>	
	Sig	MD	Sig	MD	Sig	MD	Sig	MD	Sig	MD
TL	.000	7.68	0.674	-1.15	.006	-4.7	.000	-11.15	0.005	-5.82
SL	.000	7.07	0.392	-2.21	.004	-4.64	.002	-8.45	0.002	-6.06
HL	.000	2.56	0.017	-1.199	.000	-0.87	.000	-1.98	0.939	-.015
PrOL	.008	-1.99	0.016	0.17	0.327	0.07	.002	-0.25	0.076	0.143
PrPL	.000	2.56	0.013	-1.25	.000	-0.86	.000	-1.99	0.94	-0.149
PrVL	.000	2.561	0.016	-1.2	.000	-0.87	.000	-1.98	0.939	-0.149
PrDL	.003	1.34	0.549	0.519	.000	1.56	.000	-3.48	.002	-2.114
PrAL	.022	1.15	0.243	1.44	.074	0.85	.000	-4.15	.005	-2.584
BD	.000	2.19	0.026	0.3	0.159	-0.25	.000	0.805	0.086	0.342

Keywords: Gobiidae, Morphology, Chewa, Chiring

TEMPORAL AND SPATIAL VARIATION OF CRAFT AND GEAR USED IN CRAB FISHING IN THE COASTAL AREA OF BANGLADESH

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The present study was conducted to assess the temporal and spatial variation of craft and gear used in crab fishing in coastal region. The survey was conducted at the major coastal district (Khulna, Satkhira and Bagerhat) of the country during September to December 2021. Data were collected through survey of randomly selected 150 crab collectors through questionnaire interview, focus group discussion and cross-check interviews.

Among 150 crab collectors, 92% collectors were male. However, most female collectors belonged to the Khulna district. The highest percentage (30%) of collectors belonged to the year class of 31-40, whereas only 3% belonged to under 20 years and 5% above 60 years. The investigation showed that seasonal and regional variation in using different crab fishing gears. There are four types of gear such as long line, trap, hook and net were noticed during the survey period. Among them long line and trap were used throughout the year and rest were used in particular season. Though the long line is used widely throughout the coastal area, the highest percentage (75.5%) of users belonged to Khulna district. The crab trap is used by 16% to 33% of collectors. The spatial variation noticed significantly in case of using hook. There were almost 26% collectors solely using hook in Bagerhat district whereas 16% noticed in Khulna and no single crab collectors using only hook in

Satkhira district. Most of the collectors (65%-75%) in Khulna district prefer long line in the rainy season as well as winter season whereas 65% solely used in rainy season in Satkhira district. On the other hand, 36% prefer winter season in Bagerhat district. Most of the trap users of the study area prefer winter season. It is significantly noticed that the highest percentages (28%) of hook users in Bagerhat district using hook in the rainy season whereas 16% hardly used hook in the beginning of summer in Khulna district. The most common fishing craft, which was used in mangrove area for crab fishing locally known as 'Dingi'. The study also noticed that crab collectors prefer different gear in different geographical region of coastal area also the variation of using gear depend on the seasonal change. Therefore, the study will be very helpful for the further crab fishing management of coastal area of Bangladesh.

Keywords: Crab, Fishing gear, Craft, Bangladesh coast

**DOES NUTRIENT FLUX AND PRIMARY PRODUCTIVITY ADHERE WITH
THE ABUNDANCE OF JATKA IN THE MAJOR NURSERY GROUNDS OF
HILSA, *Tenualosa ilisha* ?**

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In order to estimate the nutrient flux and primary productivity, a study was conducted from January-December, 2021 in six hilsa sanctuaries of Bangladesh. Monthly data from 15 sampling locations of the sanctuaries (S1: Shatnol, Chandpur-Alexander, Laxmipur) (S2: Tarabunia, Shariatpur) (S3: Hizla to Mehendigonj, Barisal) (S4: Bheduria, Bhola to Char Rustom, Patuakhali) (S5: Char Ilisha to Char Pial, Bhola) (S6: Kalapara Upazila, Patuakhali) were collected and analyzed. The results revealed temporal and spatial variations of nutrient flux and primary productivity. The highest average concentration of nitrate and phosphate were found at S6 (Khepupara, 0.009 ± 0.006 mg/L) and at S1 (Padma Meghna Confluence, 0.0018 ± 0.005 mg/L) whereas; the lowest nitrate and phosphate concentrations were found at S6 (Mohipur, 0.002 ± 0.005 mg/L) and at S5 (Char Ilisha, 0.001 ± 0.003 mg/L), respectively. The highest average Gross Primary Productivity (GPP) and Net Primary Productivity (NPP) was also found at S1 (Katakhali, 1.035 ± 0.024 and 0.685 ± 0.022 gC/m³/day) and the lowest at S6 (Khepupara, 0.23 ± 0.007 and 0.13 ± 0.005 gC/m³/day). The highest Catch Per Unit Effort (CPUE) of jatka (415 nos./100m net/hour/boat) was found at Katakhali which established a coherence with nutrient flux and GPP. Chlorophyll-a concentrations ranged from 0.895 to 12.45 μ g/L. The highest and lowest concentration of Chlorophyll-a was found S6 (Baillatoli 12.45 ± 0.43 μ g/L and Khepupara 0.98 ± 0.96 μ g/L). The ranges of all studied parameters were found within the acceptable limits. Phytoplankton largely dominated over the zooplankton in all sampling locations. The highest number of taxa were identified at S1 (Katakhali: 20 taxa; phytoplankton-17 and zooplankton-3) and the lowest at S4 (Bheduria: 9 taxa; phytoplankton-6 and zooplankton-3). Among the phytoplankton, *Zygnematophyceae* (>65%) and *Ulotrichaceae* (>30%) were dominating whereas, among the zooplankton, *Bdelloidea* and *Branchiopoda* were dominating (>60%) groups. The outcomes of the study show that concentration of estimated limiting nutrients for primary producers (nitrate and phosphate) comply with the acceptable limit of the World Health Organization (WHO) for the river ecosystem.

Keywords: Nutrient flux, Primary productivity, *Tenualosa ilisha* nursery grounds

OCCURRENCE OF MICROPLASTICS IN DRIED FISH FROM THE BAY OF BENGAL, BANGLADESH COAST

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We examined microplastic (MP) in the two commercially important dried fish, Bombay duck (*Harpadon nehereus*) and ribbon fish (*Trichiurus lepturus*), collected from two sites of the coastal Bangladesh (Cox's Bazar and Kuakata). The number of MP found in dried Bombay duck and ribbon fish from Kuakata were significantly higher (41.33 g⁻¹ and 46.00 g⁻¹, respectively) than the MP present in samples collected from Cox's Bazar (28.54 g⁻¹ and 34.17 g⁻¹, respectively). Fibers were the most common type of MP identified in all samples (41-64%), followed by fragments (22-34%), microbeads (9-16%), films (3-4%), foams (1-4%), and pellets (0-2%). ATR-FTIR analysis revealed 3 different types of MP polymer - polyethylene (35-45%), polystyrene (20-30%) and polyamide (30-45%) in the dried fish samples. The study confirms the presence of high MP loads in dried fish from the Bay of Bengal Bangladesh coast, with high potential of trophic transfer of MP to the human body.

Keywords: Microplastic, Dried fish, *Harpadon nehereus*, *Trichiurus lepturus*

CAGE CULTURE OF ASIAN SEABASS (*Lates calcarifer*) IN BACKWATER OF, COX'S BAZAR COAST: A PILOT STUDY

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The Asian seabass (*Lates calcarife*), known locally as Vetki or Koral, is found in brackish and freshwater environments of Bangladesh coast, being able to tolerate a wide range of salinity. Extensive methods of seabass culture are practiced in tide-fed brackishwater *ghers* in coastal districts being completely dependent on the supply of natural seed. Recently, there has been increased interest in seabass for induced breeding and culture with tilapia in ponds. In view of mariculture potentialities, a pilot study on cage culture of seabass in Bakkhali channel of Bay of Bengal, Cox's Bazar was conducted to validate its feasibility. To develop cage culture of seabass, series of cages were constructed comprised of an outer and an inner base floating collar with a middle support collar. The collars will be made of high-density polyethylene (HDPE) pipes. The diameter and thickness of the HDPE pipes used for manufacturing the outer and inner collars will be 140 mm, 126 mm and 16 mm respectively. Natural seeds of 170 ± 6.53 g size were stocked with a density of 10 ± 2 Ind/m³. Different types of low valued chopped fish were used as live feed at the rate of 3-5% body weight. The preliminary results on growth i.e. final weight (936 ± 8.65 g), survival rate (85%), average daily growth rate (4.75 g/day), potential weight gain (451 g) and feed conversion ratio (1.8 ± 0.2) have demonstrated that cage culture of seabass is feasible. In addition, the water quality parameters were found suitable for cage culture of seabass throughout the experimental period. The main constraints was availability of same age seabass seed, although wild seed are not sustainable, yet much depends on location, abundance, costs associated with collection and the quality of seed collected.

Keywords: Cage farming, *Lates calcarife*, Cox's Bazar

OCCUPATIONAL SAFETY AND HEALTH ISSUES OF ARTISANAL HILSA FISHERS IN THE COASTAL AREA OF BANGLADESH

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Bangladesh operates one of the largest single-species hilsa shad (*Tenualosa ilisha*) fishery in the world, especially in the southern Patuakhali and Barguna coastal districts and adjacent Bay of Bengal. The hilsa shad is predominantly captured by artisanal gillnet and seine net that provides employments, income and livelihood to almost half million full-time fishers, who are regularly exposed to hazardous conditions in coastal environment. Therefore, a study was conducted based on survey and available secondary data to identify different occupational hazards and safety issues faced by hilsa fishermen and potential interventions for improvement of safety at sea are suggested. The study identified cyclonic storms in high seas as the major natural hazards due to which large numbers of fishermen perish at sea every year. Overloaded fishing vessels, slipping/accidentally being swept into the sea and entanglement while hauling nets are also amongst safety concerns identified. In recent year, 35 hilsa fishing boats were lost and 300 fishermen stranded at sea and at least 30 fishermen died from the study area. Furthermore, fishermen attacks by pirates who engage in robbery and sequestration of fishermen for ransom, often killing their victims if the ransom is not paid. To ensure the sustainable hilsa production, the government of Bangladesh enforces seasonal hilsa fishing bans in designated hilsa sanctuaries and a blanket ban on catching juvenile hilsa. During the banning period, due to lack of alternative income and governmental support (Vulnerable Group Feeding), fishermen illegally do fishing for their living. In consequence, thousands of fishermen are arrested by police every year and punished, with gross violations of human rights and social safety being commonplace. Adequate governmental subsidies, maintenance of security by coast guard and navy, GPS, life jackets, navigating instruments and social awareness creation by NGOs could be possible interventions to improve occupational safety and health of hilsa fishermen in Bangladesh.

Keywords: Safety at sea, Hilsa fishery, Bangladesh coast,

THAI PANGAS (*Pangasianodon hypophthalmus*) COULD BE SUITABLE SPECIES FOR COASTAL AQUACULTURE

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Salinity intrusion in the coastal freshwater rivers due to climate change and construction of the dam in the upstream rivers are alarming for aquaculture practices in the coastal region of Bangladesh. Hence, an experimental culture was conducted to know the effects of salinity on growth performance of Thai pangas (*Pangasianodon hypophthalmus*). The lethal concentration (LC₅₀) of salinity for Thai pangas was determined and then the fish were exposed to three salinity conditions (4, 8 and 12‰) and a control (0‰). The 96h LC₅₀ value was found to be 14.87‰. Salinity levels from freshwater to 8‰ showed optimal conditions with high survival rate and good growth performances of fish in terms of weight gain and specific growth rate (SGR). Interestingly, the lowest food conversion ratio (FCR) was found in 4‰ group. Frequencies of erythrocytic nuclear and cellular abnormalities were significantly increased with increasing salinities in the initial days of exposure. Overall, findings of the present study revealed that striped catfish might be suitable fish species for culture in the brackish water containing salinity up to 10‰.

Keywords: *Pangasianodon hypophthalmus*, Salinity tolerance, FCR

FISHERIES OF THE BAY OF BENGAL: CURRENT STATUS AND MANAGEMENT POLICY IMPLICATIONS IN BANGLADESH

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This study was dealt with the status of commercially important fishes in the Bay of Bengal using monthly fish samples through traditional fishing gears by the hired fishing boats and fishers from different fishing areas of Bangladesh coast. Sexual maturity was estimated based on gonadosomatic index and maximum length of 15 commercially important fishes using samples from October 2019 to December 2021. Data on fishers, declining of catches/production are going on through survey, Focus Group Discussion (FGD) and survey local fish market to identify the major causes for declining the fishes in the Bay of Bengal. During this study, growth pattern was determined from the calculation of length weight relationship. From these calculation, negative allometric growth were found for *L. calcarifer* ($b=2.78$), *P. heterolepis* ($b=2.83$), *M. cordyla* ($b=2.63$), *T. setirostris* ($b=2.54$), *P. macracanthus* ($b=2.81$) and *A. leiogaster* ($b=2.27$). Additionally, positive allometric growth were found for, *S. panijus* ($b=3.15$), *A. chacunda* ($b=3.16$), *H. nehereus* ($b=3.63$) and *C. dussumieri* ($b=3.32$). Isometric growth pattern found for *E. affinis* ($b=3.12$), *P. chinensis* ($b=3.03$), *P. paradiseus* ($b=3.11$), *S. taty* ($b=3.02$), and *I. megaloptera* ($b=2.94$). Size at first sexual maturity for different fishes obtained from the Bay of Bengal were 90.0 cm for *L. calcarifer*, 14.4 for *P. heterolepis*, 22.0 cm for *P. chinensis*, 33.0 cm for *E. affinis*, 15.0 cm for *S. taty*, 17.0 cm for *S. panijus*, 14.5 cm for *P. paradiseus*, 20.0 cm for *M. cordyla*, 17.5 cm for *H. nehereus*, 13.5 cm for *C. dussumieri*, 12.8 cm for *T. setirostris*, 17.8 cm for *A. chacunda*, 16.7 cm for *I. megaloptera*, 19.0 cm for *P. macracanthus*, and 16.5 cm for *A. leiogaster*. Most of the commercially important marine fishes spawn from April to September. May to July is peak spawning season of our studied 9 species. The estimated current exploitation rate (E ; 0.49) is higher than the predicted values of $E_{max} = 0.47$ for *Panna heterolepis* in the Bay of Bengal, Bangladesh. Exploitation rate for other fishes were obtained as 0.64 for *L. calcarifer*, 0.30 for *P. chinensis*, 0.44 for *E. affinis*, 0.27 for *S. taty*, 0.49 for *S. panijus*, 0.61 for *P. paradiseus*, 0.41 for *M. cordyla*, 0.50 for *H. nehereus*, 0.43 for *C. dussumieri*, 0.52 for *T. setirostris*, 0.42 for *A. chacunda*, 0.46 for *I. megaloptera*, 0.35 for *P. macracanthus*, and 0.65 for *A. leiogaster*. Recently indiscriminate fishing is increased through an introduced fishing gear namely China Duarinet. Finally, this study will contribute towards a scientific basis for stock assessment and sustainable management policy of marine fish species in the Bay of Bengal.

Keywords: Bay of Bengal Bangladesh, Length-weight relationship, Exploitation rate

STOCK ASSESSMENT OF MUD CRAB (*Scylla olivacea*) IN SUNDARBAN MANGROVE FOREST, BANGLADESH

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The world's largest single block mangrove forest, Sundarbans is playing central habitat for the mud crabs and at present, more than 60% of crab is captured from the Sundarbans only. Taking too many young and adult mud crabs can ultimately deplete the wild crab population. The information on the sex ratio, carapace width-weight connection, growth coefficient (K), recruitment, the mortality rate (Z, M, F), exploitation levels (E), etc. are required to build effective management of the resources. The present study was conducted to evaluate the above-mentioned necessary information to develop impactful protection and conservation policies for mud crab resource management in Bangladesh's territorial Sundarban mangrove ecosystem.

Six sampling stations were selected from the three sub-districts associated with Sundarbans, like Koyra (Khulna), Symnagor (Satkhira), and Mongla (Bagerhat). Year-round samples were taken using a long-line (100 baits/long-line) and baited traps (40 traps) from January 2021 to December 2021. A total of 1202 male and 824 female specimens were collected during the study period. The asymptotic carapace width (CW_{∞}), growth coefficient (K), total mortality (natural and fishing mortality), recruitment pattern, and exploitation rate were calculated by FiSAT-II (FAO-ICLARM Stock Assessment Tools; Sparre & Venema 1998). The female crabs were dominant over males with a sex ratio of 1:0.69. The catch per unit effort (CPUE) was 6.00 hr⁻¹ for long-line and 3.98 hr⁻¹ for baited traps respectively. The range of CPUE was 2.00-10.67 hr⁻¹ with the average higher value recorded in Koyra in both gears. The

carapace width-body weight (CW-BW) relationship indicated that the increment rate in the BW of the male crabs ($b=2.03$, $R^2=0.8$) was higher than that of females ($b=1.33$; $R^2=0.68$). The b value differed significantly ($p < 0.006$) from isometric growth ($b=3$) where males and females exhibited negative growth allometry. Estimated CW_{∞} for males and females were 125 mm and 112 mm along with K values 0.86yr⁻¹ and 0.47yr⁻¹, respectively. Total mortality (Z) was 1.75yr⁻¹ and 1.48yr⁻¹, natural mortality (M) was 1.102yr⁻¹ and 0.764yr⁻¹ and fishing mortality (F) was 0.648yr⁻¹ and 0.716yr⁻¹ for male and female, accordingly. The estimated exploitation rate (E) for males (0.37) was lower than the female (0.49) where the E for both sexes were not exceeded the maximum permissible limit ($E=0.50$).

Keywords: Sundarbans, Crab fishery, Exploitation rate

DIVERSITY OF FISHERIES IN SARAWAK, NORTHWEST BORNEO: PRESENT STATUS AND CONSERVATION ISSUES

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Information on fisheries resources in East Malaysia (non-peninsular Malaysia) is scarce and poorly known. The current review aims to compile a checklist of fisheries resources in the Northwest Borneo (currently Sarawak, Malaysia), South China Sea from available published literature, as well as to address the present status of the resources, and suggest future monitoring needs for selected critical species. The study also aims to determine several land use issues in Sarawak that are in flux, and responsible for habitat degradation. A total of 564 species belonging to 123 families and 32 orders were recorded from Sarawak waters. Freshwater fish species comprised 48.0% of the total, followed by marine (36.6%), marine-euryhaline (12.9%), and brackish water (2.5%) species. Of this, Cyprinidae was the most dominant group accounting for the greatest number of species (82 species), followed by Balitoridae (34 species), Bagridae (21 species) and Penaeidae (21 species). Available fisheries resources ought to be managed carefully as 48 species (9.0%) are currently vulnerable to extinction. Furthermore, the presence of 20 alien species in Sarawak water bodies also requires attention from the authorities, due to potential disruption of aquatic ecological balance. Changing land use issues in Sarawak such as forest degradation, agricultural expansion, peatland deforestation and conversion, logging, destruction of mangrove forests, and construction of hydroelectric power dams and flood mitigation channels, all pose significant challenges to fishery management in Sarawak. Our study documents the priority of fishery monitoring and conservation in Sarawak water bodies to ensure sustainable management of fisheries resources.

Keywords: Fisheries diversity, Critical species, Sarawak, Checklist, East Malaysia

AVAILABILITY OF MARINE FISHES AT THE FISH LANDING CENTER, COX'S BAZAR, BANGLADESH

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Study on species availability at the Cox's Bazar landing center will shed some light on the reference inventory of species abundance and composition of marine fishes of the maritime area of the Bay of Bengal. With the aim to investigate the availability and species abundance at the BFDC fish landing centre, Cox's Bazar total number of 54 species were recorded, of which 42 were marine fish species, 7 shellfish species and 5 mega-fauna species. The dominant order of recorded marine fish species were Perciformes (56%), Scombriformes (17%) and Clupeiformes (10%). According to IUCN red list, among the marine fish species 56% were of Least Concern (LC), 22% were Not Evaluated (NE), 10% were Near Threatened (NT), 10% were Data Deficient (DD) and only 2% Vulnerable (VU). The dominant order of shellfish was Portunidae (43%) with other species belonging to Penaidae, Loligonidae and Octopopidae. The IUCN red list status of shellfish were 71% Least Concern (LC) and 29% Not Evaluated (NE). As for mega-fauna, 60% sharks and 40% rays were recorded with an IUCN red list status of 40% Not Evaluated (NE), 40% Data Deficient and 20% vulnerable (VU). The recorded vulnerable species of marine fish and megafauna were Bigeye Tuna (*Thunnus obesus*), Smooth hammer-headed shark (*Sphyrna zygaena*) and Giant oceanic manta ray (*Mobula birostris*).

Keywords: Fish landing center, Marine fishes, Cox's Bazar

IMPACT OF 65-DAYS FISHING BAN ON PRODUCTIVITY AND CATCH IN THE NIJHUM DWIP AREA, BANGLADESH

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Nijhum Dwip is a well-known island under Hatiya Upazila, Noakhali where the local people are predominantly dependent on fisheries resources. The ecological impacts of the temporal fishing ban are proven to contribute substantially to future stock regeneration as seen by the 22-days fishing ban between the months of October-November to protect Hilsa spawning. The present study sheds light on catch data provided by the small-scale fishermen in Hatiya and to account for bias and the difference in effort used when collecting the data, a random sample of 29 measurements was taken from the ban period so as to match with data length taken in 2022 for the fishing period. The data was collected toward the end of the fishing seasons and 1 week prior to the end of the fishing ban. The results show that there is a larger abundance of fish <30cm caught during the ban period when compared with the fishing period (Fig. 1) which is corroborated by the results of the two-way ANOVA which results in weight being significantly dependent by the time of year ($p=3.99e^{-07}$) caught, meaning that the null is rejected. Site was shown to have no significance in the weight or length variables as confirmed by the chi-squared test for independence yielding a $p>0.05$. Fig. 1 gives us an understanding of the size of fish being caught with the average size during the ban being >500g and during the fishing period <300g. From these results, we conclude that the ban period is having a positive impact on the size of the stock and as such large individuals are carrying into the start of the fishing period. This, alongside our results representing the productivity of the two sites sampled, leads us to believe that the ban period is provided a significant buffer/renewal period for the stock and that impact of illegal fishing on the survival of the stock is very small, although further research needs to be conducted to fully assess the impact of unregulated fishing during the ban period.

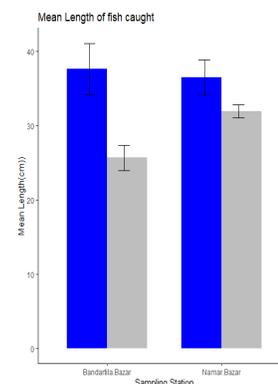


Fig. 1. Mean length and weight at each station sampled.

Keywords: Hilsa catch banning period, Nijhum Dwip, 65-days fishing ban

AVAILABILITY OF FISH SPECIES IN KHULNA FISH LANDING CENTER

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Fish landing center plays fundamental activity in quick and smooth disposal of fresh fish throughout the country. Khulna region of Bangladesh is recognized as a major fisheries zone and it is adjacent to the Sundarbans mangrove forest in the vicinity of the Bay of Bengal. Different varieties of fish species are available in the fish landing center of Khulna. A study was carried out to investigate the fish species availability in the fish landing center of Khulna. The survey was conducted for a period of 10 months from June 2021 to March 2022. The survey revealed that, Bay of Bengal and Sundarbans water ways are the main sources of accumulation of the fresh fishes in the landing centers of Khulna. For the availability index, in the present investigation, it was categorized (according to frequency of observations) as most available (8-10 times), available (5-7 times), less available (3-4 times) and very less available (1-2 times) of available fishes. A total of 102 fish species were documented which comprised of 29 orders and 61 families. Perciformes was the dominant order contributing 13.73% of the fish diversity. According to the availability category, it was noticed that 61, 12, 16 and 13 fishes were most available, available, less available and very less available, respectively. It was showed that higher diversity of fishes (55 species) in winter season than compare to other seasons. Among 102 fish species, four species were vulnerable and one species was critically endangered according to IUCN red list category. This investigation provides baseline information for the fishery managers. Various fish species are landed in fish landing center of Khulna district which also reflecting the present status of coastal and marine fish diversity in Bangladesh.

Keywords: Fish landing centers, Khulna, Sundabans, Seasonal availability

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

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

Keywords: Hilsa fishery, Transboundary fishery, Fishing ban

**SUSTAINABLE ARTIFICIAL BREEDING AND MARICULTURE OF
ASIAN SEABASS, *Lates calcarifer* IN BANGLADESH:
CONSTRAINTS AND OPPORTUNITIES**

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The Asian seabass (*Lates calcarifer*) is a commercially important and a popular food fish throughout Asia-Pacific. Being a common coastal fish of Bangladesh coast, successful initiative for adopting its breeding technologies could not till achieved. To evaluate the stakeholder's perception on constraints of seabass breeding, analysis with Kendal's W showed that the major constraints affecting the seabass breeding and aquaculture in Bangladesh are absence of skilled manpower, lack of marine hatchery facilities, lack of technical know-how on breeding biology and technological initiative. The identified potential opportunities are suitable natural habitat, culture potentialities, growth gate, high value and market demand etc. From this study it was revealed that the main constraint of hatchery production of seabass seed in Bangladesh could be overcome through strong integration of intensive research with development of brood rearing and hatchery facilities and availability of technology.

Keywords: *Lates calcarifer*, Breeding, Culture

**EXTRACTION, CHARACTERIZATION AND ANTIOXIDANT ACTIVITY
EVALUATION OF FUCOIDAN FROM SEAWEED *Sargassum* sp.
OF BANGLADESGH COAST**

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Fucoidan is a sulfated polysaccharide commonly found in the cell walls of brown seaweeds. In this study fucoidan was extracted by water extraction method, salt extraction method, and enzyme extraction method from *Sargassum* sp. of Saint Martin Island, Bangladesh coast. Fucoidan yield was obtained highest of 7% in enzyme extraction method, where 5.7% in water extraction method and 4.1% in salt extraction method. FT-IR analysis was carried out to determine the functional groups of extracted fucoidans which are in agreement with the previous finding. Compositional study of extracted fucoidans was done by carbohydrate, sulfate, and protein content analysis. ¹H NMR spectroscopy analysis was carried out for the structural study of extracted fucoidans. The antioxidant activities of the fucoidan fractions were further evaluated by DPPH radical scavenging assay, ABTS radical scavenging assay, Nitric Oxide (NO) radical scavenging assay, and Phosphomolybdenum assay. The correlation of sulfate content with antioxidant activities was positive.

Keywords: Seaweed, *Sargassum* sp., Fucoidan, Antioxidant

SEAWEED (*Ulva lactuca*) SEEDLING PRODUCTION THROUGH THE APPLICATION OF FRAGMENT REGENERATION METHOD

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Seaweeds are primarily macroscopic, multicellular, and photosynthetic marine algae and mostly grow in the rocky part of the littoral zone of the sea. About 142 seaweed species are available in Bangladesh coast, of which 23 species are considered economically important species. *Ulva lactuca*, also known as sea lettuce, belongs to the Chlorophyta (green seaweed) group and is considered an economically important species. *Ulva* species are getting popular as possible biofuel crops, with ethanol yield of around 10% on a dry biomass basis. Due to a lack of consistent supplies of biomass at the appropriate scales, commercial-scale biofuel generation from seaweed resources is still a long way off. This study aimed at the production of year-round *U. lactuca*'s seedlings by fragment regeneration method at indoor conditions. The laboratory test trials were conducted to assess the effectiveness of the production of seedlings by fragmented regeneration. From the fragment regeneration method, after 30 days from 0.258mg of fragmented *U. lactuca*, about 122gm of matured *U. lactuca* was found. Initially, the fresh thalli were chosen and then chopped into 2 ± 1 mm in size pieces and cultured in flat-bottomed round aerated flasks with 10 ml/L PES medium under white fluorescence tube lights at $30 \mu\text{mol photon m}^{-2} \text{s}^{-1}$ irradiance with 12:12 light and dark photoperiod at $20 \pm 1^\circ\text{C}$. The media was added every 3 days interval and the medium was changed every 10 days interval. After 55 to 60 days, matured thalli were harvested. These study results will initiate land-based seaweed production throughout the year in indoor conditions.

Keywords: Seaweed, *Ulva* sp., Tissue culture, Seaweed seedling

AN OVERVIEW OF PRESENT DIVERSITY, DISTRIBUTION AND CULTURE PRACTICES OF SEAWEED FLORA IN BANGLADESH

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Seaweed is a marine macroscopic alga and is considered the most fascinating and multifarious living resource of the ocean. Seaweeds are valuable sources of protein, fiber, fatty acids, vitamins, macro and trace elements, as well as important bioactive compounds. This study describes the present diversity, distribution, and culture practices of seaweed in Bangladesh. Seaweeds are mainly available in St. Martin's Island, Cox's Bazar, the Sundarban mangrove forests, and the southeastern part of Bangladesh. They are generally found from October to April on Cox's Bazar coast, but the highest abundance occurs from January to March. On the other hand, in mangrove forests, seaweeds are available throughout the year. About 142 seaweed species are available on our coast, of which 29 belong to green (Chlorophyta), 38 brown (Phaeophyta), and 75 red (Rhodophyta). The Chlorophyta group contributed 20.42%, the Phaeophyta group 26.76% and the Rhodophyta group 52.82% of all the species. Among them, 23 species are considered economically important species based on their availability, abundance, and use. Additionally, six species (*Hypnea musciformis*, *Ulva intestinalis*, *U. lactuca*, *Caularpa racemosa*, *Sargassum oligocystum*, and *Padina tetrastromatica*) are considered as commercially cultivable species. St. Martin Island had the highest biomass production (Kg/m²) of seaweed due to its favorable water quality parameters. Some species have also shown significant weight increases in the case of indoor culture methods in selected media. The industries based on seaweed have the potential to contribute to the socio-economic upliftment of the coastal inhabitants.

Keywords: Seaweeds, Diversity, Seasonal abundance

PARTICIPATORY SEAWEED AND GREEN MUSSEL FARMING IN COASTAL WATERS OF COX'S BAZAR FOR LIVELIHOOD SUPPORTS OF FISHING COMMUNITIES

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With the assistance of CVASU and Falcon International, ECOFISH II introduced green mussel and seaweed farming practice in the coastal waters in Cox's Bazar, Bangladesh engaging local coastal communities. Green mussel and seaweed farming system requires a small investment or cheaper infrastructure and no feed but can fetch lucrative profit within a short time period. In 2021, three farming sites were selected for green mussel and five farming sites were selected for seaweed. For green mussel farming Khurushkul, Chaufaldandi and Mudirchara sites were selected through site feasibility assessment. As of now, 102 selected Fisher's households are actively engaged in green mussel farming and overseeing the culture systems. Three types of culture systems were developed based on the raft system such as raft system with hanging rope and plastic basket, raft system with hanging rope and plastic basket + mussel socks and raft system with hanging rope and plastic basket + cages. Total 34 raft culture units were established at 3 farming sites among which 14 units were established at Khurushkul, 8 at Caufaldandi and 12 at Mudirchara site. Final harvesting of green mussel has not been done yet from any site as the green mussels still don't reach the harvesting size. Green mussels from khurushkul site were partiality harvested (about 20kg) in December and final harvesting will be done within March. The selected farming sites for seaweed were- Rasterpara-Khuruskul (Cox's Bazar Sadar), Nuniachara (protected beach between Sonadia and Moheshkhali), Mudirchara (Moheshkhali), Sonarpara (Ukhiya) and ShahparirDwip (Teknaf). Based on the suitability, Gracilaria (red seaweed) was considered for seaweed farming with 4 farming systems (Floating long-line, Off-bottom long-line, Floating net and Off-bottom net). Total 200 beneficiaries were selected and trained for seaweed farming. Beneficiaries began harvesting in five locations along the coast of Cox's Bazar in November. A total of 9350 kg (wet weight) of seaweed was collected till the end of December (7064 kg from Nuniarchara site, 1863 kg from Khurushkul site and 423 kg from Sonarpara site). Around the end of January, seaweed harvesting will take place in the Mudirchara and ShahporirDwip areas. The gathered raw biomass was either sold in local markets or processed for a higher price during the lean season. The total selling price of the harvested seaweed was 40,2240 taka. Seaweed can sequester carbon about 30% of the dry weight. Based on this assumption, it is calculated that only 3528 m² area sequester 402.2 kg atmospheric carbon in only 5 months. As a result, ECOFISH II will continue to strengthen green mussel and seaweed production and marketing systems, contributing to the country's blue development.

Keywords: Seaweed, Green mussel, Fishing community

MULTIVARIATE MORPHOMETRIC VARIABILITY OF *Pampus argenteus* IN THE BAY OF BENGAL, BANGLADESH

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A total of 47 fishes were analyzed based on 25 different morphometric variables of *Pampus argenteus*. The fishes were collected from BFDC fishery landing centre, Cox's Bazar during May-August 2020. The study showed that body length for both sexes was ranged from 14.1 to 36.1 cm and body weight ranges from 36 to 472 gm. Among 25 analyses, 23 of them showed a strong correlation where PoAL (post anal length) showed moderate and AL (anal length) showed a weak correlation with TL (total length) (length-length relationship) and a strong correlation between TL against BW (body weight) for all fishes (length-weight relationship). The coefficient of correlation of TL against other morphometric characters ranged from 0.1729 to 0.9636 (length-length relationship) and 0.87 to 0.90 for TL against BW (length-weight relationship). The regression coefficient 'b' ranged from -0.2808 to 1.6855 for length-length and from 0.1197 to 0.1397 for the length-weight relationship. Five parameters showed positive allometric growth ($b > 1$) while the rest of the parameters showed negative ($b < 1$) allometric growth (length-weight relationship) and negative allometric growth for TL against BW (length-weight relationship). Relationship of TL with other length-length relationships showed the slowest growth in PC (pectoral length) (-0.0282) and the fastest growth in DL (dorsal length) (1.6855). In the length-weight relationship, the slowest growth (0.1197) were shown between TL and BW of female fishes and the fastest growth were shown in male fishes (0.1379).

Keywords: *Pampus argenteus*, Length-weight relationship, Fish landing center

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

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

Keywords: Pesticides, Heavy metals, Dried fish

ASSESSMENT OF CONTAMINANTS AT DIFFERENT STAGES OF FISH HANDLING AND PRESERVATION IN FISH LANDING CENTERS OF BANGLADESH

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To assess the hygienic condition, water samples from source water and fishes were collected from five landing centers of the country i.e., Cox's Bazar, Chattogram, Rangamati, Chandpur and Patuakhali from pre-monsoon to winter seasons. The study revealed that Total Dissolved Solid (TDS) in source water was much higher in pre-monsoon than other seasons. The overall bacterial load was higher in Chattogram (1.03×10^6 cfu/ml) and Cox's Bazar (7.6×10^5 cfu/ml) than Patuakhali, Chandpur and Rangamati fish landing centers. Total Coliform (TC) count in the water used for washing exceeded the standard limit during monsoon and winter. The ANOVA detected significant variation ($p < 0.05$) in the median values for the abundance of pathogenic bacteria *Shigella* between sampling sites. The fecal coliform was higher in numbers in ice and then wash water in case of all landing centers. Fish samples (Ribbon fish, *Trichiurus haumela* and Bombay duck, *Harpodon nehereus*) from the Cox's Bazar fish landing sites were examined for microbiological quality. Total Count (TC) in the sampled fishes exceeded the standard limit during monsoon and pre-monsoon. In addition, heavy metal contamination in ice and source waters of landing centers was also studied. Among all heavy metals only iron (Fe) and zinc (Zn) were observed in ice and source waters and their levels were acceptable. On the other hand, in the sampled fishes only copper (Cu), iron (Fe), and zinc (Zn) were observed. Chandpur landing centers showed comparatively higher levels of heavy metals in sampled fishes like *Tenualosa ilisha*, *Labeo calbasu*, *Gudusia chapra*, *Sperata aor*, however, the level was within the acceptable limit. Bioconcentration Factors (BCF) and Metal Pollution Index (MPI) showed that *Tenualosa ilish* accumulates higher level of heavy metals than other fishes. Target Hazard Quotient (THQ) and Hazard Index (HI) showed the absence of non-carcinogenic health risks (i.e. < 1) for the sampled species. Periodic monitoring of microbial status and trace metals in the fish landing centers is a key factor for establishing a hygienic environment for the safe consumption of fishes from the fish landing centers.

Keywords: Fish landing centers, Contaminants, Total bacterial count, Heavy metals

SENSORY AND PHYSICO-CHEMICAL QUALITY ANALYSIS OF TRADITIONAL, IMPROVED AND MARKET DRIED *Puntius sophore*

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The study was performed to evaluate the sensory and physico-chemical quality analysis of traditional, improved and marketed dried punti (*Puntius sophore*). In order to achieve the objective, fresh punti fishes were collected and dried using traditional and improved methods (properly washed and dressed fish mixed with 4-5% salt and turmeric powder 2-3%). Dry fish samples collected from local markets. The sensory evaluation of the improved dried products showed superior quality than traditional and marketed dried punti fish respectively. The results showed that improved dried punti were rehydrated more rapidly than traditional and market dried punti. The moisture content of the dried punti were varied from $22.5 \pm 0.8\%$ (marketed dried punti), to $14.2 \pm 0.45\%$ (improved dried punti). Moreover, the highest crude protein, crude fat and ash value were found in the improved dried fish as compared with traditional and market dried fish. Dried fish collected from local markets showed positive result in formalin test and also found insect infestation after 1-month of storage whereas traditional and improved dried fish were found negative in formalin test and insect infestation was not seen after 4-month storage. The results revealed that the dried fish produced by improved drying methods provided the best product in terms of sensory and physico-chemical qualities as well as food safety aspect.

Keywords: *Puntius sophore*, Sensory evaluation, Proximate composition

DEVELOPMENT AND QUALITY EVALUATION OF FISH CRACKERS UNDER MODIFIED ATMOSPHERE PACKAGING

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Fish crackers are popular snack foods in many Southeast Asian countries which is made by forming dough from a mixture of starch, comminuted fish, salt, sugar, monosodium glutamate, and water. A number of previous studies have attempted to improve the quality and acceptability of fish cracker. We have developed fish crackers by optimizing the different processing parameters with freshwater and marine fishes. The fish crackers were made by mixing 100 g fish flesh (Tilapia or Tuna), 90 g tapioca starch, 6 g sugar, 7 g salt, 15 g ice, and 1 g sodium bicarbonate and other ingredients as required. The dough was shaped into cylindrical and steamed followed by chilling in refrigerator overnight. Then it was cut into 2 mm thickness and put into oven of 50°C for 10 to 12 hours until the moisture content reading was $10\% \pm 2\%$ and fried in vegetable oil at 180-200°C.

Then the quality and shelf-life of ready-to-eat (RTE) tilapia and tuna crackers were evaluated by biochemical and microbiological analysis (pH, TVBN, FFA, TBARS and APC) under air pack (control), modified atmosphere packaging with 100% N₂(MAP-1) and 50% CO₂& 50% N₂(MAP-2) in multilayered (PE/PA/PE) pouch with 100 µm density in a month interval during storage at room temperature.

In both crackers, comparatively higher pH values were observed in MAP samples than control during the storage period. There were no significant ($p > 0.05$) differences in TVBN, FFA and TBARS values among three packaging conditions during the storage period. The pH, TVB-N, FFA and TBARS values of the samples under all packaging conditions were within the acceptable limit during the storage period. On the other hand, significantly ($p < 0.05$) lower APC values were observed on 5th and 6th month in Tilapia crackers and 5th, 6th and 7th month in Tuna crackers under MAP conditions compared to control sample during the storage period. In the current study, APCs exceeded the 6 log CFU/g which is considered as the upper acceptable limit for RTE fishery products on approximately 4th month in both crackers for air pack sample and 5th month in tilapia crackers and 6th month in tuna crackers for both MAP-1 & MAP-2 sample. Therefore, the MAP is suitable packaging compared to air pack to increase the shelf-life, which can make the fish crackers a convenient and nutritious snack items in Bangladesh.



Plate: Linear expansion of tilapia crackers during frying

Keywords: Fish crackers, Modified atmospheric packing, Quality control

DEVELOPMENT OF READY-TO-EAT SASHIMI MEAT FROM CUTTLE FISH (*Sepia officinalis*)

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The cuttlefish belong to the family Sepiidae. It has significant commercial export value for the artisanal and industrial fisheries. Cuttlefish are primarily bottom dwellers in a range of habitats, including rocky, sandy, and muddy substrates, seagrass, seaweed, and coral reefs. The increase in the human population has led to a greater demand for fishery products. Cephalopods have high commercial value, particularly in the Asian and Mediterranean markets. Cuttlefish is a good source of protein, minerals, vitamins, and essential lipids. Generally, cuttlefish are consumed in various forms, i.e., eaten raw as sashimi or sushi, cooked as tempura, deep-fried or boiled. The objective of this study was to produce value-added raw-ready-to-eat/cook sashimi meat from local cuttle fish, *Sepia officinalis*.

The process flow for the frozen cuttlefish bulk was landing on deck, washing, grading, freezing in a blast freezer in sac, and storage in the cold room inside the vessel. For this study, the whole frozen block of cuttlefish in gunny sac was purchased from the fish trawlers, defrosted, and processed while complying all good manufacturing practices. Prepared sashimi meat, after weighing and panning, was frozen in a blast freezer for 4 hours, the block was packaged and then stored in a refrigerated container for export. A 20,354 kg of frozen whole cuttlefish of sizes ranged from 50- 300 g, produced 10,304.58 kg of final *shashimi* meat. The head part of the final product was 4595.5 kg, and the meat was 5709.08 kg. The overall yield was 50.62%, with the meat accounted for 55.40% and the head accounted for 44.60%. Among the by products, offal defrosted wastage was 1.5 %, other fish mixed with block was 0.5%, trim meat wastewas 4%, egg waste was 3%, drop waste was 4%, under sized cuttle fish (10 to 20 g) was 4.5%, and other wastes were 36%. Daily production was 500 kg. The final product packet size was either 1 kg or 2 kg. Eightcategories of finished products were made as per the weight and buyer's requirements. Organoleptic and microbiological tests were done in the FIQC laboratory of the DoF. *Salmonella* was nil, *Vibrio* was absent, *E. coli/F.coli* was less than 0.30/g, and the SPC was 6.6×10^4 . The product was processed and exported under the approved HACCP program. After adding value to the frozen cuttlefish, the export price was set to USD 7.16/kg, which was 178% higher than that of the whole frozen cuttlefish.

Keywords: Cuttlefish, Value addition, *Sashimi* meat, Ready-to-eat, HACCP

ENHANCEMENT OF QUALITY AND SHELF LIFE OF FROZEN NILE TILAPIA *Oreochromis niloticus* FILLETS USING WATER LILY EXTRACTS

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To prevent the chemical deterioration and delay the microbial changes in fish, various preservation methods are used. The water lily (*Nymphaea nouchali*), locally known as “*Shapla*”, contains many bioactive compounds as they are able to produce a great variety of secondary metabolites with potential antioxidant and antimicrobial activities. Therefore, this study was conducted to investigate the quality and shelf-life of frozen Nile tilapia (*Oreochromis niloticus*) fillets using water lily extracts. Fish fillets were obtained from fresh Nile tilapia using sharp knives and chopping board. The fillets were divided into five treatment groups and treated with sterilized distilled water (control); water extract solution (0E); 50% ethanolic extract solution (50E); 75% ethanolic extract solution (75E); and 100% ethanolic extract solution (100E). The untreated and treated fillets were kept in the extract solutions for ten minutes and stored at $-18 \pm 1^\circ\text{C}$ for 14 weeks. The effect of the water lily extracts on chemical (proximate composition, pH, thiobarbituric acid reactive substances (TBARS), total volatile base nitrogen (TVB-N)), microbiological and sensory properties of Nile tilapia was investigated periodically.

Results of this study revealed that no significant ($p > 0.05$) variation was found in crude protein, crude lipid and ash contents among the treated and untreated samples on dry matter basis. The initial pH value of Nile tilapia fillet was 6.36. The pH value reduced significantly within 2 weeks and then increased gradually during the storage period. However, increment of pH values was comparatively lower in treated fillets than that of control. Similarly, TBARS and TVB-N values were comparatively higher in untreated fillet than treated fillet. During the storage period, aerobic plate count of ethanolic/hydro-ethanolic extract treated fillets were found comparatively lower than that of control. The fish fillets treated with ethanolic extracts had acceptable sensory attributes up to 12th week, while control fillets were unacceptable after the 6th week of storage. Results of this study indicate that ethanolic extract (100E) of water lily coating extended the shelf-life and quality of Nile tilapia fillets during frozen storage.

Keywords: Tilapia fillets, Freezing, Shelf life

**DEVELOPMENT OF FISH FLESH POWDER AND POWDER BASED COOKIES
AND SNACKS (Biscuit, Chanachur and Chips) FROM LESS
COSTLY FISHES (Pangas, Tilapia and Silver Carps)**

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Pangas, silver carp and tilapia are commonly available and low-priced fish. Considering this, a method has been developed to increase the amount of protein and decrease fat content incorporating fish muscle protein as powder form with wheat flour in three popular food items of Bangladesh i.e., chanachur, biscuits and chips. Generally, the cookies and snacks available in the market are made of flour, leavener, salt, sugar, butter, egg, oil and some other extra added flavor in some special case. White, processed flour and more starch in the regular diet increase blood sugar, which in turn put unnecessary stress on the liver. Fish consumption helps to reduce coronary heart disease incidence and mortality due to having beneficial effects omega-3 PUFA, EPA & DHA. Increased protein intake also balances blood sugar and insulin, reducing cravings and detoxing the liver. Therefore, fish protein-based food is relatively nutritious and safer than carbohydrates for human body. A method was developed for producing powder from fish having protein content ranged between 80-90% (dry basis). Then, the value-added fish cookies and snacks (viz. biscuit, chanachur & chips) were made from fish powder containing 30-40% protein. Major portion of fats were removed from fish flesh which protects the products from fat oxidation. Bacterial population of the developed products were found to be ranged between 1.3×10^3 to 2.4×10^3 CFU/gm. Methods for producing fish powders from fish flesh having protein content ranged between 80-90% (dry basis) and three value added fish products namely, fish biscuit, fish chanachur and fish chips were developed using fish powder and flour as main ingredients along with mixing of other ingredients like sugar, milk powder, salt, baking powder, spices, oil, butter having protein content 20-50%. Protein content can be fixed by modifying the amount of different ingredients as per necessity. Major portion of fats were removed from fish flesh which protects the products from fat oxidation.

Keywords: Fish flesh powder, Fish biscuits, Value-added fish products

QUALITY ANALYSIS OF DRIED TILAPIA (*Oreochromis niloticus*) USING DIFFERENT DRYERS

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The aim of this experiment was to study the effect of different dryers on the drying and quality characteristics of fresh tilapia fish. Experimental drying was obtained by using three dryers named ring tunnel dryer, smoking kiln and hot air oven. Some quality indicators such as rehydration and organoleptic properties were investigated. The organoleptic tests conducted for ring tunnel-dried, smoke-dried and oven-dried samples of *Oreochromis niloticus* showed preferences for ring tunnel-dried samples in comparison with smoke-dried and oven dried ones, in terms of odor, color, texture and general appearance. However, the texture of smoke dried *Oreochromis niloticus* was more preferred to that of the ring tunnel dried and oven dried products. The scores for odor, color, texture and general appearance of the ring tunnel dried product were 7.33, 7.83, 7 and 7.5, respectively. While the same for the odor, color, texture and general appearance of oven-dried products were 6.58, 7, 6.66 and 6.33, respectively. The scores for odor, color, texture and general appearance of smoke-dried products were 6.75, 7, 7.25 and 6.75, respectively (9-point hedonic scale). The results showed that fish dried in ring tunnel held more water and rehydrated more faster than fish dried in smoking kiln and hot air oven. It is therefore understood that dried fish produced by ring tunnel dryer generated the best product in terms of rehydration and organoleptic aspects.

Keywords: Quality, Ring tunnel dryer, Smoking kiln

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

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The research was intended to investigate the microbiological state of Catla (*Catla catla*) at different marketing channel in Sylhet Sadar of Bangladesh. Selected fish samples were taken from different marketing channels during January'21 to May'21. The bacteriological parameters analyzed were Standard Plate Count (SPC), Total Coliform Count (TCC), and the prevalence of *Escherichia coli*, *Salmonella* spp. and *Vibrio* spp. Among all samples highest microbial load was found in *C. catla* in retailing point (7.46 ± 0.01) followed by aratdar (7.04 ± 0.33), wholesaler (6.56 ± 0.33) and producer (6 ± 0.01) in May. On the other hand, lowest bacterial load followed the trend, i.e. the sample from producer contained the lowest bacterial load (5.65 ± 0.03), as the same with wholesaler (6.06 ± 0.09), aratdar (6.25 ± 0.05) and retailer (6.4 ± 0.04) in January. But the load increased slowly in the rest of the months chronologically. In the month of May, there were significant difference ($p < 0.05$) only between producer and retailer. TCC of producer sample ranged from 26 ± 2.52 to 33.3 ± 2.19 , that of wholesaler sample ranged from 36.3 ± 0.882 to 43 ± 0 , of aratdar sample ranged from 57 ± 7 to 81 ± 6 and in retailer sample ranged from 87 ± 6 to 105 ± 15 . Samples from all four sources showed highest value in the month of May, while retailer sample failed to comply with ICMSF (1986) standards. In this case, substantial difference ($p < 0.05$) was found between producer and retailer in the studied samples. The highest value of isolated bacteria *E. coli*, *Vibrio* spp. and *Salmonella* spp. was observed in retailer samples as 86.66%, 93.33% and 80.00% respectively, whereas, the lower rate was found as 26.66%, 13.33% and 20.00% in producer samples. Besides, chi square test ($p < 0.05$) reveals that presence of pathogenic bacteria indicated disturbances in post-harvest management of *C. catla*, like poor handling, long distance travel, evisceration along with culture system problem.

Keywords: *Catla catla*, Standard plate count, Coliform count, Marketing channel, Sylhet

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

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

Keywords: Fish cutlet, Silver carp, Sensory evaluation

INFORMATION ON CULTURE PRACTICE INFLUENCE THE CONSUMERS' ATTITUDE TOWARDS FARMED TILAPIA

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The current research was conducted to examine the effect of information about aquaculture practices on the consumers' preference towards cultured tilapia, *Oreochromis niloticus*. Two of the most widely applied theoretical models e.g., assimilation and contrast theory for assessing customer response to external information were employed in this study. To collect data, an experimental approach was adopted in which each respondent were asked to rate their likings and intention to purchase farmed tilapia in three different conditions: i.e. blind (consumers tasted and evaluated the samples without information); ii. expected (without tasting samples, consumers evaluated the information that "tilapia were obtained from a farm that followed Good Aquaculture Practices (GAP) and did not use any harmful antibiotics or chemicals in the production"); and iii. informed (tasted and evaluated the samples with information). The experiment was carried out on 120 consumers including faculty, staff, and graduate and undergraduate students in the Faculty of Fisheries of Sylhet Agricultural University. Participants scored their preference on a 9-point hedonic scale, ranging from 1 (dislike extremely) to 9 (like extremely), and ranked their desire to buy on a 5-point scale, ranging from 1 (definitely would not buy) to 5 (definitely would buy). The results showed that farmed tilapia received a higher score overall in all three settings, implying good sensory quality of the fish. Informed liking was differed significantly from the perceived preference expressed in blind condition (7.54 vs 6.64 respectively, $p < 0.05$), indicating an assimilation of the given information. Moreover, there was no significant difference between informed and expected scores (7.54 vs 7.78 respectively, $p > 0.05$), suggesting a complete assimilation of the message. Similarly, ratings for buying intention were increased significantly from 2.51 at blind condition to 4.52 at expected condition ($p < 0.05$), confirming that information was assimilated. However, assimilation was incomplete in case of purchase intention as there was a significant difference between average expected (4.52) and informed (3.95) score, hinting that other factor might also be important in making a purchase decision. The survey investigations inferred that presenting information about how tilapia is cultured at the farm could be a promising strategy to boost customer acceptability of farmed tilapia.

Keywords: Aquaculture practice, Tilapia, Customer response

ASSESSMENT OF *Salmonella* AND *Escherichia coli* CONTAMINATION IN DIFFERENT RIVERINE CAT FISH AT NORTHERN PART OF BANGLADESH

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A variety of fishes consumed regularly are prone to pathogenic spoilage especially by different microbes. It is important to find out microbiological quality of fish that we consume regularly. This study was carried out to examine microbiological quality assessment of three cat fish *viz.* *Speratas eenghala*, *Ompok pabda*, and *Clarias batrachus*. Current research was conducted to assess the incidence of *Salmonella* and *Escherichia coli* contamination in three selected fish species of five rivers (Dhepa, Atrai, Punorvoba, Kakra, and Ghorveshori) of Dinajpur district. Collected samples were contaminated with *Salmonella* and *Escherichia coli* bacteria, highest percentage of *Salmonella* and *E. coli* were found at 39.40% in *Ompok pabda* and 63.84% in *Clarias batrachus*, respectively. Again, lowest percentage of *Salmonella* and *E. coli* were found at 26.50% and 41.07% in *Sperata seenghala*, respectively. In all samples, the presence of *E. coli* was greater than *Salmonella*. The present condition of river in Dinajpur district is not so good because of lacking water at all season. The rivers conditions were not satisfactory in terms of flood, sewage pollution, feed and waste disposal, presence of excessive fertilizer, lack of consciousness of fishermen about personal hygiene and sanitation. The presence of *Salmonella* and *E. coli* in fishes, water and scum samples are important for assessing and controlling the risk associated human health. So, microbial evaluation of pathogenic bacteria is important to ensure the safety and quality of fish and fishery products.

Keywords: Catfish, *Salmonella*, *Escherichia coli*, Contamination

COMPARATIVE ANALYSIS OF HEAVY METAL DISTRIBUTION AND PROBABLE HEALTH RISK BETWEEN SELECTED COMMERCIALY IMPORTANT WILD CAPTURED AND CULTURED FISHES FROM MYMENSINGH REGION

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The present study was conducted to know the distributions of some heavy metals and health risk assessment in cultured and wild fish spp. from Mymensingh region. The seasonal variation of water quality parameters were also determined as pre-monsoon, monsoon, and post-monsoon seasons from culture pond and river in and around Mymensingh. The water quality parameters recorded as temperature (19.9 ± 0.36 to 31.8 ± 0.22)°C, pH (7.49 ± 0.21 to 8.19 ± 0.25), DO (2.9 ± 0.22 to 5.27 ± 0.40 mg/l), ammonia (0.04 ± 0.03 to 0.086 ± 0.04 mg/l), nitrite (0.0525 ± 0.02 to 0.104 ± 0.06 mg/l), nitrate (21.2 ± 2.56 to 31.7 ± 4.95 mg/l), sulphate (40.25 ± 9.07 to 66.4 ± 11.5 mg/l), phosphate (2.1 ± 0.22 to 3.06 ± 1.44 mg/l) and total alkalinity (115 ± 12.9 to 135 ± 12.9 mg/l), where all the water parameters were found to be suitable for fish production except DO and PO₄ in the some samples. The mean concentration of heavy metals in the muscle of cultured fishes were followed the sequence as Zn (6.02) > Cu (1.73) (mg/kg, wet weight) and Cd, Cr, and Pb were absent in the sampled fishes of *Labeo rohita*, *Anabas testudineus*, *Heteropneustes fossilis* and freshwater prawn, *Macrobrachium rosenbergii* under study. The heavy metals values were increased after cooking as Zn (8.33) > Cu (1.56) (mg/kg, wet weight). On the other hand, the mean concentration of HM in the muscle of wild fishes were followed the sequence as Zn (7.46) > Cu (2.80) (mg/kg, wet weight) and after cooking, the metal values decreased as Zn (7.17) > Cu (2.63) (mg/kg, wet weight). The study showed that the wild fishes accumulated higher concentration of heavy metals than the cultured fishes and after cooking metals were increased in cultured fishes but decreased in wild fishes. The changed values of heavy metals were due to cooking process. Among the sampled fishes, wild prawn was more contaminated with Cu and Zn. Estimated daily intake (EDI), Target hazard quotient (THQ), and Hazard index (HI) studied fish species for human consumption were found to be greater in adult female than male which indicate female were more vulnerable to non-carcinogenic than male. The heavy metals in the studied fishes were within safety limit recommended by FAO/WHO, and THQ and HI levels found smaller than 1, means that there was no significant health risks through consumption of wild and cultured fishes from Mymensingh region.

Keywords: Captured fish, Cultured fish, Heavy metals

**TRANSFORMATION IN MAJOR PROTEIN SOURCE FROM FISH TO MEAT:
A PRELIMINARY ASSESSMENT OF PER CAPITA ANIMAL PROTEIN
INTAKE IN BANGLADESH**

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Contribution of animal protein is integral to the food security a population. Fisheries commodities are commonly stated to be the major contributor to per capita animal protein (PCAP) consumption in Bangladesh over the last few years. However, rapid increase in livestock production, particularly, the poultry could amend such overwhelming dominance of fisheries sector's contribution to PCAP. The likely shift of relative contribution of animal protein sources has multidimensional implications, including economy, public health, and policies. Therefore, this study aimed to estimate the contribution of major animal protein sources (i.e., fish, meat, milk and egg) to PCAP intake in Bangladesh. The net animal protein intake was estimated by adjusting the national fish and livestock production data from 2007-2008 to 2018-2019 using suitable conversion factors used by the FAO. The estimated gross consumption of each commodity is consistent with the estimates in other national level reports. However, our results demonstrated that the relative contribution of meat to the PCAP intake surpassed 50%, while the relative contribution of fisheries gradually dropped to well below 50%, hence, putting the generally reported contribution by the fisheries sources (60%) in question. Our results suggested that despite a monotonous yet remarkable growth in fish production, the swap in major animal protein source was due to a steeper growth in meat production, particularly of chicken and duck. Given the multiple nutritional benefits, such as n-3 polyunsaturated fatty acids conferred from fish consumption coupled with plausible epidemiological evidence of meat consumption in cancer and various chronic diseases, a shift from fish based dietary habit to a meat based one as indicated in this study, will have multidimensional public health consequences. Although this study suffers from the unavailability of detailed data on livestock commodities and their consumption patterns, it is a preliminary, but a systematic estimate of PCAP intake in Bangladesh. Thus, this study compels for a more comprehensive study on animal protein intakes by Bangladeshi population at various spatial and temporal scales.

Keywords: Per Capita Protein Intake, Fish protein

SOCIO-ECONOMIC IMPACTS OF A HILSA FISH SANCTUARY IN BANGLADESH

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To conserve the national fish hilsa (*Tenualosa ilisha*) and increase its production, the government of Bangladesh has established the 6th hilsa sanctuary (82 km long and covers an area of 318 km²) in Hizla and Mehendiganj Upazila of Barisal District. Any type of fishing activity is restricted in the sanctuary from March to April. Around 36,000 registered fishers and thousands of unregistered fishers are dependent on the defined sanctuary area who cannot catch fish in the ban period. But the impact of this conservation action on the dependent fishing communities is still unassessed. So, this study aimed to assess the socio-economic impact of the conservation actions on the dependent fishing communities through household questionnaire surveys (n = 213), focus group discussions and key informant interviews.

The results of this study unfortunately reveal negative socio-economic consequences after the establishment of the sanctuary. According to the perception of 67% of fishers, fish production is low after the establishment of the sanctuary. The production of hilsa, both the big size and medium size hilsa after the sanctuary establishment is also low. However, the production of small size hilsa (Jatka) is high. Results showed that the opportunity to take three meals a day, household health facility, children's education and household income are bad during the two months (March-April) fishing ban period. The opportunity for alternative livelihood activities is very bad during the ban period. The study has also found that the mean fish consumption decreased to 0.74 kg/week during the fishing ban period than 3.36 kg/week outside the fishing ban period. Fisher's income has decreased over the years since the ban was implemented. Around 67% of fishers reported that there are flaws in the design of the sanctuary. The stakeholders claimed that they were not involved in the planning and implementation activities of the conservation action. There are compensation schemes for the fishing communities during the ban but this is not that effective. Besides, only the registered fishers are provided with this compensation scheme which left a large portion of unregistered fishers suffering as the opportunity for alternative livelihood options is limited. Fishers also reported that they did not get the compensation on time and mostly they received a fraction of the full compensation. Thus, this conservation action posed a largely negative impact on the socio-economic conditions of the dependent fishing communities. The government should consider revising the policy about this sanctuary to increase its effectiveness.

Keywords: Hilsa fisheries, Sanctuary, Socio-economics

MARKET SYSTEM DEVELOPMENT OF MOLA BROODSTOCK DISSEMINATE TO FARMERS FOR STOCKING IN PONDS AND OTHER WATERBODIES

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Stocking broodstock of mola in ponds and semi-closed open waters in polyculture useful to get higher production of mola and other fish. The production system develops is nutrition sensitive, ensuring regular supply of mola along with other small indigenous species of fish rich with vitamins and minerals. However, the culture of mola is constraining due to lack of seed or broodstock of mola in the existing fish seed marketing system.

A participatory research is implementing under BMGF funded IDEA project of WorldFish. The purpose of the research is to develop mola broodstock marketing system involving the major actors. Total 30 farmers' culture mola in ponds identified as mola broodstock source, 27 fish seed traders involve for collection and trading of mola and 30 farmers out of several farmers stock mola broodstock buying from traders. All the actors selected were from nine locations in six Upazila; Nilphamari Sadar, Shadullapur, Kaligonj, Gangachara, Kaunia and Pirgacha under four districts in NW Bangladesh. The research started in January 2022 and will end on December 2022. The baseline information of actors collected and a day-long participatory training was conducted in the form of theoretical sessions with practical demonstrations held at one of the locations with large number of farmers' culture mola in polyculture with success for long years.

The primary results showed that farmers' in one of the locations 'Dhulia Beel' in Nilphamari Sadar can use as important source of mola broodstock. The results showed that there more than 30 farmers in this place culture mola. It expect that the 5 fish seed traders selected in this area buy more than 1000kg of mola broodstock to sell of 200-250 farmers stock broodstock of mola covering total pond area 4000 decimal. Mola broodstock stock in pond in polyculture at 200g/decimal around 40-50 mola broodstock per decimal. Number of farmers identified as source of mola broodstock are less around 10 farmers with potential to get supply of 300-400kg mola broodstock. Most of the fish seed traders informed that there are grow-out farmers in their areas interested to buy broodstock of mola to culture in their ponds. Unlike other fish seed, the traders have limited experience about collection and trading of live mola broodstock. They build up their confidence about transportation of mola as live, observed and build up their understanding about the systems of culture of mola with other fish in ponds (closed and open ponds) with success. The outcomes help to promote mola with other commonly cultured fish by large number of farmers.

Keywords: Mola, Broodstock, Marketing system

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

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The study intended to sketch out the existing risks and predicted consequences of climate change on dried fish output and the associated fishermen and dry fish laborers, based on fieldwork in four fish drying areas in Dublar Island. Individual interviews, focus group discussions, oral history and key informant interviews were used to obtain empirical findings. Time-series data from storms and sea-borne depressions in the Bay of Bengal were also investigated to support the empirical findings. The data was analyzed using a theoretical structure called Sustainable Livelihood Approaches (SLA). Secondary information assessment for climate change-related occurrences and regional findings indicated that the biophysical parameters of the Bay of Bengal are likely to deteriorate in the future, possibly resulting in more frequent catastrophic occurrences and threatening the livelihoods of the dried fish processing community in Dublar Island. The fishermen reported continuous climate-related threats because they live on the coast, are subjected to harsh weather events, and their profession involves risky sea fishing and fish drying. Fishers stated that they are frequently forced to revert back to the coast due to unsafe weather situations caused by cyclones and regular tropical depressions, which can decrease dry fish yield and cause economic losses or even fatalities. Such occurrences have a deleterious impact on the livelihoods and well-being of fishermen. To deal with the effects of climate change, fishers have implemented a variety of approaches at both the sea and household levels. These techniques have many constraints and only help fishers in the short term; they are insufficient for long-term perseverance.

This research provides a range of measures to help mitigate and overcome the barriers, including mitigation of climate change, proper education and awareness raising, enforcement of fishing rules and regulations, favorable credit systems, reduction of fees for fishing in the Sundarbans waterbodies, and technological development. The study advocates the implementation of the Small-Scale Fisheries Guidelines (SSF Guidelines), which promote long-term development objectives such as instant relief, rehabilitative services, restoration, and reassurance to reduce climate vulnerabilities.

Keywords: Climate Change, Dried fish, Dubla Island

COVID-19 KNOWLEDGE, PRACTICE, ECONOMIC IMPACTS AND SOCIO-ECONOMIC CONDITION OF SMALL-SCALE COASTAL FISHERS IN BANGLADESH: POLICY RECOMMENDATIONS FOR IMPROVED LIVELIHOODS

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COVID-19 has profoundly impacted global livelihoods and disrupted the food supply chain, including the aquaculture and fisheries industries. Little is known about the response to COVID-19 and the impact it has on incomes, livelihoods and knowledge and practice in the coastal artisanal fishers communities of Bangladesh. Therefore, the aim of this study was to determine the socio-demographics of selected coastal fishers, their knowledge about COVID-19 and the preventive practice taken to reduce it. The impact on their fishing habits and income was also examined to determine potential policy areas. Data were collected via a structured questionnaire from 250 respondents from three coastal districts, Cox's Bazar, Patuakhali and Barguna, Bangladesh during April–June 2020.

The research showed that the fishers' knowledge about COVID-19 and measures taken to reduce it were significantly higher in Patuakhali and Barguna than in Cox's Bazar. The pandemic caused lower consumer demand, reduced fish prices and created fish transportation issues due to movement restrictions enforced during the lockdown. Irrespective of geographical location, fishing trips were reduced by frequency and duration compared with the pre-COVID-19 period, consequently lowering the income of fishers. Fishers have received little or no support from private, non-governmental or governmental sources. Considering the evidence in this paper of economic hardship, this paper recommends artisanal fishers in Bangladesh should be provided with support to improve their health education, access to professional health facilities and financial services. This will contribute to improved food security and sustainable livelihoods that can better withstand local and/or global crises.

Keywords: Covid-19, Coastal fishers, Small-scale fisheries

APPROACHES OF RESILIENCE ASSESSMENTS IN FISHERIES SECTOR

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The word 'resilience' comes from the Latin word 'resilire,' which means 'to bounce back' or 'recoil'. The term was first used in mechanics in 1858 to describe a material's ability to resist (rigidity) as well as absorb (deformation) a force; it was then employed in psychology in the 1950s, system ecology in 1973, and social-ecological systems in the 1990s. The ability of a system, community, or society to bounce back to normalcy in order to meet its social, ecological, and economic development and growth goals in the face of climate change is referred to as resilience. This study reviews the methods of resilience assessment in different sectors that have climatic impacts and vulnerability. Due to high levels of abstraction that are difficult to empirically test, or the absence of good quality data required once adequate proxies are established, assessing resilience has proven problematic. To assess resilience, the first step involves the development or application of a theoretical framework to provide the basis for variable selection, weighting, and aggregation. The variables used to develop resilience indicators are frequently based on resilience principles or properties, which are considered the general attributes that a resilient system should possess, and have helped researchers in developing resilience indicators in various domains such as ecology, psychology, and urban sciences, among others. Indicator selection should be an iterative rather than a linear process and it should have the characteristics of relevance, suitability, construct validity and representativeness with the proposed discipline. Three approaches can be followed for the development of indicators, namely the deductive, inductive and normative approaches. After constructing indicators, the resilience of the fisheries sector can be measured based on primary or secondary data. Various frameworks and methods have been developed to measure resilience, and standardized approaches to resilience measurement can largely be divided into two categories: objective and subjective evaluations. Objective approaches usually refer to aspects of measurement that are independent of the subject's judgment, and in the case of resilience, this usually refers to approaches that use externally established characterizations of resilience. It also refers to approaches that rely on external observation for measuring. In both study and practice, objective approaches to resilience measurement have remained the norm. More recently, subjective methods of assessing resilience have been advocated. These take a fundamentally different approach, valuing people's knowledge and actively incorporating viewpoints and judgments on the subject(s) in question. Another approach of resilience measurement is subjectivity and objectivity continuum approach which is neither binary nor mutually exclusive. This is the best approach to measure the resilient because the other two approaches have more limitations. Subjective approaches have the disadvantages of needing to recognize issues with translation, faces cultural factors and biases, exist few examples, poorly researched, care needed in deciding who and how characterization of resilience chosen and can be time consuming. The drawbacks of objective approach include care is needed to be taken to limit cognitive biases, priming and social desirability, significant collection of socio-economic data needed (costly and time consuming), choice of indicators difficult for intangible components of resilience and difficult to account for conceptual factors.

Keywords: Resilience, Fisheries

**SHRIMP EXPORT COMPETITIVENESS AND ITS DETERMINANTS:
A NOVEL DYNAMIC ARDL SIMULATIONS APPROACH**

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This study aims to explore the shrimp export competitiveness of Bangladesh, China, India, Indonesia, Thailand, and Vietnam time spanning from 1990 to 2019. However, emphasizing Bangladesh as a case country, this research looks into the factors influencing shrimp export competitiveness taking into account macroeconomic and policy variables. To do so, we used the recently developed Revealed Symmetric Comparative Advantage (RSCA) index to quantify export competitiveness, while a novel dynamic autoregressive distributed lag (ARDL) simulation approach to determine the factors driving shrimp export competitiveness. The findings show that all of the aforementioned countries seem to have some degree of shrimp export competitiveness during the study period, whereas China has entirely lost its export competitiveness after 2004. However, Bangladesh's shrimp export competitiveness has dipped marginally in recent years, despite continuous growth in competitor countries such as India, Indonesia, and Vietnam. Further, economic globalization, institutional quality, trade openness, number of trade agreements, and trade freedom all have a favorable impact on Bangladesh's shrimp export competitiveness in the long-run, whereas the international or exporting price of shrimp has a detrimental influence in short-and long-run. Finally, these findings may have implications for a future shrimp export from Bangladesh and some policy recommendation are presented.

Keywords: Shrimp, Export, Policy

COVID-19'S EFFECTS AND ADAPTATION STRATEGIES IN FISHERIES AND AQUACULTURE SECTOR: AN EMPIRICAL EVIDENCE FROM BANGLADESH

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The COVID 19 pandemic has wreaked havoc on the aquaculture and fisheries sector all around the world, with the impact being exacerbated in developing countries. This study is an endeavor to identify consequences of the COVID-19 on fisheries and aquaculture sectors based on primary data collected from Bangladesh as an empirical case study. The data were collected by face-to-face interview from different supply chain actors while analyzed using descriptive statistics and problem confrontation index. As results depicted, income and employment across fish farmers, fishers, and traders were severely hurt, with a drastic fall in the market demand, coupled with a severe drop in their fish consumption. As market demand declined, fish farmers must be stocked mature fish for an extra period, and feed costs raised, eventually increasing the overall production cost. Besides, inaccessibility to inputs also made fish production and catch more troublesome. The price of all the major cultured and captured species plunged, leading to a depressing return to farmers, while inputs price underwent a significant increase except labor and fingerling. However, traders seemed to be the worst sufferers amid striking disruption in fish value chain, which ostracized the preponderance of the traders from the chain. Some of the prime obstacles that constrained the production process were but not limited to higher transportation costs, labor shortage, inability to pay for the wage, reduced consumer demand across fish farmers, fishers, and traders. Nevertheless, our article further identified a myriad of strategies that the fish farmers, fishers, and traders followed to heal the scar of the fisheries and aquaculture sector with hands-on actions.

Keywords: Covid-19, Fisheries, Aquaculture

HOW PRICE AND NON-PRICE FACTORS INFLUENCE THE MARKET PRICE OF MAJOR CARP FISH: A TIME SERIES ANALYSIS

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Recently, fish prices in Bangladesh have been growing, particularly the market price of major carps, even though the factors that may be contributing to this trend are unexplored. In this milieu, this study considers some price and non-price factors to explore the market price dynamics of major carp species in Bangladesh. To explore the factors impacting the market price of carp fish, we apply advanced time-series econometric modeling, such as the recently developed dynamic autoregressive distributed lag (ARDL) simulations model using publicly available data on fish prices from January 2005 to December 2021. This period is attributed to the rapid transformation from mostly low-intensity farming to commercialization due to a rise in productivity and market price. Among the price factors, the findings demonstrate that corn, soybean, oilcake price, and fisheries wage rate have a positive significant effect on fish price in both the short and long run. In addition, GDP per capita and inflation rate, fish consumption all have a positive significant effect on fish price in the long run, whereas total production has a detrimental effect on fish price in the long run. These findings have far-reaching policy implications for achieving the UN announced Sustainable Development Goals (SDGs) 1 (no poverty) and 2 (zero hunger) since aquaculture is one of the pertinent occupations of many rural farmers in Bangladesh. For the sake of fish farmers' profit maximization goals, the government should have a rational input-output price-fixing policy.

Keywords: Market price, Carp fishery

SOCIO-ECONOMIC IMPACTS OF MARINE FISHING BAN IN BANGLADESH: EVIDENCE FROM HATIYA

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The marine fisheries sector of Bangladesh has significantly contributed to national fish production, economic return and employment opportunities of coastal fishing communities. But overexploitation and indiscriminate use of different fishing gears are adversely affecting this sector. To conserve marine fisheries and to boost fish production, particularly Hilsa (*Tenualosa ilisha*), the government has imposed a 65-day marine fishing ban from 2015. Yet now, there are limited studies on the socio-economic impacts of the marine fishing ban on the coastal fishery dependent communities. So, this study assesses the socio-economic impacts of the 65-day marine fishing ban on the coastal fishing communities of Hatiya Upazila, Noakhali using a mixed method approach including structured questionnaire surveys, focus group discussions (FGDs) and interviews in 2021-2022.

Results showed that fisher's income from fishing has plummeted during the ban and as a result, fishers' daily food consumption, family relations, health care facilities and child education are adversely affected. Around 34% of fishers' household food consumption has reduced drastically during the ban period compared to the other months of the year. Fishers' household fish consumption has decreased to 4kg/week during the ban from 7 kg/week outside ban periods. FGDs reveal that decreased nutritional food intake adversely affected females, pregnant women, children and elderly members of the households. Family relationships weakened because of financial hardships to manage the family expenses. Around 71% of fishers became indebted during the ban due to the lack of alternative income sources. FGDs reported that children are being engaged in alternative income-generating activities (AIGAs) along with adults during the ban hampering their education. The government has taken some initiatives like providing incentives (40 kg of rice per registered fisherman) and/or AIGAs to support the fishers during the ban. However, 97% of fishers claimed that they did not get the incentives at all in 2021. According to the key informants, this is because of the very inadequate allocation of incentives from the government. Survey and FGDs data reveal that the fishers are largely dissatisfied with the ban and do not support it. The findings of this study can work as important insights for the policymakers to plan strategically for conserving marine fisheries resources as well as to safeguard the socio-economic conditions of the coastal fishing communities of Bangladesh.

Keywords: Fishing ban, Marine fisheries, Hatia

SOCIAL OUTCOMES OF CONSERVATION ACTION: A CASE STUDY ON HALTI BEEL FISH SANCTUARY IN BANGLADESH

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Beel (static wetland in inland areas) fisheries are important because they provide habitat for large ichthyo-fauna and contribute significantly to the wellbeing of millions of fishery dependent people. However, in Bangladesh it is threatened by agricultural intensification, pollution, habitat destruction, overfishing, urban development, and climate change. The dry season is a very critical time for fish in *beels* as the fish stock is fully depleted due to the extreme drop in water level. To address this issue, some fish sanctuaries have been established over the last one decade across the country. In Haldi *beel* in northern Bangladesh a fish sanctuary was established in 2012 as a conservation strategy for sustainable production of fisheries resources, by excavating 15.78 ha where fishing is partially banned and within which in 2 ha of area fishing is completely banned. However, there has been no study to assess the socio-economic impacts of the conservation action of the *beel* dependent fishing communities where this study contributes using surveys, focus group discussions and interviews conducted in 2021. Results showed that Haldi *beel* sanctuary has resulted in positive impacts on fisher households' socio-economic conditions like increased levels of earning capacity, daily food intake, child education and health-care facilities (Table 1). The amount of informal loans with very high interest rates have reduced but formal loans with low interest have increased after a few years of the sanctuary establishment. The overall fish production has also increased in the whole *beel*. As such, this study concludes that the sanctuary is effective in terms of improving the socio-economic conditions of the fishers. This model of sanctuary needed to be scaled up to other areas to improve the socio-economic conditions of the fishery dependent communities while at the same time maintaining good fish production and aquatic environment.

Table 1. Changes in fishers' households' socio-economics before and after the sanctuary establishment in Haldi *beel*

Indicators	Sanctuary establishment	Fishers' perception (%)				
		Very high	High	No change	Low	Very low
Food intake (3 meals a day)	Before	2	15	6	20	57
	After	36	56	7	1	0
Children's education	Before	1	1	5	27	66
	After	11	78	9	1	1
Health care facilities	Before	0	4	7	22	67
	After	21	67	8	0	4
Earning capacity	Before	0	2	0	24	74
	After	25	69	0	4	2
Access to low-interest formal credit	Before	7	9	63	0	21
	After	3	43	31	11	12
Access to high-interest informal credit	Before	44	35	13	1	7
	After	3	11	45	20	21

Keywords: Haldi *beel*, Socio-economics, Conservation

TOWARDS CIRCULAR ECONOMY IN BANGLADESH FISHERIES

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With the escalating number of consumers and growing environmental concerns, resource management is the key to ensuring a sustainable world. Most high-income countries, as well as several middle- and low-income countries, use the circular economy model instead of the traditional linear economy. Among different production sectors, the fisheries sector has a large scope for implementing the circular economy model, courtesy of the diversified products involved in the fisheries sector. In Bangladesh, where a notable portion of fisheries resources are currently known as trash or waste can be utilized to produce new products with a variety of applications. Through a systematic desk review, this study identified and assessed the components and sub-sectors of the fisheries sector where the circular economy model can be implemented. By-products and wastes from capture fisheries, finfish aquaculture, shrimp farms, small-scale fisheries, fish feed industry, net making industry, leftovers from fish markets, fleet industry, and canned fish industry are used to produce fish feed, drugs, plastic materials, food items, fashion wares, and a variety of new products all over the world. By introducing this novel approach in marine capture fisheries, Bangladesh will be able to partially meet its sustainable development goals (SDGs) targets of 14.1, 14.4, and 14.7 by reducing plastic pollution, unused nets, and generating income from inventing new products. Waste management in aquaculture, fish market, and feed industry will also be done smartly by using garbage as a raw material. They may face challenges to satisfying consumers because people are not psychologically adapted to take waste products as raw material.

Keywords: Circular economy, Fisheries

FINANCIAL AND RELATIONAL GOVERNANCE STRUCTURE IN INLAND FISHERIES: DO POWER DYNAMICS AND GOOD GOVERNANCE MATTER?

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The aim of this study was to provide a comprehensive understanding of the gaps in existing literature for assessing governance structure in terms of financial and relational governance, by emphasizing the importance of valuing power dynamics and good governance elements of the inland fisheries in Bangladesh. The study used perception index score to see the scenario of power, good governance, financial and relational governance. The Ordinary Least Squares (OLS) method was used to examine how power dynamics and good governance affect financial and relational governance. The study found a poor status of local power while a medium status was identified for both of collective and institutional power. Accountability and participation both were in poor condition compared to other elements of good governance. The overall state of financial governance was intermediate, and relational governance was in good shape. Furthermore, collective power had a negative impact on financial and relational governance, whereas institutional power had a positive impact on both. Furthermore, equity, transparency, the rule of law, and participation influenced financial governance positively, whereas equity, accountability, transparency, and participation influenced relational governance positively. Since, the power dynamics and good governance has substantial implications on financial and relational governance, the study suggest to planning and implementing the results to achieve long-term sustainability of inland capture and aquaculture business in Bangladesh.

Table 1. Relationship among financial governance, relational governance, power and good governance

Determinants	Financial governance		Relational governance	
	Coefficient	Std. error	Coefficient	Std. error
(Constant)	1.15	0.18	2.52	0.15
Collective power	-0.07*	0.02	-0.07*	0.02
Local power	-0.02	0.04	-0.01	0.04
Institutional power	0.10*	0.03	0.12*	0.03
Equity	0.34*	0.02	0.26*	0.02
Accountability	-0.01	0.03	0.15*	0.03
Transparency	0.06*	0.02	0.04**	0.08
Rule of law	0.09*	0.02	-0.01	0.02
Participation	0.06**	0.03	0.11*	0.02
Traceability	0.01	0.02	-0.01	0.02

Note: *Statistically significant at 1% level and ** statistically significant at 5% level

Keywords: Financial governance, Relational governance, Good governance, Inland fisheries

**CONSEQUENCES OF CATASTROPHES AND THEIR MANAGEMENT:
THE INSTANCE OF THE COVID-19 PANDEMIC ON BANGLADESH'S
FINFISH HATCHERY INDUSTRY**

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The COVID-19 outbreak, and the onset of a new normal, has shocked every entrepreneurial sector in Bangladesh including the finfish hatchery sector. To unpack the COVID-19 impacts on the finfish hatchery sector and to know more about hatchery workers., personal interviews, focus group discussion, and cross-check interviews were performed in leading fish fry producing districts named Mymensingh, Jashore, Rajshahi, and Bogra in Bangladesh using structured questionnaires with 470 hatchery workers and 135 hatchery owners. Hatchery workers' and owners' perceptions were elicited to present how the changes felt and how COVID-19 affected hatchery operations and demographic aspects of workers and found devastating impact. Decreased income, negatively impacted on livelihood, lowering household consumption, increased mental stress, negatively influenced recreational activities, increasing unemployment problem, rising family conflicts, barriers to education/drop out, the occurrence of COVID-19 infection, increased birth and child marriage rate, disruption in festival celebration, positively diversified homestead income generation, increased time spent with family and rising use of social media were identified as the primary affecting drivers. The pandemic caused lack of capital, labor shortage, inability to pay workers, low demand of fry, raising commodity price, the high price of fish feed, the low market price of fry, increased disease susceptibility, low attendance service provider, unsold fish fry, transportation obstruction, increase transportation cost, weak value chain were acknowledged as main obstacles of sound hatchery operations which may lead to lowering fisheries production throughout the country in future. In this study, some resilience are recommended and all stakeholders and authorities need to account for these points to cope with and limit the COVID-19 pandemic consequences. Furthermore, longitudinal research on the impacts of COVID-19 on livelihood, local adaptation strategies, health status, and care-seeking behavior is also strongly recommended.

Keywords: Covid-19, Fish hatchery

EFFECTIVE BROOD HILSA BAN PERIOD AND ITS IMPACT ON HILSA PRODUCTION

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The Department of Fisheries (DOF) Bangladesh implements 22-day Brood Hilsa Ban period every year to improve the spawning success and hence to increase Hilsa production. The spawning success is the major indicator of the future Hilsa production. This study was conducted to provide some insights in setting the effective brood ban period to improve the spawning success, evaluate the effectiveness of the ban period through measuring the spawning success in consecutive three years (2017-2019) and assess the impacts of the spawning success on Hilsa production, size and fishers' income. To set the effective brood ban period, the peak spawning month and then precisely the peak spawning week were determined considering the gonadosomatic index (GSI), proportions of mature Hilsa, spent Hilsa and ovary reconstructed Hilsa (Figure 1a&b).

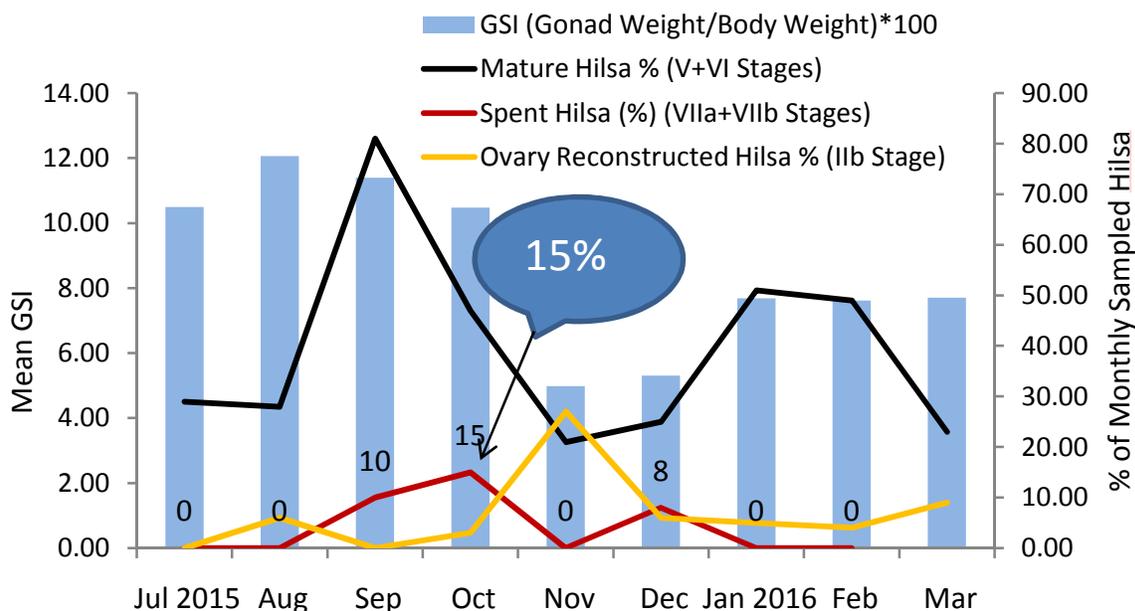


Fig. 1a: The peak spawning month of Hilsa, October was determined considering the gonadosomatic index (GSI), proportions of mature Hilsa, spent Hilsa and ovary reconstructed Hilsa.

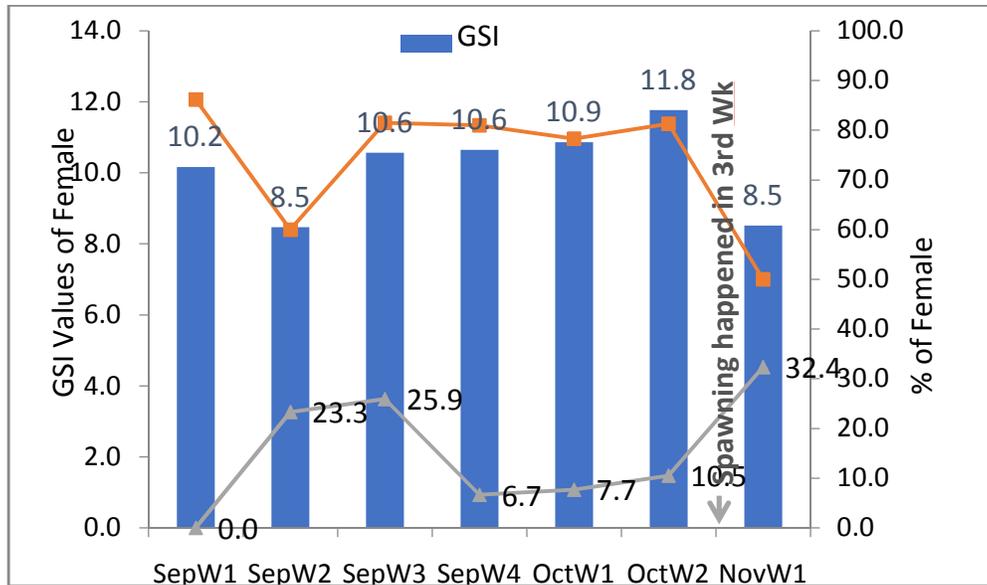


Fig. 1b: The peak spawning week, the 3rd week of October was determined considering the gonadosomatic index (GSI), proportions of mature Hilsa, spent Hilsa and ovary reconstructed Hilsa.

Then aligning with the lunar periodicity focusing on a full-moon and a new-moon spring tides, the most effective 22-day Brood Hilsa Ban period is suggested by a panel of experts and Govt. implemented that through the gazette notification and engaging all stakeholders. The spawning success (%spent Hilsa) and brood abundance were estimated through comprehensive surveys conducted during the pre-ban and post-ban periods through dissection as well as external examination in major Hilsa habitats. Then the possible present and future production was predicted considering the survival and growth and compared with estimated maximum sustainable yield (MSY), carrying capacity and actual production.

In 2017, the estimated spawning successes were found to be varied from 30% in the Padma to 70% in the Meghna with an average of 48% of the total Hilsa caught during the three consecutive days just after the ban period. In 2018 the estimated spawning success improved to 56% with variations from 13% in the Padma to 59% in the Meghna. In 2019, the estimated spawning success was found to be reduced to 33% with variations from 18% in the Padma to 48% in the Meghna. As a result of the improved spawning success and subsequent Jatka (juvenile) conservation, Hilsa production increased from 387k tons in 2015 to 517k tons in 2019. The annual incremental growth of the production increased from 5% to 9.2% per annum due to the increased spawning success and Jatka conservation. Average legally tradable Hilsa size also improved from 535 g in 2015 to 915 g in 2019. Finally, due to the increased production and improved size as well as getting supports for the alternative income generating activities (AIGAs), fishers' HHs income improved by 65% that led to improve their livelihoods.

Keywords: Hilsa, Fishing ban, Lunar circle

IMPACT OF FISH CULTURE VALUE CHAIN DEVELOPMENT PROJECT ON PRODUCTION, POND AREA, EMPLOYMENT CREATION AND TECHNICAL CAPABILITY OF PARTICIPATING FARMERS IN SOME AREAS OF NATORE DISTRICT, BANGLADESH

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This study examines the impact of the fish culture value chain development project of PKSF (Palli Karma Sahayak Foundation) funded by IFAD (International Fund for Agricultural Development) and implemented by United Development Initiatives for Program Action (UDDIPAN) of fish farmers in the Natore district. The project period was 20 months. With the views in mind, 600 project participating fish farmers were selected purposively from the study area. It is evident that 15.53% of farmers used lime regularly as a precautionary measure against fish stocks in their ponds but 84.46% of farmers applied lime irregularly. At present 100% fish, farmers apply a moderate amount of lime during the preparation of fish farming ponds. The final assessment survey found that fish feeding increased by 95% of the farmers used regular and 5% of the farmers applied irregular food. The final fish marketing capabilities increased by 58.58% sold fish from farms, 20.32% from local markets, and 21.12% from national markets. Fry marketing increased by 83.57% sold fry to farmers, 16.27% to potters, and 6.18% to other places. Water change increased by 90% of the farmers change the water regularly and 10% of the farmers change the water irregularly in the pond after participating in the fish culture value chain development project of PKSF implemented by UDDIPAN. Fish production has been 14.77 kg per decimal in the pond. Finally, the study concludes that PKSF on fish culture value chain development project had positively influenced on production, pond area, employment generation, and technical capability of participating farmers in the project area.

Keywords: Fish Production, Employment, Value chain

IMPACT OF TRADE CREDIT ON AQUACULTURE FARM PERFORMANCE AND FACTORS INFLUENCING FARMERS DECISION ON TRADE CREDIT USE

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Most small-scale aquaculture producers in the developing countries have limited access to formal external finance. More easily accessible alternative source of finance for these producers is trade credit. Based on farm level cross section data, this study analyze the impact of access to trade credit on farm performance and factors influencing farmers' decision to finance through trade credit using stochastic meta frontier and probit regression. The analyses showed that the technical efficiency reflecting the ability to maximizing outputs using given level of inputs is higher for non-users of trade credit, and credit from bank and NGO. Furthermore, collateral, documentation, number of suppliers and revenues influence the farmers decision on use of trade credit as financing tool. Besides, convenience and interest rate are the most important influencing factors.

Keywords: Aquaculture, Credit, Farmers

LIVELIHOOD OF THE FISHERIES RELATED PEOPLE DURING COVID-19 PANDEMIC: NECESSITY OF RESILIENCE PROGRAM IN COX'S BAZAR, BANGLADESH

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COVID-19 pandemic had significant impacts worldwide on the food supply chain, including aquaculture and fisheries. The study was conducted in Cox's Bazar (Doriyanagar, Sonapara, Kacha Bazar, Shutki Palli, and Fish Landing Center) to assess the livelihood scenario of the peoples related to fish value chain during the lockdown period of COVID-19. The data was collected during September-October, 2021 by a semi-structured questionnaire from 130 respondents. Several aspects were considered including education, health services, marketing status, finance services, and occupation transformation.

Among the respondents, 95% male and 5% female, 77% Muslims and 23% were Hindus. Highest 40% of the participants were young aged (21-30), 28% had fishers' ID and the literacy rate was found 42.5%. According to the respondents, 72% didn't get rations from the government; 46%, 33%, 18%, and 3% participants were not able to access to education, market services, financial services, and health facilities respectively during the lockdown.

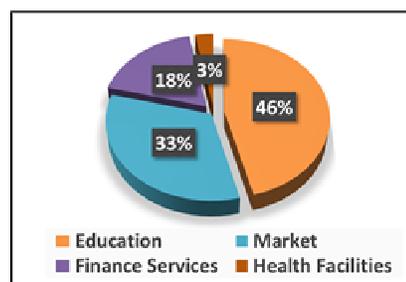


Figure: Reduction of access to the basic services during COVID-19

Moreover, the participants transformed their profession from fishing to rickshaw puller (37.5%), day laborer (27.5%), carpenter (17.5%), van driver (10.4%), and others (7.1%). Daily income reduction was found among the fish seller 45%, middle man, 40% and Aratdar 40%. Among the participants, 85% borrowed loan from NGOs, local moneylenders, and government organizations. The study recommends strengthening resilience programs for the people related to the fish value chain to cope with the livelihood constraints during COVID-19.

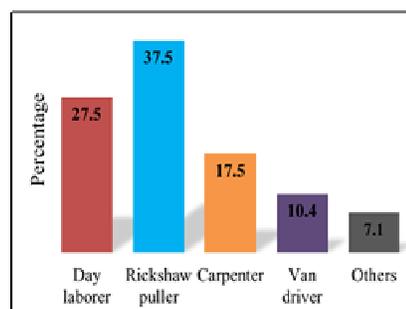


Figure: Job transformation of fishing community during lockdown

Keywords: Covid-19, Dried fish, Cox's Bazar

BARRIERS FACED BY WOMEN FISH FARMERS IN PUBLIC PONDS IN BANGLADESH AND WAYS TO OVERCOME

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In Bangladesh, women are mainly involved in small-scale fisheries and fish processing centers. This study assess the barriers faced by Bangladeshi women in the public pond aquaculture and ways to overcome those barriers gaining evidence from Sirajganj district, Bangladesh. Raiganj and Tarash upazilla where 30% of the members are women. Using both quantitative and qualitative approaches data were collected from 7 - 13 January, 2022 from the stakeholders of two ponds; Joysagor dighi from Raiganj upazila and Ulipur dighi from Tarash upazila using structured questionnaire interviews (n=60), focus group discussion (n=04) and key informant interviews (n=14).

This study has identified six categories of barriers faced by most of the women such as;(1) cultural: ancient beliefs that women cannot work outside the home, and (2) social - lack of education, poverty, fear, conflict, discrimination. Financial-lack of money, resources, technological lack of digital equipment for fish farming, (3) informational lack of updated market information (4) lack of training on fish farming (5) governance and institutional weak enforcement of fisheries policies (6) lack of proper monitoring. Arrangement of measures to overcome the barriers faced by women fish farmers such as; ensuring primary education, stop child marriage, personal bank accounts for women, separate ponds only for women, access to technology, proper monitoring of the existing pond management and ensuring active participation of the women in pond aquaculture and management.

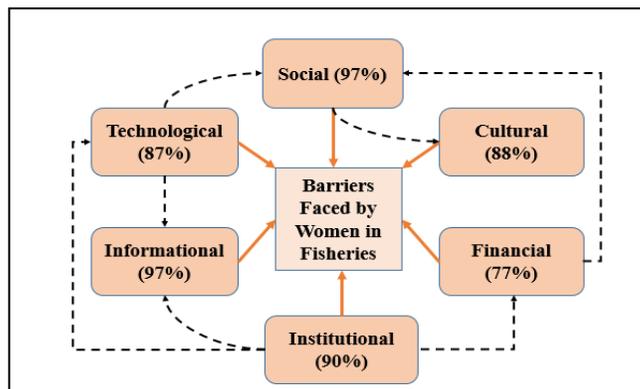


Fig. 1. Types of barriers women faced in fish culture in public ponds and the interrelationship among barriers. (Orange arrow represents barrier and dotted arrow represents interrelationship among the barriers)

Keywords: Fish culture, Women participations, Financial

SUSTAINABLE MEASURES TOWARDS IMPROVING HILSA PRODUCTION- LESSONS FROM ECOFISH BANGLADESH

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Hilsa shad (*Tenualosa ilisha*) is an anadromous fish that lives in the Bay of Bengal and migrate to the upstream rivers of Bangladesh, India and Myanmar for breeding and nursing of the offspring. It is the most important commercial transboundary species of which Bangladesh has the major share (86%), followed by India (8%), Myanmar (4%) and other countries within the Bay of Bengal region. It is the single-most dominant food fish in the Bay of Bengal region with an average 44% contribution to capture fish production in Bangladesh. The production of hilsa has remarkably increased over 0.5 million tons over last three years since 2016 owing to the implementation of Hilsa Fisheries Management Action Plan (HFMAP) jointly by the Department of Fisheries and WorldFish under a USAID funded “Enhanced Coastal Fisheries in Bangladesh (ECOFISH-Bangladesh Activity, 2014-2019). This project supported the Department of Fisheries (DoF) and local communities in establishing a collaborative science-based management approach called “co-management” that focused on reducing overfishing, protection of juveniles and brood hilsa in the peak spawning season by involving all stakeholders including fishers and government institutions. The project also focused on empowering the fishing community by targeting on women and livelihood diversification in order to improve the communities’ resilience in enduring strict compliance during fishing ban periods. Hilsa production reached to about 0.55 million tons, which is about 12.22% of country’s total fish production of about 4.5 million tons (DoF 2021). The retail market price of Hilsa largely varies from US\$5 to US\$ 15 with an average of US\$10 per kg of fresh fish. Based on that, the direct economic value of the 0.55 million tons of Hilsa worth about US\$ 5.5 billion (@US\$10/kg) per annum.

ECOFISH engaged the IIED to conduct a study to identify the nonmarket (cultural, spiritual, historic) value of the fishery as well as to evaluate the impact of the compensation scheme to address both issues. The study revealed that the non-consumptive value of Hilsa to the people of Bangladesh is worth more than USD 355 million per year. To improve compliance through supporting law enforcing agencies, 400-trained community Fish Guards (CFGs) were engaged along the six sanctuaries. Created a revolving Hilsa Conservation and Development Fund (HCDF) amounting BDT 350 million (US\$ 0.43) as seed money to support the co-management committees for the conservation of hilsa juveniles and brood stock as well as support the community fish guards during the fishing ban periods. Finally, Ecosystem Approach to Fisheries Management (EAFM) was initiated involving all stakeholders to sustain the improvement.

As a synergistic impact of the general management activities as well as science-based co-management through combined efforts of DoF, WorldFish and other law enforcing and administrative officials, annual incremental total Hilsa catch increased from 5% to 11%, resulting a total catch of 0.517 million tons in 2018, which is almost the estimated MSY level. In addition, Hilsa size has also improved from an average 510 g in 2014 to 915 g in 2019. Now, the government has taken up the best practices and hilsa production that led to further increase to 5.5 lac tons in 2020. The adoption of improved management practices ensuring the compliance of the fishing bans, mesh size regulations, reducing the illegal harvesting of juveniles and brood stock, and providing the compensation to a vast majority fishing households to endure the hardship during fishing bans triggered this success. After a rigorous study over 3 years, combing the efforts of Chattagram Science and Technology University, Terengganu Malaysia University, and Apical Laboratory of USA, DoF-WorldFish collaboration first time ever discovered that there are three distinct races of hilsa that are found in the marine waters, the Meghna River and the Padma River. High quality genetic studies proved that the juveniles come back to the same river as broods for breeding where they spent early hood for nursing. This would help in formulating future management plan not for Bangladesh but for the entire region.

In spite of commendable success in hilsa fisheries management that has become a role model for inland capture fisheries for the region, there are many challenges ahead for Bangladesh for sustainability of this enhanced production. A gradual reluctance among various stakeholders in stricter monitoring of juveniles and brood hilsa catch since the beginning of the pandemic situation is visible, and huge quantity of Jatka harvesting and marketing is reported almost every day. A strong political commitment is now necessary to control the local influential people and boat owners who encourage the poor fishers to go for illegal fishing with illegal current jal (monofilament nets) and behundi jal (set bag nets). It is also observed that trawlers in the coastal waters actively catch undersized hilsa within the 40 m depth zone (area earmarked for the artisanal boats) when the Jatka start migration from the rivers to the ocean for spending their adulthood. The use of illegal gears and small mesh (legal mesh size 6.5 cm) size gears in fishing is now becoming a common practice. Another important regional issue has appeared as hindering the production of hilsa as it is a transboundary fish and we share the stock with India and Myanmar. Both neighboring countries are yet formulate and follow the sustainable management approach as that of ours, so they catch hilsa during the ongoing brood hilsa ban period in Bangladesh. A transboundary hilsa management especially with our neighbors is essential for sustainable hilsa production for the benefits of all countries within the Bay of Bengal region. A continuous flow of water in the river Padma and other rivers may enhance the production of this iconic hilsa fish in both countries, Bangladesh and India.

In conclusion, precautionary measures to avoid over-harvesting through continuous monitoring and maintenance of the resilience of the river and that of the fishers reliant on it through implementation of EAFM, institutionalization and mainstreaming of the co-management focusing on the Community Savings Groups, Community Fish Guards, and Hilsa Conservation and Development Fund, are strongly recommended. The success story of the revival of declining Hilsa fishery in Bangladesh has been recognized globally, so we should continue to attach enhanced importance to remain the leader in inland fisheries management and enhanced hilsa production.

Keywords: Hilsa, Ecofish, Transboundary fish

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