

ANNUAL REPORT

2022-2023



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Bangladesh Fisheries Research Institute
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Father of the Nation
Bangabandhu Sheikh Mujibur Rahman



Sheikh Hasina
Hon'ble Prime Minister of the People's Republic of Bangladesh



Md. Abdur Rahman MP
Minister
Ministry of Fisheries And Livestock
Govt. of the People's Republic of Bangladesh
Bangladesh Secretariat, Dhaka

Message

I'm delighted to know that Bangladesh Fisheries Research Institute (BFRI) is publishing its Annual Report for 2022-23, representing a noteworthy and commendable undertaking.

The fisheries sector in Bangladesh holds immense potential in addressing food security, nutrition, and economic development. Under the Prime Minister **Sheikh Hasina's** leadership, there's a dedicated effort to conserve and manage fisheries resources of the country sustainably, ensuring stability of fish production.

BFRI has been instrumental in advancing aquaculture technologies, including breeding techniques for endangered species and establishing Live Gene Bank at preserving fisheries resources. Government initiatives further aim to enhance the sector through programs such as Hilsa fish management and habitat restoration.

Honorable Prime Minister **Sheikh Hasina**, following the father of nation footsteps, has endeavored to secure rights in the country's maritime boundary. Her diplomatic acumen has led to the establishment of sovereignty over a vast marine area nearly equivalent to Bangladesh's land area, ushering in a new era of the blue economy. BFRI scientists are dedicatedly working on harnessing the potentiality of blue economy through indentifying and developing culture technology of commercially valuable seaweed species along the coastal region of Bangladesh. Additionally, breeding technology has been developed for other potential blue economy species such as Blue Swimming Crab, Chitra and Datina. The ongoing 'Sustainable Coastal and Marine Fisheries' initiative aims to bolster these endeavors, alongside a 65-day fishing ban from May 20 to July 23 annually, aimed at regulating exploitation and preserving marine biodiversity.

I encourage collaboration among stakeholders in realizing objectives outlined in governmental strategies like the 8th Five Year Plan and Vision 2041, aligned with **Bangabandhu Sheikh Mujibur Rahman's** vision for a prosperous Bangladesh.

Best wishes for the continued progress of the fisheries sector.

Joy Bangla, Joy Bangabandhu
Long Live Bangladesh

(Md. Abdur Rahman MP)



Md. Selim Uddin
Secretary
Ministry of Fisheries And Livestock
Govt. of the People's Republic of Bangladesh
Bangladesh Secretariat, Dhaka

Message

Following the footsteps of Father of the Nation Bangabandhu Sheikh Mujibur Rahman, Bangladesh has already achieved self-sufficiency in fish production under the dynamic leadership of his worthy daughter Hon'ble Prime Minister Sheikh Hasina. Not only that, the sector has made a special position in world fish production, being one of the top ten fish producing countries. In global production, Bangladesh ranks 3rd in inland capture fisheries and 5th in inland aquaculture production. These two sectors have made much advancement due to scientific research. Now the government has given special attention on the development of the marine fisheries resources which have great potential to enhance Blue Economy.

The present per capita daily fish intake in the country is 67.80 g which exceeded the targeted 60 g. According to the FRSS, 2021-22 the fisheries sector contributes 2.43% of the country's total GDP and 22.14% of the agricultural GDP. In 2008-09 the country produced 27.01 lakh MT fish, which has increased to 47.59 lakh MT in 2021-22. More than 12% of the total population of the country, directly or indirectly are engaged in fisheries and ancillary activities.

The present government is fully committed to maximizing the potential of the fisheries sector through various development projects aimed at balanced growth in both inland capture and culture fisheries, as well as coastal and marine fisheries. Key initiatives include cluster-based shrimp farming, eco-friendly aquaculture, community-based fisheries management, habitat conservation, establishment of fish sanctuaries, and more. These efforts have led to a significant increase in production, addressing the previous scarcity of fish.

The Bangladesh Fisheries Research Institute (BFRI) has played a commendable role in fisheries research and development, particularly in breeding and culture technologies for endangered fish species, now widely adopted by fish farmers and entrepreneurs. The institute's current research focus is on non-conventional marine fisheries resources, with notable progress is already achieved. In addition, BFRI has successfully produced various seaweed-based food products with high demand in export markets. There is a need to further refine and promote these value-added products to consumers.

I extend my best wishes for the continued progress of BFRI in all its research endeavors.


(Md. Selim Uddin)



Dr. Md. Zulfikar Ali
Director General
Bangladesh Fisheries Research Institute

Foreword

The fisheries sector plays a crucial role in ensuring nutritional food security, livelihood development, poverty reduction, export earnings, and overall economic growth in Bangladesh. However, there is significant potential for further enhancing for the contribution of this sector through demand driven research and development efforts. In line with this, the Bangladesh Fisheries Research Institute (BFRI) conducts research aligned with national policies to explore the thrust area of this sector. BFRI has developed 83 improved aquaculture and management technologies, many of which have been implemented in the field. This has led to a notable increase in fish production, rising from 2.70 million MT to 4.915 million MT over the past 12 years.

The mandate of BFRI is to conduct and coordinate fisheries and aquaculture research in accordance with national policies, plans, and the Sustainable Development Goals (SDGs) of the United Nations. To achieve this, collaborative research initiatives with universities and relevant organizations are undertaken to expedite the development of appropriate technologies, utilizing the available expertise within the country. The Institute adopts a bottom-up approach in planning research programs, with finalization achieved through annual workshops involving various stakeholders such as academicians, scientists, extension workers, policymakers, farmers, and entrepreneurs.

The Annual Report (2022-23) imprinted with the research programs and administrative activities undertaken by the Institute to advance the fisheries sector. Throughout the reporting period, a total of 53 research projects were implemented across various regional Stations and Sub-stations. Notable achievements include the development of seed production and culture technologies for endangered fish species like Balachata (*Somileptes gongota*) and Mud Crab (*Seylla olivacea*) as well as the identification of a new breeding ground for Hilsa in the Baleshwar River of Barisal district. Other activities comprised in the report include training, publications, and financial matters of the Institute.

While aquaculture has seen significant progress due to technological advancements, new and emerging issues require serious attention to sustain the advancement of the industry. The marine sector is particularly emphasized, necessitating priority research interventions. BFRI has prioritized the development of non-conventional marine fisheries items such as snails, mussels, crabs, and seaweeds, alongside conventional resources.

It is hoped that this Annual Report, focusing on the major research conducted in last year, will serve as a valuable resource for researchers and planners from national and international organizations in formulating project proposals and policy guidelines for fisheries development.

(Dr. Md. Zulfikar Ali)

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BFRI Annual Progress Report 2022-2023

Annual Report 2022-2023

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Annual Report 2022-2023. Bangladesh Fisheries Research Institute, Mymensingh. 370 p.

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Bangladesh Fisheries Research Institute: An Overview

Fish and fisheries have a significant role in the culture and heritage of Bangladesh. The sector has a substantial impact on nutrition, employment creation, and foreign exchange revenue. Considering the significant opportunities in the sector for improving nutrition and creating job opportunities, especially for the most disadvantaged, and the need to effectively utilize aquatic resources through science, the President of the People’s Republic of Bangladesh was pleased to promulgate an Ordinance entitled “The Fisheries Research Institute Ordinance 1984” on 11 July 1984. In pursuance of this Ordinance, the Fisheries Research Institute (FRI) was established in July 1984. In 1997, the FRI has been renamed as Bangladesh Fisheries Research Institute (BFRI) through the amendment of the 1984 Ordinance.

The Institute was established in 1984 but started functioning in 1986 after employing the necessary employees while setting up first research facilities. Since then, the institute has been evidential in helping the nation realizing the target of the fisheries development outlined in consecutive development plans.

Vision of the Institute

Development of need-based technology leading to increasing fisheries production of the country.

Mission of the Institute

To conduct research for the development of need-based technology on aquaculture and fisheries resource management of the country.

Mandate of the Institute

- To carry out basic and adaptive research for development and optimum utilization of all living aquatic resources and coordinate fisheries research activities in Bangladesh;
- To conduct experiment and standardize techniques for maximizing productions and better management of living aquatic resources;
- To identify new production opportunities and develop them to usable levels;
- To develop skilled research manpower through training;
- To transfer developed technologies to users through training of extension workers, planners, fish farmers and other stakeholders;
- To advise the Government in all matters relating to research and management of living aquatic resources.

Management of the Institute

The Institute (BFRI) is an autonomous research organization that is administratively affiliated with the Government of the People's Republic of Bangladesh through the Ministry of Fisheries and Livestock. The general direction, administration and supervision of the affairs of the institute is vested in the Board of Governors consisting as follows:

Board of Governors

Chairman	: Hon'ble Minister, Ministry of Fisheries and Livestock
Vice-chairman	: Secretary, Ministry of Fisheries and Livestock
Members	: Executive Chairman, Bangladesh Agricultural Research Council : Vice-chancellor, Bangladesh Agricultural University, Mymensingh : Member (Agriculture), Planning Commission : Director General, Department of Fisheries : Two Members of the Parliament to be appointed by the Govt. : Two persons to be appointed by the Govt. among the persons having interest in fisheries development : Two persons to be appointed by the Govt. engaged in research in BFRI
Member-Secretary	: Director General, BFRI

The Board of Governors has the authority to exercise all powers and accomplish all actions that the Institute is capable of. The Board can establish committees to aid in carrying out its duties as deemed essential. The Director General, as the Chief Executive of the Institute, implements its programmes according to the policies and directives set by the Board of Governors.

BFRI Organogram

The Headquarters of the Institute is located at Mymensingh. The Institute has five (05) research stations and five (05) sub-stations based on different aqua-ecological zones. The organogram of the institute is shown in next page.

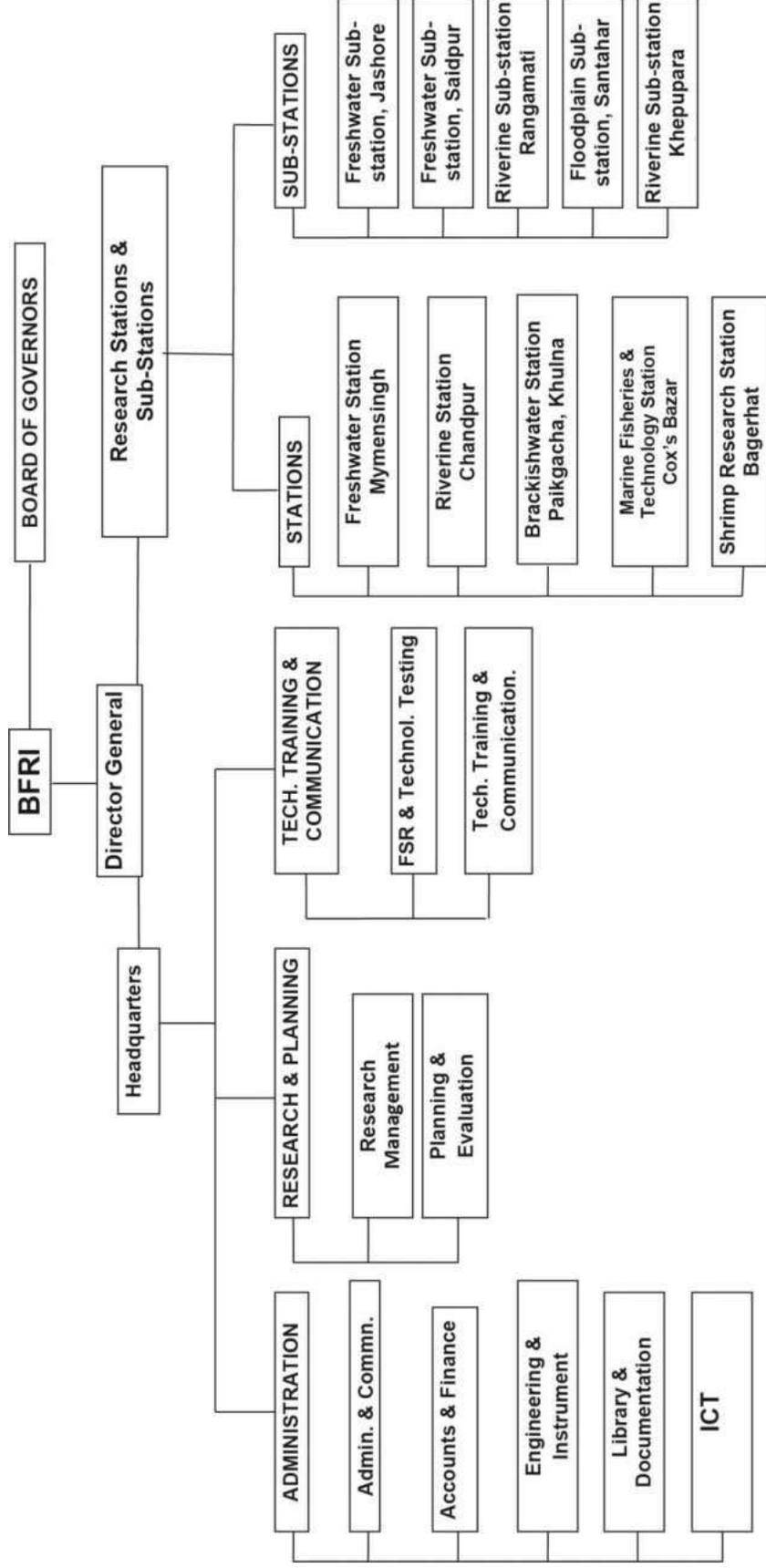
Stations and Sub-stations

Headquarters, Mymensingh

The Headquarters of the Institute is located at the south-west corner of the Bangladesh Agricultural University, Mymensingh, which is about 120 km north of the capital city, Dhaka. The Headquarter functions through its various divisions in respect of administrative development, coordination and operation of its research programs. The divisions are:

- Research and Management,
- Planning and Evaluation
- Technology Testing, Training and Communication,
- Administration and Common Service,
- Engineering and Instrument,
- Library, Documentation and Public Relations,
- ICT, and
- Accounts and Finance

ORGANOGRAMME
Bangladesh Fisheries Research Institute
Mymensingh



Freshwater Station (FS), Mymensingh

The largest station of the Institute, with an area of 40 ha is located at Mymensingh attaching to the BFRI Headquarters. The station has well established and sophisticated carp and prawn hatcheries. The station has as many as 118 drainable ponds consisting of 20 mini ponds; 52 nursery ponds (0.1 ha each), 47 rearing ponds (0.25 ha each) and 16 grow-out/brood stock ponds (1.6-2.6 ha each). Other physical facilities include a feed store, office buildings, residential quarters, a 35-bed dormitory, a community center and a 5-bed guesthouse. The station is actively involved in conducting research on hatchery management, fish genetics and reproduction, carp polyculture, integrated fish farming, fish feed and nutrition, pearl culture, fish disease, health management and socio-economic aspects. The various research activities of the station are implemented by the following divisions:

- Reproductive Physiology and Genetics
- Aquaculture and Farming System
- Nutrition, Food and Feed Technology
- Fish Disease Diagnosis and Health Management
- Soil, Water and Productivity Management
- Fisheries Socio-economics

Three sub-stations are attached to the Freshwater station. These are:

Floodplain Sub-Station, Santahar

To support the floodplain fisheries development program taken up by the Government, studies on the ecology, limnology and gear selectivity of floodplains are being undertaken at the Santahar Sub-station. The sub-station succeeds in breeding and culture of certain endangered fish species like., *Aspidoparia jaya*, *Neotropius atherinoides* etc.

Freshwater Sub-Station, Jashore

To support freshwater aquaculture farmers and hatchery operators of greater Jashore region, the Freshwater Sub-Station has been conducting research on breeding and culture of BFRI Super Tilapia, carp disease diagnostic services and also farming system research and development.

Freshwater Sub-Station, Saidpur, Nilphamari

To support the fisheries development program in northern region of Bangladesh, a freshwater sub-station is established in Saidpur Upzilla under Nilphamari district. The prime objective of the sub-station is to conduct need-based research to suit with the ecosystem of northern Bangladesh and to transfer technology to the farmers through effective training and demonstration. The sub-station succeeds in breeding and culture of certain endangered fish species like., *Barilius barila*, *Mystus bleekeri*, *Labeo dero*, *Labeo angra* etc.

Riverine Station (RS), Chandpur

The station is situated in the riverine port city of Chandpur, with an area of 17.2 ha and has 36 non-drainable ponds ranging in size from 0.12 to 0.37 ha each and with a total of 8.6 ha. water area. In addition, the station has one carp, one catfish and one prawn hatchery, two deep tube-wells, specialized laboratories, library, office buildings, residential quarters and an 8-bed guest house. One research vessel, one mechanized wooden boat equipped with research facilities, and three speed boats are available for

undertaking riverine survey and studies relating research and management to hilsa and other riverine fisheries resources. The Riverine Station consists of 6 research divisions, which are as follows:

- Stock Assessment and Resource Dynamics
- Fisheries Resource Management and Conservation
- Culture-based Fisheries Management
- Reproductive Biology of Riverine Species
- Environment and Aquatic Pollution

Two Sub-Stations are attached with the Riverine Station, and these are:

Riverine Sub-station, Rangamati

To devise sustainable management and development strategies for the Kaptai lake fishery, Riverine Sub-station (RSS) undertakes various adaptive research programs. Priorities are given on continuous monitoring of biological productivity, stock assessment, natural spawning, and population dynamics of various commercially important fishes and major carps, in particular. Recently, RSS has been introducing pen and cage aquaculture programs in the creeks and lagoons of Kaptai lake to culture fingerlings of major carp and thus to support artificial stocking of the lakes by Bangladesh Fisheries Development Corporation (BFDC), Kaptai lake project. Extension works are being carried out through adaptation of pen and cage aquaculture, installation of pens and cages in the creeks/coves in Kaptai lake on participatory basis.

Riverine Sub-station, Khepupara, Patuakhali

The fish landing and wholesale center of BFDC at Khepupara Upazilla has been handed over to BFRI to develop as a Sub-station and carry out research mainly on hilsa fishery. The old infrastructure has now been renovated by BFRI. Due to manpower, funds and logistic constraints, research is being conducted on hilsa in a limited scale. In addition to this, technical advice to the fish farmers is being provided and improved fish seeds are distributed to the local farmers time to time.

Brackishwater Station (BS), Paikgacha, Khulna

The station was established in 1987 with a view to undertake research and development activities on various aspects of coastal aquaculture and fisheries management. The station is located at Paikgacha Upazilla under Khulna and has an area of 30.56 ha. The station has got 53 drainable experimental brackishwater ponds of different sizes ranging from 0.05 to 1.0 ha, an experimental hatchery for the production of prawn and commercially important brackishwater fin-fish seeds and a number of laboratories. The station has 5 research divisions, such as:

- Nutrition and Feed Technology
- Disease Diagnostic and Health Management
- Brackishwater Aquaculture
- Estuarine Ecology and Environment
- Soil, Water and Productivity Management

This station is involved in conducting research on increasing productivity of coastal *ghers*, environment friendly shrimp culture development, crab seed production and fattening, seed production and culture of commercial finfishes, diseases management, aquatic environment monitoring etc. The research work undertaken so far by this station includes socio-economic studies on shrimp farming, survey and

assessment of shrimp fry resources and its breeding ground, production potential of *gher* fishery (with improved management practices), polyculture of shrimp and mullet, breeding, culture and fattening of mud crab (*Scylla spp.*), breeding and nursing of *Macrobrachium rosenbergii*, improved method of shrimp farming, breeding and culture of brackishwater catfish and green back mullet etc.

Marine Fisheries and Technology Station (MFTS), Cox’s Bazar

This station, with an area of 4 ha, was established at Cox’s Bazar in 1991. The station is being equipped with a crab breeding hatchery, live feed laboratory, outdoor complex with 39 cisterns (200 m² each), residential buildings for officers and staff accommodation, service building and an 8-bed guest house. There is a new 7-storied laboratory cum office building to conduct the research activities.

The mandate of the station includes research on marine ecology, seaweeds culture, environmental studies, stock assessment and population dynamics of commercially important species, diseases diagnosis and control, development of processing and preservation technologies, socio-economic studies of marine and coastal fishers and quality control of marine products.

Shrimp Research Station (SRS), Bagerhat

The station was established on 2010 at Sadar Upazilla under Bagerhat with an area of 8.0 ha. The mandate of the station is to conduct research on enhancing shrimp production, shrimp health management, shrimp feed and nutrition, post harvest handling and quality control of shrimp and shrimp products. The station consists of a 2-storied Office-cum-Laboratory building, 3-storied Staff dormitory, and 4-storied Training dormitory of the station. Moreover, a pond complex composing 9 experimental ponds of different sizes are being used for experimental purposes. The laboratories of the station are:

- Shrimp Health Management
- Quality Control
- Shrimp Feed and Nutrition
- Water and Soil Quality Management

Manpower

The manpower status of the Institute is highlighted in the following table:

Head	Approved posts			Filled up posts		Vacant posts	
	Officer	Staff	Total	Officer	Staff	Officer	Staff
Revenue	268	257	525	112	186	155	71

Development of Technologies

Regular research activities of the institute lead to generate various aquaculture and management technologies for better management of the resources and increase the fish production. Upto 2023, the Institute has evolved more than 83 aquaculture and fisheries management technologies. Among them, 11 technologies have been developed during 2022-23 period and these are as follows:

- ✓ Induced breeding and seed production of endangered fish species i.e., Balachata (*Somileptes gongota*)
- ✓ Breeding and seed production technology of Mud crab (*Scylla olivacea*)
- ✓ Induced breeding technology of Boirali (*Barilius barila*)
- ✓ Induced breeding technology of Angus (*Labeo angra*)

- ✓ Induced breeding technology of Kholisha (*Colisa fasciatus*)
- ✓ Induced breeding technology of Jatpunti (*Puntius saphore*)
- ✓ Pearl culture in freshwater Mussel
- ✓ Induced breeding technology of Kursha (*Labeo dero*)
- ✓ Induced breeding technology of Loitta tengra (*Mystus bleekeri*)
- ✓ Induced breeding and seed production technology of Dhela (*Osteobrama cotio*)
- ✓ Determination of standing biomass sustainable yield (MSY) of Hilsa (*Tenualosa ilisha*)

Technology transfer

Subsequent to development of technologies or management practices, the generated research results were transferred through various mechanisms. Different government agencies including Dept. of Fisheries, NGOs, farmers and entrepreneurs were offered training on research-evolved technologies. After successful validation of technologies, printing materials like manuals, booklets, leaflets, posters etc. were published and distributed among the users.

On-Farm trials

Field trials of the on-station research findings were conducted for adaptation of technologies in on-farm conditions through government and non-government extension agencies, private entrepreneurs and NGOs.

Farmer's Advisory Services

The Institute through its different Stations and Sub-stations provided advisory services to the farmers on improved fish farming technologies, water quality monitoring, feed quality, diseases control etc. Scientists of the Institute also provided service on national crises related to fisheries and environmental issues as and when deemed necessary.

Training Programs

Training on different aspects of fisheries is utmost important for boosting -up of fish production and to ensure better management of aquatic resources. A series of well-structured training programs are organized by the Institute every year to disseminate the research evolved technologies to the end users. Moreover, effective transfer and dissemination of the technologies and management procedures such as training of extension workers both of Government and NGOs, teachers, students and journalists are also organized by Institute. The training programs organized on different aspects are as follows:

- Improved fish culture and management
- Seed production and culture techniques of endangered fish species
- Pearl culture techniques in freshwater ponds
- Shrimp nursery, culture and management
- Crab fattening techniques
- Pen and cage culture techniques
- Fisheries and aquaculture research management
- Mud eel culture technique
- Seaweed culture and product development
- Effect of sanctuary on Hilsa production
- Culture technique of Mussels and Snails in Bangladesh

The Institute also conducts training on research methodology, financial management, office management, e-filing, e-GP and other research-oriented programs for researchers of the Institute to shine up their capability.

Training programs conducted

For boosting-up fish production and to ensure better utilization of aquatic resources, BFRI organizes series of training programs every year for farmers, entrepreneurs, unemployed youth, rural women and university students, extension workers both of Government and NGOs, teachers, journalists and LGED fisheries facilitators. The main objective of offering such type of need and opportunity-based training is to transfer and disseminate technologies among various stakeholders and end users. During July 2022-June 2023 a total of 146 training batches were completed and 3,090 nos. of people were trained up by the Institute.

Institutional manpower development

For strengthening the capabilities of scientists, administrative and management personnel, the Institute organizes different in-country and overseas short-term and long-term training programs, study tour and experience-sharing visits. During 2020-22, a total of 13 scientist achieved overseas short-term and long-term training in 4 programs, besides, 14 different in-country training programs have been organized for the scientists and officers. 2 scientists have been awarded PhD from abroad.

Workshop/Seminar organized

The Institute organized 8 numbers of National workshops and seminars in different disciplines to identify the problems and sharing and exchanging knowledge generated through research in this year. The Institute and its Stations and Sub-stations organize Regional and National workshops every year to review the research projects and to present the research progress of the Institute.

Public Relation and Publications

Public Relations (PR) division of BFRI provides information among different stakeholder of fisheries sector and so on. Public Relations (PR) also give information as well as latest research success to the Press. During 2019-20 a total of 145 news and reports have been published in different print and electronic media including the daily Ittefaq, the daily Prothom Alo, the daily Jugantor, the daily Kaler Kantho, the daily Star, The daily Financial Express, the daily Bangladesh Pratidin and so on. Besides, some well circulated agri news magazines also publish BFRI news for example: Monthly Krishi Surakkha, Krishi Projukti, Monthly Khamar etc. In addition, BTV, ATN Bangla, Ekushey TV, Jamuna TV, Channel i, Channel 24, DBC, Independent etc. also broadcast BFRI news and achievements.

The Institute publishes research findings, annual reports, newsletters, journals, workshop proceedings, training manuals, extension materials in the form of booklets, leaflets and posters. The publications are available at the Library and Documentation Center as well as at different regional stations and sub-stations of the Institute. The following publications were published during the reporting period:

Institute gives special value to publication and documentation of aquaculture and management technologies for their wider adoption. For this reason, extension manuals, leaflets, posters, handouts etc. were well circulated to govt. and non-govt. extension agencies, farmers, entrepreneurs etc.

Items	2022-2023
Books	185
Journals	17
Reports/Proceeding of seminars and workshops/papers	11
Newsletters/Bulletins/Reprints/Off prints	43
ASFA (Aquatic Sciences and Fisheries Abstract) DVD	up to 2017
TEEAL (The Essential Electronic Agricultural Library)	up to 2013

The library maintained free mailing of institutional publications to various research organizations, universities, NGOs, entrepreneurs and farmers to keep the aware with the latest development in fisheries research.

Working Linkage

The institute conducted its research, training, and management endeavors in close collaboration and through connections with numerous national and international organizations and agencies. Additionally, the institute maintained close ties with public extension organizations and various non-governmental organizations operating in the country in order to disseminate technologies and solicit their feedback. BFRI maintained close liaisons with national institutions and engaged in collaborative efforts pertaining to fisheries research and development (R&D). The Department of Fisheries (DOF) is unquestionably the primary focus among national collaborators, followed by NARS institutions and joint research and development programmes with various NOGs.

Finance and Accounts

The sources of funds of the institute comprise grants from the government, and grants from different donor agencies. Government grant from the revenue budget is usually provided to meet only salaries and a little portion of the operational costs belonged for the allowances of the staff. The cost of development, maintenance and research is also borne by the government from its development budget provided in the form of development project.

Receipts and expenditure

The institute received an amount of Tk. 4274.50 lakh during the year 2022-23.

Stock Improvement of Major Carps (Rohu and Catla) and DNA-Barcoding of Important Freshwater Fishes in Bangladesh

Researchers

Dr. Jonaira Rashid, SSO

Md. Amdadul Haque, SO

Objectives

- To improve Rui and Catla stocks using DNA technology
- To analyze genetic variability of Rui stocks using DNA markers
- To identify freshwater fishes at the species level based on DNA barcoding data

Achievements

Component A

Experiment 1. Stock Improvement of Rohu through Genetic Selection

One of the main objectives of a selection breeding program is to maximize the genetic gain per generation of selection. Sixty (60) families of improved F_5 progeny group were produced from the F_4 generation of BFRI Suborno Rui through a series of pair mating between selected pairs of female and male fish according to the plan and design (Figure 1). The selection breeding program was conducted on family selection using best-selected individuals to produce the F_5 generation of Rohu in the month of May-July 2023 at the FS hatchery complex. The matured 60 pairs of males and females were selected based on their morphological criteria i.e., size, color, and weight attainment from the F_4 rohu generation. An equal volume of fertilized eggs of about 200 g from each pair of fish was incubated in hapas which was set up before in the hatchery and maintained as separate family groups. The sixty F_5 progeny families were reared for primary and secondary nursing systems in sixty separate hapas in a pond with nursery feed @ 10-15% body weight.

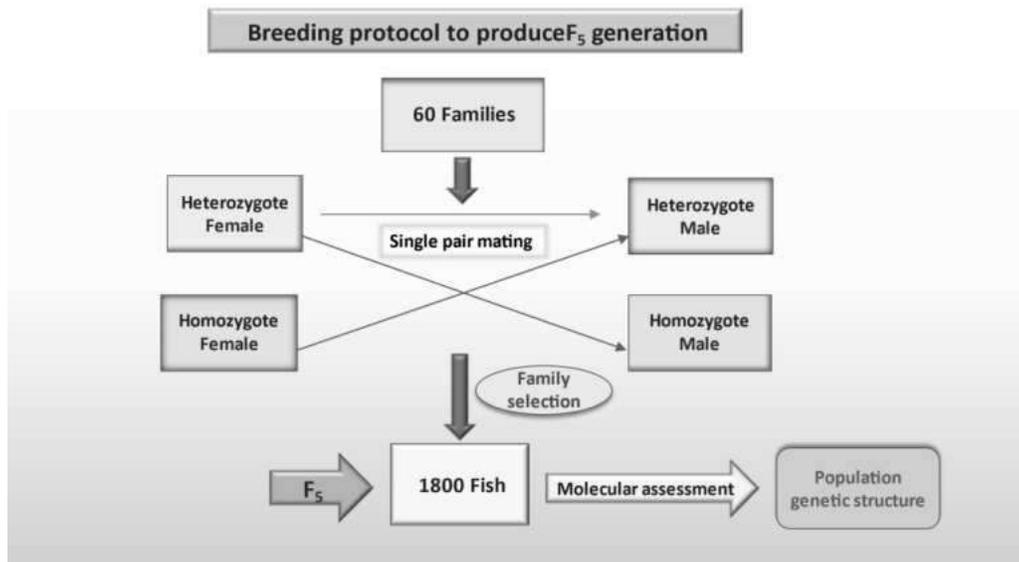


Figure 1. Protocol to produce F_5 generation of BFRI Suborno Rui (2022-23).

Molecular Marker Assessment

Developing conservation and stock improvement initiatives requires knowledge of the genetic structure. The evolutionary potential and fitness of a population are preserved by genetic diversity. Comparing the genetic diversity of the hatchery stock with that of a reference natural stock, or preferably the base population, allows one to evaluate the level of hatchery management success as well as the condition of the hatchery bloodstock. Five pairs of microsatellite marker were used to reveal population genetic structure of BFRI Subarno Rui and compared with wild stock. The selection of Lr3, Lr21, Lr28, Lr38, and Lr46 primers is based on polymorphism. PCR amplification has already been done using those primers.

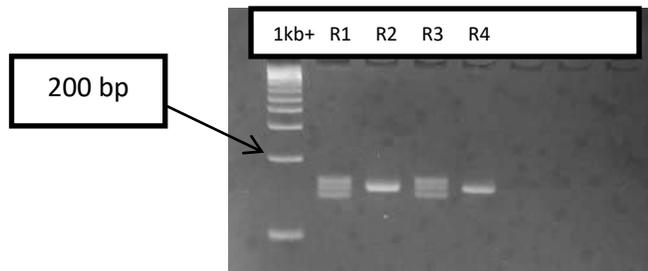


Figure 2. Lr3 locus amplification of BFRI Subarno Rui in 5% agarose gel.

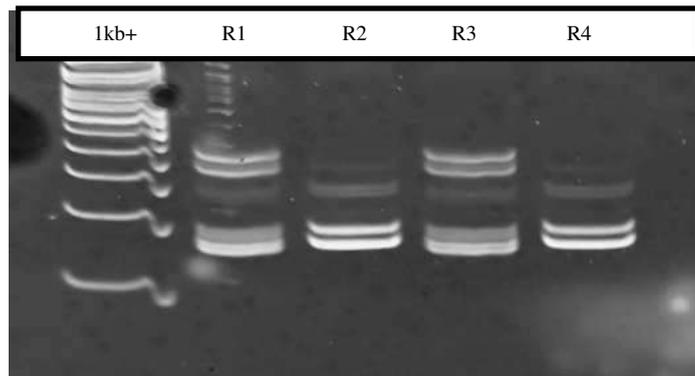


Figure 3. 10% polyacrylamide gel run to analyze Lr3 locus of BFRI Subarno Rui.

Experiment 2. Stock Improvement of Catla through DNA-Based Protocol

The collected wild stocks of Catla (The River Halda and Jamuna stocks) were reared in earthen ponds with an average depth of 1 m located in the pond complex of Freshwater Station, Bangladesh Fisheries Research Institute (BFRI), Mymensingh following all scientific management practices, including fertilization, liming, supplementary feeding and water management. Fishes were fed with supplementary feed containing 28-30% protein at 5-3% body weight daily. Basic water quality parameters were measured with the aid of water quality testing devices at the pond site fortnightly. The present statuses of Catla (The River Halda and Jamuna stocks) are shown in Table 1 and 2. After complete maturity, fishes will be used for selection by di-allele crossing along genetic variability data for the development of base populations.

Table 1. Present status of Catla (The River Halda origin) in grow-out pond.

Parameters	Initial status (July 2021)	(December 2021)	(June 2022)	(December 2022)	(June 2023)
Length (cm)	46.75±5.12	49.15±4.83	54.82±4.17	58.43±1.60	63.21±3.10
Weight (g)	1385.23±230.37	1642.07±245.41	1907.49±243.13	2716.4±213.62	3254.10±185.6

Table 2. Present status of Catla (The River Jamuna origin) in grow-out pond.

Parameters	Initial status (July 2021)	(December 2021)	(June 2022)	(December 2022)	(June 2023)
Length (cm)	36.80±3.14	39.27±3.48	43.15±3.56	46.66±1.07	52.00±2.09
Weight (g)	498.68±35.14	782.31±34.53	1015.53±46.18	1474±142.10	2225.73±157.2

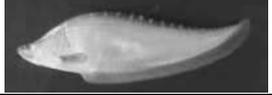
Component B

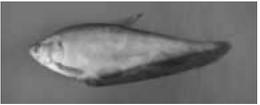
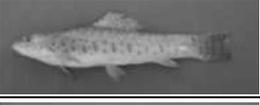
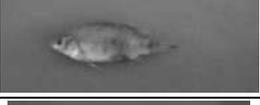
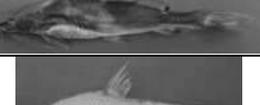
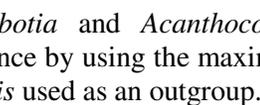
Expt. 1 Identification and Characterization of Selected Freshwater Fishes Based on DNA Barcoding Data

Sample Collection and DNA Isolation

A total of 27 freshwater fish samples were collected from different regions of Bangladesh for DNA barcoding. COI gene was successfully amplified using Fish F1 and Fish R1 primer. The PCR products were purified using a PureLink™ PCR purification kit for sequencing and data analysis. Thermal cycling conditions: initial denaturation at 95 °C for 4 min, followed by 35 cycles of denaturation at 94 °C for 35 sec, primer annealing at 52 °C for 30 sec, and primer extension at 72 °C for 40 sec and final extension for 5 min at 72 °C. Amplified products of COI will be separated on 1.5% agarose gel, and stained with ethidium bromide, followed by gel elution using a spin column-based gel extraction kit as per the manufacturer's instructions. DNA extractions and PCR amplifications were completed for 16 samples.

Table 3. Collected fish specimens for identification at the species level.

SL	Sample ID	Family	Species	Similarity (%)	Photograph
1	ST	Cyprinidae	<i>Tor barakae</i>	100	
2	BT	Cyprinidae	<i>Tor barakae</i>	100	
3	KT 68	Notopteridae	<i>Notopterus notopterus</i>	100	
4	KT 27	Notopteridae	<i>Chitala chitala</i>	100	
5	KT 35	Notopteridae	<i>Chitala chitala</i>	100	

SL	Sample ID	Family	Species	Similarity (%)	Photograph
6	KT 58	Notopteridae	<i>Notopterus notopterus</i>	100	
7	KT 65	Cobitidae	<i>Acanthocobitis zonalternans</i>	90	
8	KT 61	Badidae	<i>Badis pallidus</i>	99.22	
9	KT 48	Bagridae	<i>Sperata aor</i>	100	
10	KT 47	Bagridae	<i>Sperata aorella</i>	100	
11	KT 39	Cyprinidae	<i>Pethia guganio</i>	99.84	
12	KT 15	Cyprinidae	<i>Cirrhinus reba</i>	100	
13	Ab1	Gobiidae	<i>Glossogobius giuris</i>	99.85	
14	lb1	Cyprinidae	<i>Labeo bata</i>	100	
15	Mb	Cyprinidae	<i>Barilius barila</i>	99.53	

Phylogenetic tree reconstruction:

A phylogenetic tree was reconstructed to differentiate *Acanthocobitis botia* and *Acanthocobitis zonalternans* where both species form separate clades with 0.06 genetic distance by using the maximum likelihood method with 1000 bootstrap value (Figure 2). *Lamellidens marginalis* used as an outgroup.

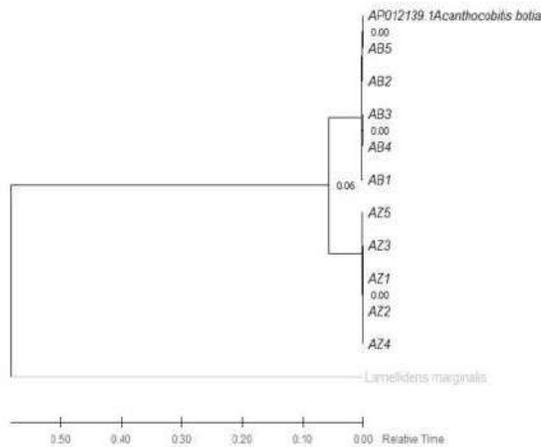


Figure 2. Phylogenetic tree of *Acanthocobitis botia* and *Acanthocobitis zonalternans*.

Library and Documentation

Bangladesh Fisheries Research Institute Library and Documentation Centre (FRILDOC) act as a repository of literature and technical information and provides latest information on scientific research and experimental development in all branches of fish and fisheries. The most of the FRILDOC collection backup on the subjects: aquaculture, brackish water aquaculture, mariculture, marine science, biology, ecology, environmental science, agriculture, life sciences, sea weeds, plankton, food processing, feeds, zoology, botany, geography, economics, marketing, geology, socioeconomics, rural development etc. The library has 9108 technical and general books 186 titles of scientific periodicals 5120 miscellaneous publications. In addition to above collection, the library has kinds of reference books, academic dissertations, government and others departmental publications.

ক্রমিক নম্বর	প্রকাশনার নাম	প্রকাশনার ধরণ
১.	বিলুপ্তপ্রায় মাছের প্রজনন ও চাষ প্রযুক্তি নির্দেশিকা	প্রযুক্তি নির্দেশিকা
২.	Bangladesh Journal of Fisheries Research Vol. 19(1-2), 2020	জার্নাল
৩.	বৈরালি মাছের কৃত্রিম প্রজনন ও পোনা উৎপাদন কৌশল	লিফলেট
৪.	জাতপুঁটি মাছের কৃত্রিম প্রজনন ও পোনা উৎপাদন	লিফলেট
৫.	আঙ্গুস মাছের প্রজনন ও পোনা উৎপাদন কৌশল	লিফলেট
৬.	খলিশা মাছের কৃত্রিম প্রজনন ও পোনা উৎপাদন কলাকৌশল	লিফলেট
৭.	স্বল্পমূল্যে বাণিজ্যিক গুরুত্বসম্পন্ন স্পিরুলিনা চাষ প্রযুক্তি কৌশল	লিফলেট
৮.	Fisheries Newsletter	নিউজলেটার

The FRILDOC is operating in fully automated environment. The various activities of the centre have been computerized using Library Management Information System (LMIS) software.

The FRILDOC provides the following documentation services:

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- Current Awareness Service
- i) Current Content Service
- ii) Monthly Accession list
- iii) Monthly News paper Articles
- Reference service
- Bibliographical service
- Abstracting service
- SDI (Selective Dissemination Information) Service
- Internet Service
- Photocopy Service
- ASFA (Aquatic Sciences and Fisheries Abstract) DVD Service
- TEEAL (The Essential Electronic Agricultural Library) Service
- Digital Library Service (BFRI in Aquatic Commons digital repository (http://aquaticcommons.org/view/issuing_agency/Bangladesh_Fisheries_Research_Institute.html)).
- Hinari, AGORA, OARE, ARDI and GOALI (The Research4Life programme) Service

During the reporting period of July 2020 to June 2022, a number of books, Journals, periodicals etc. procured for the library. The library has also received a noticeable number of books journals, periodicals, proceedings, research reports, annual report, newsletters and magazines on complimentary and exchange basis. The library-maintained exchange programme with more than 75 leading national and International organizations. The category wise list is shown below:

Conservation and Seed Production of Indigenous Fish Species in Bangladesh

Researchers

Dr. Md. Moshir Rahman, SSO

Md. Shahin Alam, SO

Al-Amin, SO

Objectives

- To collect and domesticate Hiralu (*Barilius bendelisis*), Gang tengra (*Gagata youssoufi*) Garua (*Clupisoma garua*) and Shal Baim, (*Mastacembelus armatus*)
- To study the reproductive biology of the Garua (*Clupisoma garua*)
- To optimize hormone doses for Shal Baim, (*Mastacembelus armatus*) and Titputi (*Pethia ticto*) for mass seed production
- To collect indigenous freshwater fish species from different regions for live gene-bank

Achievements

Experiment 1. Collection and domestication of Hiralu (*Barilius bendelisis*), Gang tengra (*Gagata youssoufi*) Garua (*Clupisoma garua*) and Shal Baim, (*Mastacembelus armatus*)

Hiralu (*B. bendelisis*)

A total of five hundred (500) Hiralu (*B. bendelisis*) were collected from Brahmaputra River of Mymensingh (Figure 1) and stocked at the rate of 30-35/decimal in the pond at Freshwater Station, BFRI having an area of 10 decimal and 1m or 0.8m water depth. Fishes were reared with supplementary feed @ of 4-5% body weight twice daily for raising gonad development. Supplementary feed was used twice a day at 8.00am and 4.00pm.

Gang tengra (*G. youssoufi*)

A total of five hundred (500) Gang tengra (*G. youssoufi*) were collected from Brahmaputra River of Mymensingh (Figure 1) and stocked at the rate of 30-35/decimal in the previously prepared pond at Freshwater Station, BFRI having an area of 10 decimal and 1m water depth. Fishes were reared by supplying commercial feed @ of 4-5% body weight twice daily.

Garua (*C. garua*)

A total of five hundred (500) Garua (*C. garua*) were collected from Brahmaputra River of Mymensingh (Figure 1) and stocked at the rate of 30-35/decimal in the pond at Freshwater Station, BFRI having an area of 10 decimal and 1m or 0.8m water depth. Fishes were reared with supplementary feed along with chicken viscera @ of 4-5% body weight twice daily for raising gonad development. Supplementary feed was used twice a day at 8.00am and 4.00pm.

Shal Baim, (*M. armatus*)

A total of five hundred (500) Shal Baim, (*M. armatus*) were collected from Brahmaputra River of Mymensingh (Figure 1), Dingaputa haor, Ichapur haor of Netrokona and stocked at the rate of 30-35/decimal in hapa which is placed in the pond at Freshwater Station, BFRI having an area of 10 decimal and 1m or 0.8m water depth. Fishes were reared with supplementary feed along with live chingri and fish paste. After gonadal development breeding program were done.



Figure 1 : Collection activities of different fish

Experiment 2. Study of the reproductive biology of the Garua (*Clupisoma garua*)

Collection of fish samples

The experiment was carried out for a period of 6 consecutive months, in the Freshwater Station, Bangladesh Fisheries Research Institute, Mymensingh. Total numbers of 10 female and 10 male of Garua (*Clupisoma garua*) were collected from Brahmaputra River of Mymensingh in each month, through the fishermen for the determination of fecundity and Gonado-Somatic Index.

Gonado-Somatic- Index (GSI)

Gonado-Somatic Index (GSI) of female and male Garua (*Clupisoma garua*) was calculated during January 2023 to June 2023 and Month-wise changes in mean GSI values of female and male are presented in Table 1 and 2.

Table 1. Detail data and GSI values of female Garua (*Clupisoma garua*) from July 2022 to June 2023.

Month	No. of fish examined	Body Length of fish (cm)	Body wt. of fish (g)	Ovary wt. (g)	GSI (%)
September	10	17.0–28.8	70.0–248.0	0.24–2.27	0.80
October	10	17.3–19.5	80.0–123.0	0.72–0.83	0.77
November	10	14.8–19.0	23.0–91.0	0.03–0.75	0.31
December	10	13.4–19.5	24.0–119.0	0.03–1.68	0.41
January	10	18.5-20.1	75.0-167.0	0.29 - 1.82	0.57
February	10	17.56-22.3	73.0-176.0	0.33-2.07	0.65
March	10	17.90-23.5	86.0-180.0	0.41-2.10	0.76
April	10	18.50-26.2	81.0-205.0	0.40-2.15	0.81
May	10	20.31-32.5	90.1-224.5	0.56-2.20	0.84
June	10	21.90-33.3	91.5-229.3	0.63-2.69	0.96
July	10	22.69-33.9	92.6-231.5	0.91-2.96	1.03
August	10	23.53-34.5	94.6-238.8	0.67-2.71	0.93

Table 2. Details data and GSI values of male Garua (*Clupisoma garua*) from from July 2022 to June 2023.

Month	No. of fish examined	Body Length of fish (cm)	Body wt. of fish (g)	Gonad wt. (g)	GSI (%)
September	10	5.5-7.1	14.0-18.0	0.32-1.36	0.61
October	10	5.4-7.0	12.0-19.0	0.35-0.98	0.54
November	10	5.9-7.3	14.0-18.3	0.16-0.53	0.43
December	10	6.2-7.5	13.5-20.2	0.24-1.02	0.32
January	10	6.5-8.1	16.6-22.6	0.26-0.98	0.46
February	10	7.1-8.3	16.9-23.3	0.29-1.21	0.63
March	10	7.4-8.5	17.0-23.6	0.31-1.30	0.67
April	10	7.6-8.7	17.0-24.1	0.33-1.35	0.69
May	10	7.8-9.0	17.4-25.0	0.35-1.40	0.70
June	10	8.1-9.5	17.3-26.0	0.42-1.69	0.86
July	10	8.2-9.6	17.9-28.0	0.56-1.73	0.98
August	10	8.2-9.8	17.6-28.6	0.48-1.39	0.73

Experiment 3. Optimization of induced breeding technique of Shal Baim, *Mastacembelus armatus* and Titputi (*Pethia ticto*)

Induced breeding trials of Titputi (*Pethia ticto*) were conducted during April-June, 2023 (Figure 2). In this trials, different dose of PG Hormone *viz.* 4, 6, and 8 mg/kg body weight of female fishes were used to refine the breeding trials that before were done. On the other hand, male fishes were treated with 2, 3, and 4 mg/kg body weight. Single dose was applied in male and female fishes. Matured male and female fishes were collected from the pond early in the morning. After six hours of conditioning, different doses of PG hormone were used for induced breeding of Titputi (*Pethia ticto*). The efficacy of PG hormone doses on Titputi (*Pethia ticto*) and observed and collected data on ovulation, fertilization, hatching and survival rates are summarized and shown in Table 3.

Table 3. Details of synthetic hormone doses on Titputi (*Pethia ticto*) and corresponding data on ovulation, fertilization, hatching and survival rates during study period

Treatments	Mean Body weight (g)		1 st Injection dose (mg/kg)		Ovulation period (hrs)	Ovulation rate (%)	Fertilization rate (%)	Hatching period (hrs)	Hatching Rate (%)	Incubation Temp. (°C)	Remarks
	Male	Female	Male	Female							
T ₁	6.01±0.40	12.84±2.10	2.0	4.0	6	71.5 ±4.0	75.4 ±5.0	22	76.94±13.79	30	Ovulation, Successful fertilization & hatching
T ₂	5.90±0.82	11.61±2.90	3.0	6.0	6	90.5 ±5.0	90.4 ±8.0	22	89.94±13.79	30	Ovulation, Higher fertilization & hatching
T ₃	5.73±0.24	11.30±4.20	4.0	8.0	6	-	-	-	-	-	No Ovulation

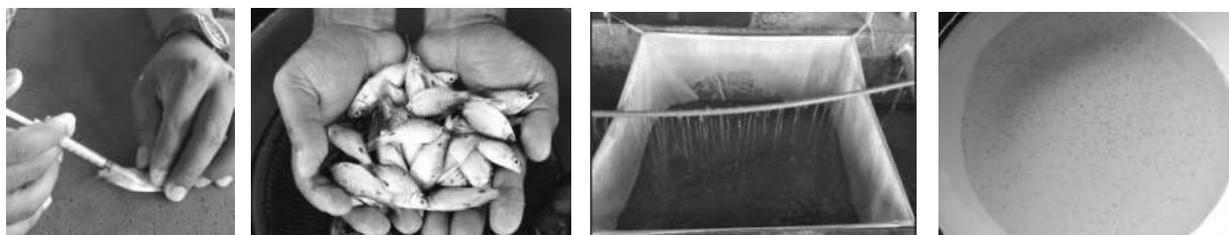


Figure 2 : Breeding activities of Titputi (*Pethia ticto*)

Induced breeding trials of Shal Baim, (*M. armatus*) were conducted during June 2022-September, 2023. In this trials, different dose of PG Hormone viz. 30,40 and 60 mg/kg body weight of female fishes were used to refine the breeding trials that before were done. On the other hand, male fishes were treated with 15, 20 and 30 ml/kg body weight. Single dose was applied in male and female fishes. Matured male and female fishes were collected from the pond early in the morning. After six hours of conditioning, different doses of PG hormone were used for induced breeding of Shal Baim, (*M. armatus*). The efficacy of PG hormone doses on Shal Baim, (*M. armatus*) and observed and collected data on ovulation, fertilization, hatching and survival rates are summarized and shown in Table 4.

Table 4. Details of synthetic hormone doses on Shal Baim, (*M. armatus*) and corresponding data on ovulation, fertilization, hatching and survival rates during study period

Treatment	Mean Body weight (g)		Dose of Injection, PG (mg/kg)		Ovulation period (hrs)	Ovulation rate(%)	Fertilization rate (%)	Hatching period (hrs)	Hatching Rate (%)	Incubation Temp. (oC)	Remarks
	Male	Female	Male	Female							
T ₁	120±4.5	170±5.5	15	30	-	-	-	-	-	-	
T ₂	135±5.8	180±6.8	20	40	35-42	90	85±2.0	40-45	65±30	30	Ovulation, Successful fertilization & hatching
T ₃	125±8.3	165±4.3	30	60	-	-	-	-	-	-	



Picture: Breeding activities of Shal Baim (*M. armatus*)

Exp. 04: To collect indigenous freshwater fish species from different regions for live gene-bank

A live gene-bank has been established at BFRI, 2020. There are about 260 freshwater fish species in Bangladesh, among them 112 species have been collected and stocked in different pond based on their food and feeding habit having an area of 40 decimals. During stocking, initial length and weight of the collected fish was recorded. Fishes are being reared by supplying commercially floating feed @ of 2-3% body weight twice daily. Physico-chemical parameters of pond water viz-water temperature, pH, DO and ammonia are being monitored at monthly interval. Feed ration are being adjusted monthly.

Identification of etiological agents responsible for fish diseases using PCR techniques and mitigation measures

Researchers

Dr. Md. Shirajum Monir, SSO
Farjana Jannat Akhi, SO

Objectives

- To isolate and identify the causal agents responsible for emerging fish diseases with special references to catfishes (Gulsha, Tengra, Pabda and Pangus)
- To detect the etiological agents based on PCR techniques
- To determine the pathogenicity and antibiotic sensitivity of isolated pathogens
- To develop inactivated whole-cells fish vaccines with the local isolated bacteria against the emerging fish diseases

Achievements

1. Collection of infected Pangus

The samples of Pangus (*Pangasianodon hypophthalmus*) were collected due to fish death report in different cultured ponds in greater in the infected pangas farms is up to 60 to 80% acute, and numerous fish died within two weeks. Around 90% infected fish showed gross lesions that were associated with motile septicemia, including necrosis and haemorrhages of fins and tails (Figure 1a). Ocular haemorrhages accompanied by exophthalmia were occasionally observed affecting some of the infected fish, alongside extensive erosive skin lesions affecting the dorsal half of the body. Upon dissection, the liver and spleen of most of the affected fish were enlarged with moderate to severe congestion (Figure 1b).

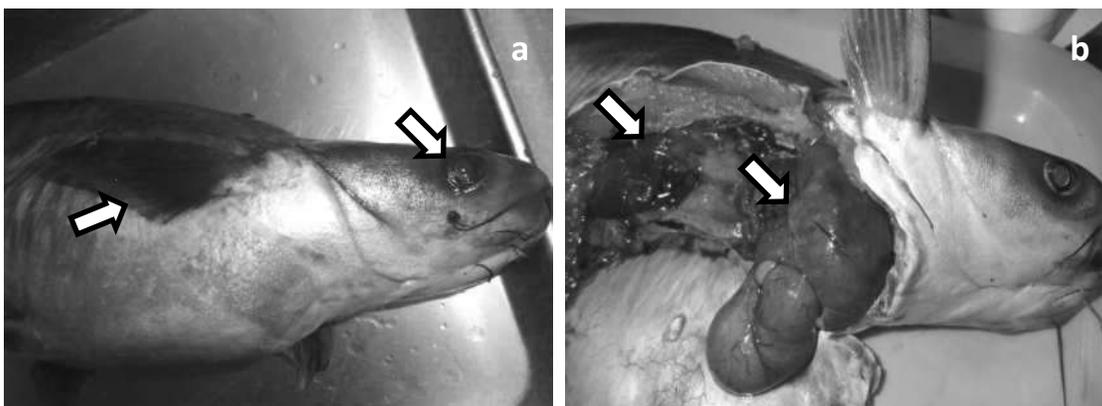


Figure 1. Gross lesions observed in necropsied with suspected *Aeromonas* sp. infection: (a) Infected Pangas with fin erosions and haemorrhages (thick arrow); and (b) haemorrhagic with enlarged liver, kidney and spleen (thick arrow).

2. Biochemical and molecular tests for the isolated bacterial from infected Pangus

Aeromonas sp. and *Edwardsiella* sp. bacteria were detected in the skin and fin lesions, liver, kidney, and brain of the affected Pangus, as showed in Table 1. The identified *Aeromonas* sp. strains exhibited positive results for motility, oxidase, O/F, VP, catalase, indole, H₂S production, and nitrate reduction tests, while MR and urease production tests showed negative results (Figure 2). On the other hand, the remaining isolated strains were classified as oxidative Gram-negative rods and tested negative for indole,

H₂S production, nitrate reduction, and urease production, but were sensitive to the O/129 test. Furthermore, *Edwardsiella* sp. were isolated from the internal organs of moribund or dead fish. They showed fermentative capacity, positive catalase activity and negative oxidase activity. Additionally, the strain of *Edwardsiella* sp. showed motile and nitrate reduction test was positive whereas, MR, VP, indole and urease production tests were negative.

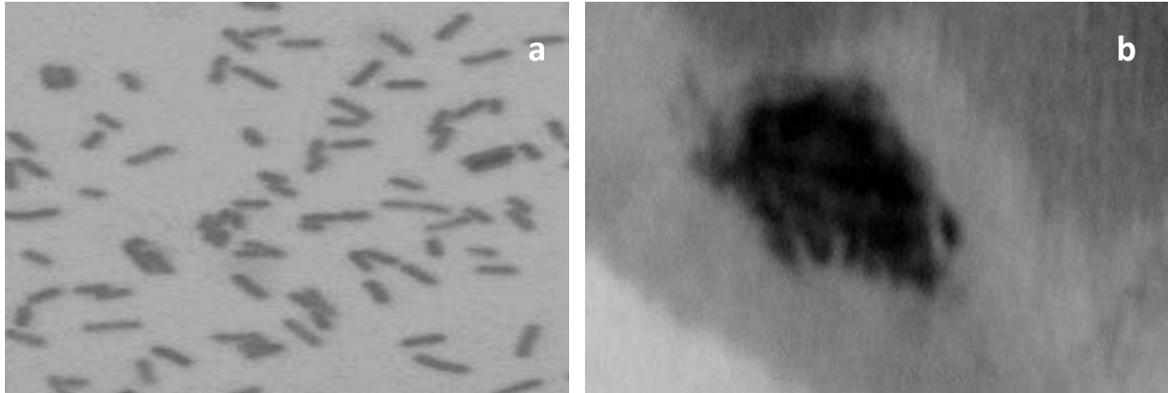


Figure 2. Micrograph of Gram staining of *Aeromonas* isolated from infected Pangus. (a) The color of cell bacteria was red, Gram-negative and straight rod; and (b) Oxidase-positive.

Table 1. Biochemical characteristics of the isolated bacteria from infected Pangus

Test name	Isolated bacteria											
	Ah 11-22	Ah 12-22	Ah 13-22	Ah14-22	Av 15-22	Av 16-22	Av 17-22	Av 18-22	Ei 19-22	Ei 20-22	Ei 21-22	Ei 22-22
Gram staining	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
Motility	+	+	+	+	-	+	+	+	+	+	+	+
Oxidase test	+	+	+	-	+	+	+	-	-	-	-	-
O-F test	+	+	+	+	+	+	+	+	F	F	F	F
MR test	+	-	d	-	-	-	-	-	-	-	-	-
VP test	+	-	+	+	+	+	+	+	-	-	-	-
Catalase test	+	+	-	+	+	+	-	+	+	+	+	+
Indole test	+	+	-	+	-	+	+	+	-	-	-	-
H ₂ S production	+	+	+	d	+	+	+	+	-	-	-	-
Nitrate reduction	+	d	-	+	-	+	+	+	+	+	+	+
Urease production	d	-	-	-	+	d	-	+	-	-	-	-
TSI test	K/A	A/A	K/A	A/A	K/A	A/A	K/A	A/A	A/K	A/K	A/K	A/K
Production of acid from												
Glucose	+	-	+	+	+	+	-	+	+	+	+	+
Galactose	+	+	+	+	d	+	-	d	+	+	+	+
O/129 test (10 µg & 150 µg)	R	R	R	R	R	R	R	R	S	S	S	S

A total of 120 samples of diseased Pangus were examined, and as a result, 97 bacterial strains were isolated (Table 1). The anatomical parts of the infected Pangus that had the highest isolation frequencies for these 97 strains were lesions (skin and fin) at 44.33%, liver at 23.71%, kidney at 17.53%, and brain at 14.43%.

Table 2. Bacteria isolated from different organs of infected Pangus

Isolated bacterial strains	Distribution (Number & %) of different bacterial stains (n=50) according to site of isolation				Total
	Anatomical parts of infected Pangus				
	Infected area (skin & fin)	Liver	Kidney	Brain	
Ah 12-22	3(3.09)	3(3.09)	2(2.06)	1(1.03)	9(9.28)
Ah 14-22	5(5.15)	2(2.06)	3(3.09)	0(0.00)	10(10.31)
Ah 16-22	7(7.22)	6(6.19)	3(3.09)	0(0.00)	16(16.49)
Av 17-22	8(8.25)	3(3.09)	2(2.06)	2(2.06)	15(15.46)
Av 18-22	11(11.34)	4(4.12)	4(4.12)	4(4.12)	23(23.71)
Ei 19-22	4(4.12)	2(2.06)	1(1.03)	3(3.09)	10(10.31)
Ei 22-22	5(5.15)	3(3.09)	2(2.06)	4(4.12)	14(14.43)
Total	43(44.33)	23(23.71)	17(17.53)	14(14.43)	97(100.00)

Table 3. Antibiotics sensitivity test on isolated bacteria from infected Pangus

Isolated bacterial strains	Antibiotic sensitivity									
	Oxy	Chl	Cef	Cip	Lev	Step	Dox	Azi	Ery	Pen
Ah 11-22	+	+	++	++	++	+	+	++	+	-
Ah 12-22	-	-	+	++	+	+	+	++	+	-
Ah 13-22	-	-	++	+++	++	-	++	++	++	-
Ah 14-22	+	+	++	++	++	+	++	++	+	-
Av 15-22	+	++	++	++	+++	+	+	-	-	-
Av 16-22	-	+	++	+++	+	-	-	+	++	-
Av 17-22	+	+	-	++	++	+	+	-	+	-
Av 18-22	+	+	++	+	+++	-	-	++	++	-
Ei 19-22	+	+	++	++	+	-	+	+	++	+
Ei 20-22	-	+	+	+	+	+	-	++	++	+
Ei 21-22	++	+	+	+	++	-	++	+	++	+
Ei 22-22	-	+	+++	++	++	+	+	++	++	+

4. Susceptibility to antimicrobial agents in-vitro condition

All of the bacterial strains that were isolated during the study were found to be susceptible to ciprofloxacin, levofloxacin and azithromycin. Ciprofloxacin and levofloxacin exhibited a high level of effectiveness against *Aeromonas* sp. except for *Edwardsiella* sp, as shown in Table 3. However, ampicillin and penicillin showed no efficacy against *Aeromonas* sp. and *Edwardsiella* sp.

5. Virulent test of the isolated bacteria for vaccine development

To help ascertain which isolates to select for vaccine development, the virulence of a selection of *A. hydrophila* and *A. veronii* isolates were assessed following the intraperitoneal (ip.) infection challenges. Thirty out of thirty-five isolates with a history of causing severe mortality in farmed fish (higher than 80%) were selected as virulent isolates and five isolates eliciting low mortality (less than 40%) was selected as an avirulent isolates.

6. Preparation of formalin inactivated whole-cells bacterial vaccines

The pathogenic bacterial strains of *Aeromonas hydrophila* and *A. veronii* were used to develop inactivated whole-cells vaccines for pangas. Briefly, the selected bacterial stocks of *Aeromonas*

hydrophila and *A. veroni* were grown individually on TSA (Oxoid; Hampshire, UK) plates for overnight at 28 to 30 °C. Then, 10 colonies from each cultured bacteria were inoculated into two separate flasks of 500 mL containing brain heart infusion broth (BHIB; Oxoid, Hampshire, UK) and cultured in an incubator at 130 rpm for 24 h at 30 °C. After incubation, 10-fold serial dilution and colony counts were utilized to determine each of the bacterial concentrations by following the standard method. The *A. hydrophila* and *A. veronii* bacterial cells were re-suspended separately in sterile PBS solution to keep the final bacterial concentration of 3.6×10^9 CFU/mL. Each of the propagated bacteria was then inactivated through adding around 0.5% formalin and left at 4 °C for overnight. Afterwards, the inactivated bacteria were harvested by using a refrigerated centrifuge at $6000 \times g$ for 14 min and washed with sterile phosphate buffered saline (PBS). After that, the vaccine was prepared by combining both the inactivated whole-cells (FICs) of the monovalent *A. hydrophila* and *A. veronii* vaccines at a ratio of 1:1 and finally by adding of Freund's complete adjuvant (FCA).

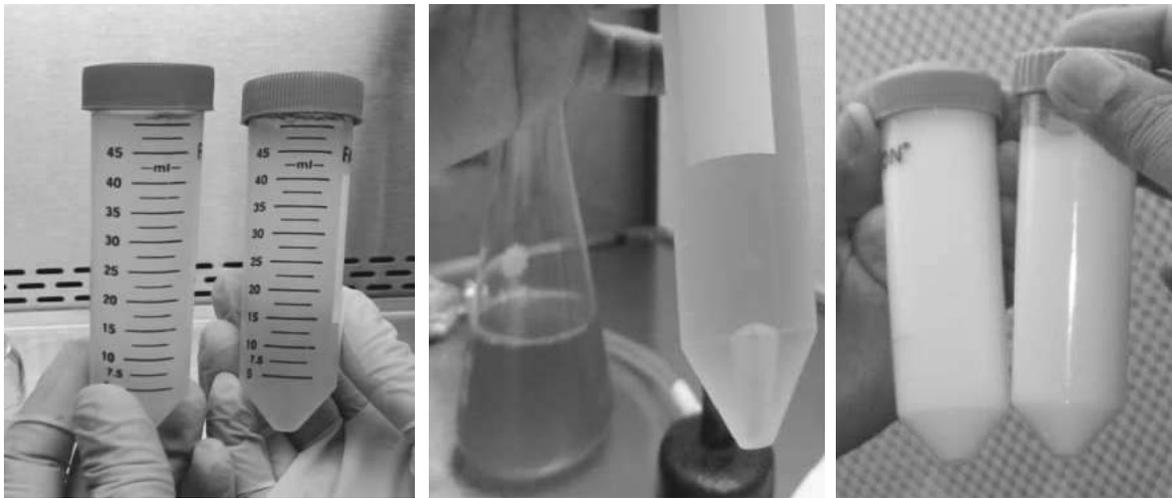


Figure 3. Inactivated whole-cells pellets of *Aeromonas hydrophila* and *A. veronii* after centrifuged and formulated vaccine after mixing with Freund's complete adjuvant (FCA).

7. Quality and safety tests of the developed vaccines

Prior to vaccination trials, the sterility and safety of the prepared vaccines were verified following the standard methods. There was no indicative signs of diseases after vaccination in laboratory trials, which indicates the prepared vaccines are safe for immunization of Pangus.

8. Immunization of broodstock with inactivated vaccine, breeding and sampling

Before vaccination and blood sampling, the selected male and female Pangus broodfish were anaesthetized. The broodfish were vaccinated by interperitoneal (i.p.) injection with 0.4 mL/kg fish (3.6×10^9 CFU/mL). Besides on, the phosphate-buffered saline (PBS) group was a control group where the broodfish were injected with only PBS. All fish were clinically healthy after receiving the vaccines. The immunized male and female broodfish were allowed to breed in hatchery after one month vaccination. The larvae samples at 5, 10, 15, and 20 days after hatching were collected from the immunized and non-immunized groups and all samples were stored at -80 °C for further use to determine the antibody (IgM) level, lysozyme and phagocytosis.



Figure 4. Immunization of brood Pangus with inactivated whole-cells vaccines in Freshwater Station hatchery, BFRI, Mymensingh.

Ecological assessment of inland open water fisheries population with bio-physicochemical properties to frame EBFM approach (Comp-A)

Researchers

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Objectives

- To estimate population ecology and diet composition of some commercially significant inland (*haor* and *beel*) open water fishes
- To assess bio-physicochemical properties of inland water bodies (*haors* and *beels*) with the seasonal variation
- To assess stock of commercially significant open water fish groups through using modern technique based on catch and CPUE data
- To assist for farming or formulating ecosystem based management approach for inland open waters with emphasizing to increase productivity and conservation of the fisheries resources

Achievements

Water quality parameters of the studied haors from July 2022 to June 2023

Water quality parameters observed and recorded during the study were summarized in Table 2. Water quality parameters measured for the three haors and different seasons. Water temperature varied from $30.28 \pm 4.51^\circ\text{C}$ (Pre-monsoon) to $22.57 \pm 2.19^\circ\text{C}$ (post-monsoon), water transparency was $39.17 \pm 5.68\text{cm}$ (pre-monsoon) to $26.57 \pm 0.52\text{cm}$ (Monsoon), Depth from $5.79 \pm 2.42\text{m}$ (Monsoon) to $1.06 \pm 1.56\text{m}$ (pre-monsoon), DO was $8.14 \pm 1.46\text{mg/L}$ (Post-monsoon) to $4.51 \pm 0.69\text{mg/L}$ (pre-monsoon) and water pH was 7.89 ± 1.17 (Post-monsoon) to 7.02 ± 0.51 (pre-monsoon). $\text{NO}_3\text{-N}$ was $0.37 \pm 0.08\text{mg/L}$ (pre-monsoon) to $0.14 \pm 0.01\text{mg/L}$ (monsoon), $\text{PO}_4\text{-P}$ was $1.91 \pm 0.61\text{mg/L}$ (pre-monsoon) to $1.15 \pm 0.01\text{mg/L}$ (monsoon). Total alkalinity and TDS was higher in pre-monsoon (127.59 ± 6.25 and 121.37 ± 12.76) and lower in monsoon (101.42 ± 4.23 and 76.25 ± 5.24) season in the studied haor.

Plankton analysis

A total of 41 phytoplankton species were identified under 4 classes. A total of 20 genera of Chlorophyceae, 11 genera of Bacillariophyceae, 7 genera of Cyanophyceae and 3 genera of Euglenophyceae classes were listed from the study area Table 3. A total of 13 groups of zooplankton were identified i.e. Rotifera, Cladocera and Copepoda in studied haors. A total of 5 genera of Rotifera, 4 genera of Copepoda and 4 genera of Cladocera were identified during the study period in the studied haors. Analysed plankton groups with their abundance value in different sampling seasons at the studied haors are shown in Figure 1. Pre-monsoon showed higher abundance of phytoplankton and post-monsoon exhibit higher abundance of zooplankton in the studied haor whereas shown lowest phytoplankton and zooplankton found in monsoon season in Figure 3. Chlorophyceae was the dominant among the four phytoplankton groups. Phytoplankton groups were arranged in order of Chlorophyceae > Bacillariophyceae > Cyanophyceae > Euglenophyceae in all the studied locations Figure 4, 5. Among the zooplankton, Rotifera was the most dominant followed by Cladocera and Copepoda Figure 1 and 2.

Table 2. Seasonal variation of water quality parameters of studied Haor during (July 2022- June 2023).

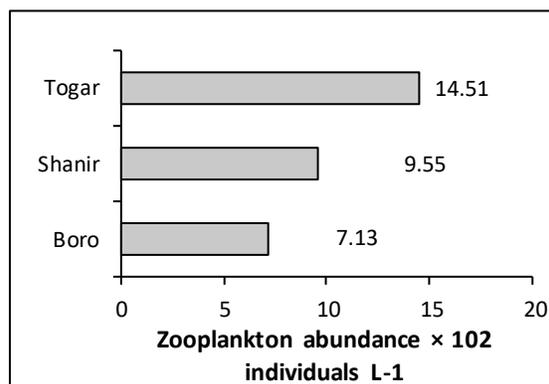
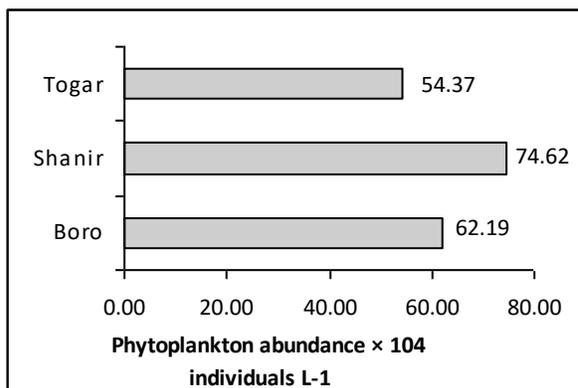
Parameters	Boro Haor			Shanir Haor			Togar Haor		
	Mon	Post-mon	Pre-Mon	Mon	Post-mon	Pre-Mon	Mon	Post-mon	Pre-Mon
Temperature (°C)	28.61 ±0.63	22.57 ±2.19	30.06 ±0.63	28.81 ±0.74	22.67 ±4.91	29.26 ±3.28	28.54 ±1.35	24.08 ±4.29	30.28 ±4.51
Transparency (cm)	26.57 ±0.52	31.74 ±4.15	36.47 ±5.13	29.18 ±6.24	33.58 ±5.09	38.61 ± 7.39	27.92 ±4.27	32.18 ±7.30	39.17 ±5.68
Depth (m)	5.13 ±1.82	2.42 ±0.19	1.80 ±0.89	5.79 ±2.42	2.57 ±2.16	1.06 ±1.56	5.30 ±1.56	2.31 ±2.67	1.46 ±2.67
pH	7.15 ±0.62	7.59 ±0.61	7.02 ±0.51	7.52 ±0.69	7.81 ±0.72	7.24 ±2.13	7.53 ± 2.75	7.89 ±1.17	7.29 ±0.31
DO (mg/l)	4.59 ±0.35	7.66 ±0.68	4.51 ±0.69	5.19 ±0.28	8.14 ±1.46	4.88 ±0.35	5.02 ±1.58	7.83 ±1.61	6.34 ±1.69
NH ₃	0.0±0.01	0.02 ±0.01	0.03 ±0.04	0.01 ±0.01	0.01 ±0.01	0.03 ±0.03	0.01 ± 0.01	0.02 ±0.02	0.03 ±0.03
NO ₃ -N (mg/l)	0.14 ±0.01	0.22 ±0.11	0.36 ±0.04	0.15 ±0.04	0.33 ±0.13	0.37 ±0.08	0.21 ±0.11	0.26 ±0.12	0.34 ±0.13
PO ₄ -P (mg/l)	1.15 ±0.01	1.26 ±0.07	1.35 ±0.13	1.23 ±0.12	1.91 ±0.61	1.62 ±0.56	1.24 ±0.18	1.64 ±0.53	1.87 ±0.61
Total alkalinity (mg/l)	101.42 ±4.23	110.27 ±2.16	125.29 ±7.55	102.11 ±4.91	115.37 ±6.61	127.59 ±6.25	103.80 ±8.27	113.71 ±9.74	126.37 ±8.93
TDS (mg/l)	76.25 ±5.24	92.48 ±7.20	119.68 ±5.64	78.81 ±7.23	101.76 ±8.37	114.25 ±6.58	102.57 ±12.73	108.62 ±15.97	121.37 ±12.76

Table 3. Check list of plankton of the studied areas during study period (2022-2023)

Plankton	Group	Genera	Boro	Shanir	Togar
Phytoplankton	Chlorophyceae	<i>Actinastrum</i>	+	+	—
		<i>Ankistrodesmus</i>	+	—	+
		<i>Chlorella</i>	+	+	+
		<i>Chlamydomonas</i>	+	+	+
		<i>Botryococcus</i>	—	+	—
		<i>Closterium</i>	+	+	+
		<i>Coleochaete</i>	+	—	+
		<i>Cosmarium</i>	+	+	+
		<i>Melosira</i>	+	+	—
		<i>Sorastrum</i>	—	+	+
		<i>Microspora</i>	+	+	+
		<i>Pediastrum</i>	+	+	+
		<i>Spirogyra</i>	+	+	+
		<i>Staurastrum</i>	+	+	+
		<i>Tetraedon</i>	+	+	—
		<i>Scenedesmus</i>	+	+	+
		<i>Ulothrix</i>	+	+	+
		<i>Volvox</i>	—	+	+
		<i>Oocystis</i>	+	+	+
		<i>Coelastrum</i>	+	+	—
	<i>Selenastrum</i>	+	+	—	
	<i>Zygnema</i>	+	—	+	
	Bacillariaophyceae	<i>Eunotia sp</i>	+	+	+
		<i>Asterionella</i>	+	+	—
		<i>Bacillaria</i>	+	+	+

Plankton	Group	Genera	Boro	Shanir	Togar
		<i>Chaetoceros</i>	+	-	+
		<i>Cyclotella</i>	-	+	+
		<i>Fragilaria</i>	+	+	+
		<i>Gyrosigma</i>	+	+	-
		<i>Navicula</i>	+	+	+
		<i>Nitzschia</i>	+	+	+
		<i>Pinnularia</i>	+	+	+
		<i>Surirella</i>	+	+	+
		<i>Rhizosolenia</i>	-	+	-
		<i>Synedra</i>	+	+	+
		Cyanophyceae	<i>Anabaena</i>	+	+
	<i>Spirulina</i>		+	+	+
	<i>Apanizomenon</i>		+	+	+
	<i>Chroococcus</i>		-	-	+
	<i>Microcystis</i>		+	+	+
	<i>Nostoc</i>		+	+	+
	<i>Oscillatoria</i>		-	+	+
	<i>Gomphospheria</i>		+	+	-
	Euglenophyceae	<i>Euglena</i>	+	+	+
		<i>Phacus</i>	+	+	+
		<i>Trachelomonas</i>	-	+	-
Zooplankton	Rotifera	<i>Asplanchna</i>	+	+	+
		<i>Brachionus</i>	+	+	+
		<i>Filinia</i>	+	+	+
		<i>Keratella</i>	+	+	+
		<i>Polyarthra</i>	+	+	+
	Cladocera	<i>Bosmina</i>	+	+	+
		<i>Daphnia</i>	+	+	+
		<i>Diaphanosoma</i>	+	+	+
		<i>Moina</i>	+	+	+
	Copepoda	<i>Cyclops</i>	+	+	+
		<i>Diaptomus</i>	+	+	+
		<i>Macrocyclus</i>	+	+	+
		<i>Mesocyclops</i>	+	+	+

Note: + = present, - = absent



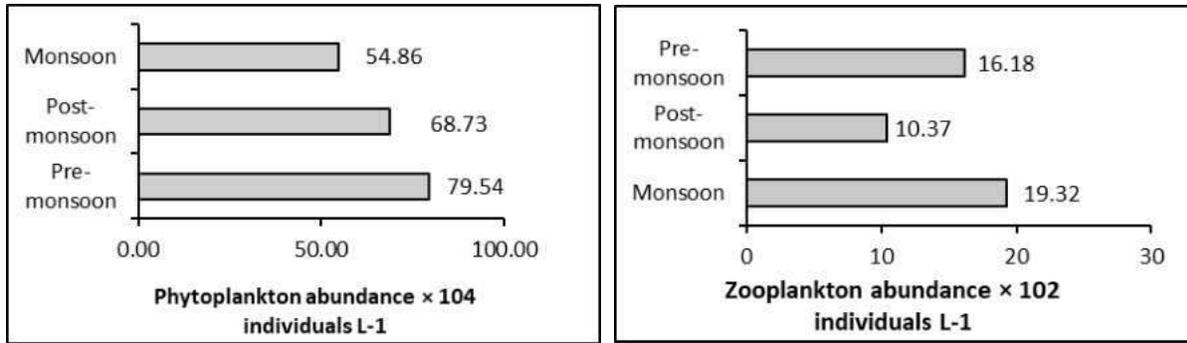


Figure 1: Location and season wise total abundance of Phytoplankton and Zooplankton of Studied haors (2022-2023)

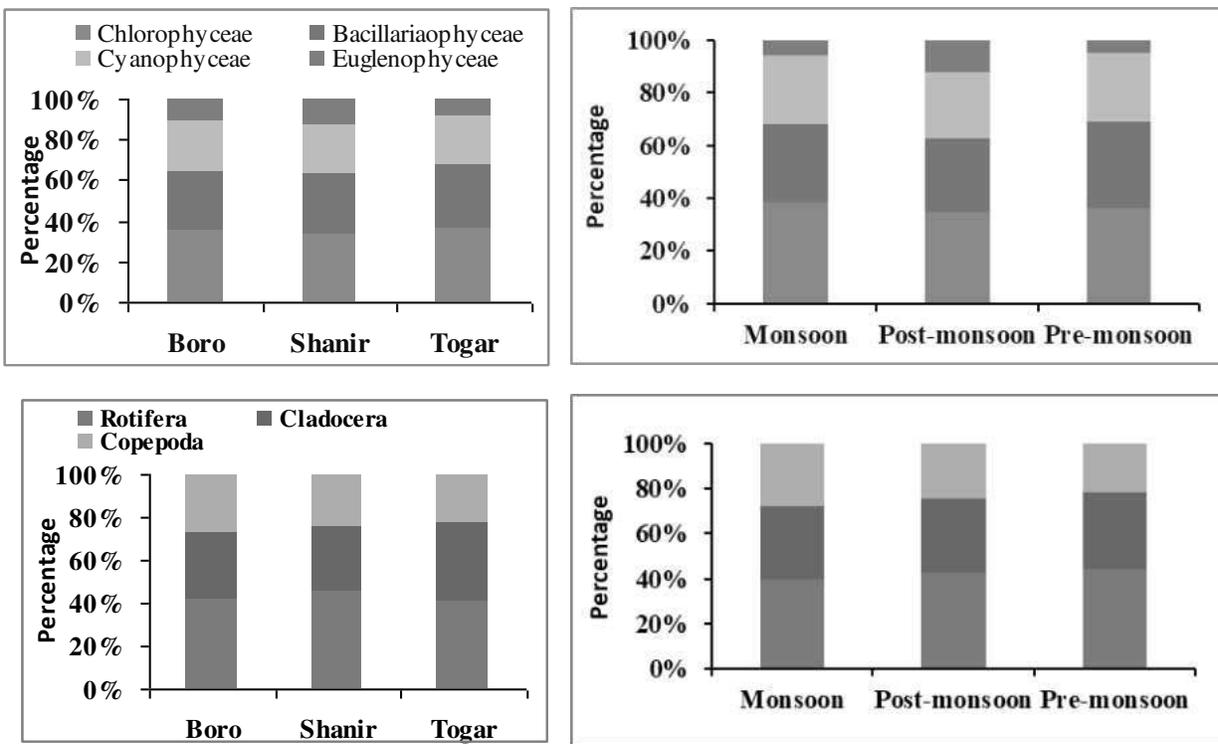


Figure 2. Group wise location and season of percentage of Phytoplankton and Zooplankton of Studied haors during 2022-2023

Fish catch composition and species diversity

A total of 53 fish species was recorded from 20 families and 7 orders (Table 4). Cypriniformes was the largest group in all the studied locations Figure 3. Plantivores was the most dominant trophic groups followed by omnivores and the least dominant trophic was detritivores in all the studied locations Figure 4. Shannon-wiener, Evenness and Margalef richness index of fishes at studied haors during the study period were shown in (Table 5). Shannon index was the highest (4.51) at Shanir haor and the lowest (3.31) at Togar haor. Evenness index was also the highest (0.64) at Shanir and the lowest (0.59) at Togar. Furthermore, Margalef index of richness was the highest highest (5.11) at Shanir and the lowest (4.37) at Togar.

Table 4. Check list of fish of the studied areas during study period 2022-2023.

Order	Family	Local Name	English Name	Scientific Name	Shanir	Boro	Togar
Beloniformes	Belontiidae	Kakila	Freshwater Garfish	<i>Xenentodon cancila</i> (Hamilton, 1822)	+	+	+
		Ek Thuita	Congaturi Halfbeak	<i>Hyporhamphus limbatus</i> (Valenciennes, 1846)	-	+	-
Channiformes	Channidae	Taki, Lata	Spotted Snakehead	<i>Channa punctatus</i> (Bloch, 1793)	+	+	+
		Shol	Stripped Snakehead	<i>Channa striatus</i> (Bloch, 1793)	+	+	+
		Cheng	Walking Snakehead	<i>Channa orientalis</i> (Bloch & Schneider, 1801)	+	+	+
		Gajar	Giant Snakehead	<i>Channa marulius</i> (Hamilton, 1822)	+	+	+
Clupeiformes	Clupeidae	Kachki	Ganges River-Sprat	<i>Corica soborna</i> (Hamilton, 1822)	+	+	+
		Chapila	Indian River Shad	<i>Gudusia chapra</i> (Hamilton, 1822)	+	+	+
Cypriniformes	Cyprinidae	Catla	Catla	<i>Gibelion catla</i> (Hamilton, 1822)	+	+	+
		Rui	Rahu	<i>Labeo rohita</i> (Hamilton, 1822)	+	+	+
		Bata	Bata Labeo	<i>Labeo bata</i> (Hamilton, 1822)	+	+	+
		Kalibaus	Kalbasu	<i>Labeo calbasu</i> (Hamilton, 1822)	+	+	+
		Gonia	Kuria Labeo	<i>Labeo gonius</i> (Hamilton, 1822)	+	+	+
		Mrigel	Mrigal	<i>Cirrhinus cirrhosus</i> (Bloch, 1795)	+	+	+
		Carpio	Common Carp	<i>Cyprinus carpio</i> (Linnaeus, 1758)	+	+	+
		Mola	Mola Carplet	<i>Amblypharyngodon Mola</i> (Hamilton, 1822)	+	+	+
		Chela	Chela	<i>Chela Laubuca</i> (Hamilton, 1822)	+	+	+
		Laacho	Reba	<i>Cirrhinus reba</i> (Hamilton, 1822)	+	+	+
		Baspata	Danio	<i>Devario devario</i> (Hamilton, 1822)	-	+	+
		Dhela	Cotio	<i>Osteobrama cotio</i> (Hamilton, 1822)	+	+	+
		Sar Punti	Olive Barb	<i>Pontius sarana</i> (Hamilton, 1822)	+	+	+
		Jat Punti	Pool Barb	<i>Puntius sophore</i> (Hamilton, 1822)	+	+	+
		Tit Punti	Ticto Barb	<i>Pethia ticto</i> (Hamilton, 1822)	+	+	+
Katari	Large Razor Belly	<i>Salmostoma Bacaila</i> (Hamilton, 1822)	+	+	+		

Order	Family	Local Name	English Name	Scientific Name	Shanir	Boro	Togar
			Minnow				
		Darkina	Flying Barb	<i>Esomus danricus</i> (Hamilton, 1822)	+	+	+
	Cobitidae	Rani	Queen Loach	<i>Botia dario</i> (Hamilton, 1822)	+	+	+
		Rani	Queen Loach	<i>Botia lohachata</i> (Hamilton, 1822)	+	+	+
		Gutum	Guntea Loach	<i>Lepidocephalichthys Guntea</i> (Hamilton, 1822)	+	+	+
Poia	Gongota Loach	<i>Somileptes gongota</i> (Hamilton, 1822)	+	+	+		
Osteoglossiformes	Notopteridae	Chital	Humped Featherback	<i>Notopterus chitala</i> (Hamilton, 1822)	+	+	+
		Foli Kanla	Gray Featherback	<i>Notopterus notopterus</i> (Pallas, 1769)	+	+	+
Perciformes	Anabantidae	Koi	Climbing Perch	<i>Anabas testudineus</i> (Bloch, 1775)	+	+	+
	Ambassidae	Nama Chanda	Glass-Perchlet	<i>Chanda nama</i> (Hamilton, 1822)	+	+	+
		Ranga Chanda	Indian Glassy Fish	<i>Pseudambassis ranga</i> (Hamilton, 1822)	+	+	+
	Gobidae	Bailla	Tank Goby	<i>Glossogobius giuris</i> (Hamilton, 1822)	+	+	+
		Chuno Bele	Glass Goby	<i>Gobiopterus chuno</i> (Hamilton, 1822)	+	+	+
	Mastacembelidae	Tara Baim	Lesser Spiny Eel	<i>Macrognathus aculeatus</i> (Bloch, 1786)	+	+	+
		Guchi	Sriped Spiny Eel	<i>Macrognathus pancalus</i> (Hamilton, 1822)	+	+	+
		Sal Baim	Tire-Track Spiny Eel	<i>Mastacembelus armatus</i> (Lacepede, 1800)	+	+	+
	Nandidae	Bheda, Meni	Mud Perch	<i>Nandus nandus</i> (Hamilton, 1822)	+	+	+
	Osphronemidae	Khalisha	Giant Gourami	<i>Colisa fasciata</i> (Bloch, 1801)	+	+	+
		Lal Khalisha	Dwarf Gourami	<i>Colisa lalia</i> (Hamilton, 1822)	+	+	+
	Pristolepidae	Napte Koi	Badis	<i>Badis badis</i> (Hamilton, 1822)	-	+	-
	Sciaenidae	Poa	Pama	<i>Otolithoides pama</i> (Hamilton, 1822)	-	+	-
Siluriformes	Bagridae	Air	Long Whiskered Catfish	<i>Mystus aor</i> (Hamilton, 1822)	+	+	+
		Tengra	Day's Mystus	<i>Mystus Bleekeri</i> (Hamilton, 1822)	+	+	+
		Gulsha	Gangetic Mystus	<i>Mystus Cavassius</i> (Hamilton, 1822)	+	+	+
		Gulsha	Stripped Dwarf	<i>Mystus vittatus</i>	+	+	+

Order	Family	Local Name	English Name	Scientific Name	Shanir	Boro	Togar
		Tengra	Catfish	(Bloch, 1797)			
		Rita	Rita	<i>Rita rita</i> (Hamilton, 1822)	+	+	+
	Siluridae	Kani Pabda	Butter Catfish	<i>Ompok bimaculata</i> (Bloch, 1797)	+	+	+
		Pabda	Pabda Catfish	<i>Ompok pabda</i> (Hamilton, 1822)	+	+	+
		Boal	Boal	<i>Wallago attu</i> (Schneider, 1801)	+	+	+
		Kajuli	Gangetic Ailia	<i>Ailia coila</i> (Hamilton, 1822)	+	+	+
		Ghaura	Garua Bacha	<i>Clupisoma garua</i> (Hamilton, 1822)	+	+	+
		Bacha	Indus Garua	<i>Eutropiichthys vacha</i> (Hamilton, 1822)	+	+	+
		Shilong	Silond Catfish	<i>Silonia silondia</i> (Hamilton, 1822)	-	+	-
		Sisoridae	Baghair	Gangetic Goonch	<i>Bagarius bagarius</i> (Hamilton, 1822)	+	+
	Gogni		Indian Gagata	<i>Gagata cenia</i> (Hamilton, 1822)	-	-	+
	Clariidae	Magur	Walking Catfish	<i>Clarias batrachus</i> (Linnaeus, 1758)	+	+	+
	Heteropneusti -dae	Shing, Jiol	Stinging Catfish	<i>Heteropneustes fossilis</i> (Bloch, 1794)	+	+	+
	Chacidae	Chaka	Squarehead Catfish	<i>Chaca chaca</i> (Hamilton, 1822)	-	+	+

Note: + = present, - = absent

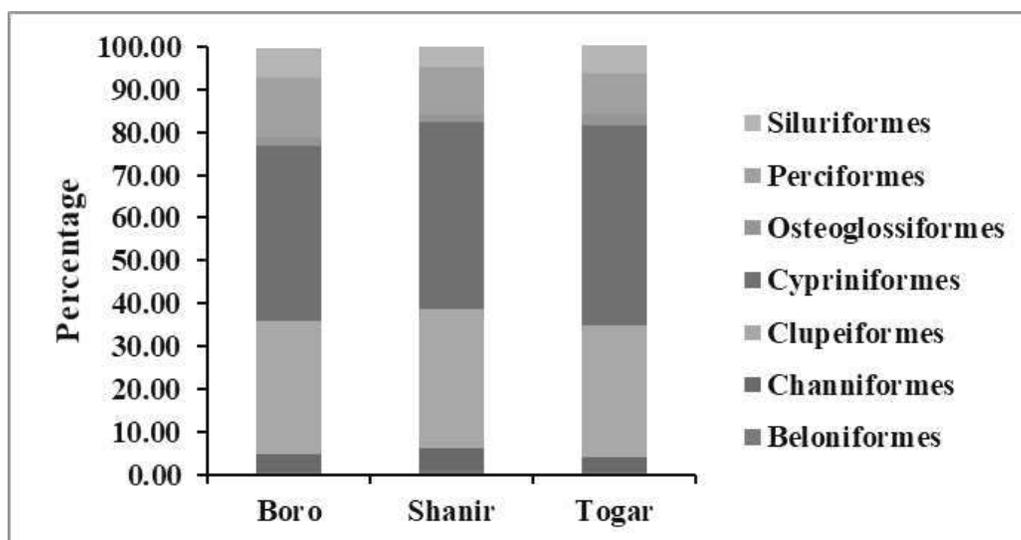


Figure 3. Order wise catch composition of fish at different locations of the studied haors

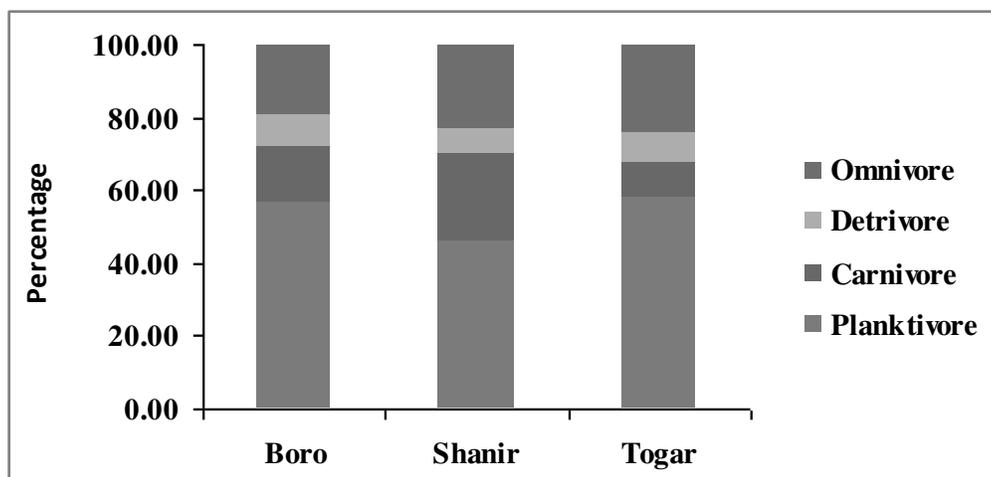


Figure 4. Feeding habit group of fish at different location of the studied haor

Table 5. Analysis of Species Diversity indices during 2022-2023

Haors	Variables	Sampled Spp	Sampled Individuals	Shannon_Diversity Index (H')	Evenness Index (J)	Margalef Richness Value (d)
Boro		46	4819	3.44	0.53	4.16
Shanir		53	6423	4.51	0.64	5.11
Togar		41	4527	3.31	0.59	4.37

Primary productivity

The productivity of studied Haor calculated in terms of gross primary productivity (GPP), Net primary productivity (NPP) and community respiration (CR) results shown in Table 6. There was not much variation in primary productivity among the studied Haor. The highest and lowest GPP, NPP and CR were observed during the pre-monsoon season (2.32 ± 3.55 , 1.32 ± 2.03 and $0.71 \pm 1.06 \text{g.cm}^{-3} \text{ day}^{-1}$) and monsoon season (0.51 ± 2.02 , 0.53 ± 0.15 and $0.57 \pm 0.48 \text{g.cm}^{-3} \text{ day}^{-1}$) at the studied haors. Net Primary Production, Total Biomass, Carrying capacity, Predicted yield of the studied haor shown in Table 7. Net Primary Production, Total Biomass, Carrying capacity, Predicted yield were highest at Shanir haor and lowest at Togar haor during the study period.

Table 6. Seasonal variation of primary productivity of studied Haor during (2022-2023).

Haors	Seasons	GPP (mgC/m ³ /day)	NPP (mgC/m ³ /day)	CR (mgC/m ³ /day)
Boro	Monsoon	0.75 ± 1.16	0.69 ± 1.10	0.26 ± 0.51
	Post-monsoon	1.29 ± 2.12	1.33 ± 1.76	0.44 ± 0.18
	Pre-monsoon	2.18 ± 2.20	1.37 ± 2.26	0.64 ± 1.14
Shanir	Monsoon	0.69 ± 0.54	0.60 ± 1.24	0.38 ± 0.40
	Post-monsoon	1.13 ± 2.08	1.01 ± 2.05	0.62 ± 0.39
	Pre-monsoon	2.25 ± 3.17	1.19 ± 1.16	0.71 ± 1.06
Togar	Monsoon	0.51 ± 2.02	0.53 ± 0.15	0.57 ± 0.48
	Post-monsoon	1.43 ± 2.08	1.22 ± 2.07	0.56 ± 0.27
	Pre-monsoon	2.32 ± 3.55	1.32 ± 2.03	0.65 ± 1.13

Table 7. Estimates of yield, effort and remaining biomass proportion for EMY(Effort corresponding to maximum yield) and E0.1 strategy for selected Haor areas.

Parameter Haors	Net Primary Production t.ha ⁻¹ yr ⁻¹	Total Biomass t.ha ⁻¹ yr ⁻¹	Carrying capacity or MY (Maximum Yield) t.ha ⁻¹ yr ⁻¹	Actual yield (E _{MY} : Effort corresponding to maximum yield) Kg.ha ⁻¹ yr ⁻¹	Predicted yield (Prediction model)Y _{E0.1} (Kg/ha)
Boro	63.14	6.87	1.91	592	1622
Shanir	69.32	7.08	1.95	631	1712
Togar	59.40	6.12	1.79	536	1581

Improvement of Breeding and Culture Technique of Cuchia, *Monopterus cuchia*

Researchers

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Objective of the project

- To refine fry to fingerling of *M. cuchia* rearing technique using different types of feed;
- To develop artificial breeding technique of cuchia, *M. cuchia* using hormones;
- To develop formulated feed for brood management.

Achievements

Experiment 1. Refinement of fry rearing technique of *M. cuchia* using different types of feed

An experiment was conducted to improve rearing technique of *M. cuchia* at the cistern (size: 2.76m²) complex of Freshwater Station, BFRI, Mymensingh during July to August. Nine cisterns were selected, dried and cleaned with lime @ 250 kg/ha and then water was supplied from a deep tube well and filled up to the depth of 1 meter. Baby eel or cuchia fry were stocked @ 50/m² in all Treatments. In Treatment 1, cuchia fry were fed only commercial eel feed. In treatment 2, fry were fed commercial eel feed (50%) comprising with fishmeal (50%). In Treatment 3, cuchia fry were fed commercial eel feed (90%) and earthworm (10%). Vermi or earthworms are being produced in the Vermi Compost Unit. Vermi or earthworm were used as feed ingredients and applied 10 % of total feed utilization. The initial weight in all treatment was 9.21±1.12, 9.17±1.38, 9.28±1.82g. After 30 days of rearing the final weight were 35.81±6.39g in Treatment-1, 35.67±6.59g in Treatment-2, 37.00±4.54g in Treatment-3 where survival rate were 88.53%, 87.76% and 88.92%, respectively.

Table 1. Effects of different types of feed on growth and survival of fry of *M. cuchia*

Treatments	Initial Weight (g)	Final weight (g)	Survival (%)
T ₁ (commercial eel feed)	9.21±1.12	35.81±6.39	88.53±0.06
T ₂ {Com. eel feed (50%) +Fish meal (50%)}	9.17±1.38	35.67±6.59	87.76±0.08
T ₃ {Com. eel feed (90%) +Earthworm (10%)}	9.28±1.82	37.00±4.54	88.92±0.04

Experiment 2. Optimization of hormone doses for artificial breeding technique of cuchia, *M. cuchia*

The experiment was conducted in cistern ecology during 2nd week of March and continued up to the middle of April. Before hormone application cistern was prepared with soil. Brood were collected from natural sources and matured male and female broods acclimatized for 3-4 days in cemented cisterns. Brood were selected based on visual examination of the sexual characteristics *i.e.*, abdomen and genital opening. Brood treated with different types of hormone (PG, LHRH and busserelin). Hormone was injected in the abdomen, in front of the ovary, into each fish body cavity in a single injection. Males were injected with only half the female dose, 24 h later than female. After hormone administration, the fish were stocked in cisterns. After 48h of hormone application gentle abdominal pressure was done for ovulation.

Table 2. Different doses of hormone application

Hormone	Applied doses	
	Female	Male
Trial: 01		
LHRH	T1: 100 µg/kg	50 µg/kg
	T2: 200 µg/kg	100 µg/kg
	T3: 300 µg/kg	150 µg/kg
Trial: 02		
Buserelin	T1: 0.50 mg/kg	0.25 mg/kg
	T2: 0.75 mg/kg	0.35 mg/kg
	T3: 1.0 mg/kg	0.50 mg/kg
Trial: 03		
LHRH (1 st dose)	T1: 200 µg/kg	100 µg/kg
	T2: 200 µg/kg	100 µg/kg
	T3: 200 µg/kg	100 µg/kg
PG (2 nd dose)	T1: 20 mg/kg	10 mg/kg
	T2: 30 mg/kg	15 mg/kg
	T3: 40 mg/kg	20 mg/kg
Trial: 04		
Buserelin	T1: 0.10 mg/kg	0.05 mg/kg
	T2: 0.20 mg/kg	0.10 mg/kg
	T3: 0.30mg/kg	0.15 mg/kg
	T4: 0.40 mg/kg	0.20 mg/kg
	T5: 0.50 mg/kg	0.25 mg/kg
	T6: 0.75 mg/kg	0.35 mg/kg
	T7: 1.00 mg/kg	0.50 mg/kg

After hormone application cuchia were stocked in the cistern and observed up to 14 days. No mortality showed in treated male and females. Most of broods were found to absorb gradually inside their gametes.

Experiment 3. Refinement of brood management technique for breeding of *M. cuchia*

The experiment was conducted from July to June. Pond preparation was done at the end of February by setting glass nylon net. Soil was removed around 0.19/m² from the bottom of the pond and then glass nylon net was placed. Removed soil was further used on the glass nylon net. Deep tube well water was provided in pond. For the experiment, control diet (T₁) was formulated using fish paste+ fish meal+ wheat flour and another experimental diet (T₂) was prepared using same ingredients with vitamin E and minerals. The proximate composition of two diets was done from nutrition lab of FS, BFRI.

Table 3. Proximate composition of diets (dry weight basis)

No.	Sample	Proximate Composition (dry weight basis)			
		Protein (%)	Lipid/Fat (%)	Ash (%)	Moisture (%)
01.	Diet 1 (T ₁)	36.83	4.87	13.73	44.57
02.	Diet 2 (T ₂)	40.71	5.81	13.25	40.23

Stocking density of brood cuchia was maintained 45/decimal where male and female ratio maintained as 1:2. Water hyacinth was provided as shade and shelter. Two Treatments each with two replications was maintained and diets were treated as treatment.

About 2250 nos./decimal from treatment-1 and 2586 nos./decimal baby eel collected from treatment-2. Baby eel has been found strong and good in treatment-2 than treatment-1.



Figure 1. Baby eel collection

Improving Feed Formulation and Quality from Conventional and Non-Conventional Feed Ingredients Supplementation with Amino Acids for Commercially Important Fish Farming

Researchers

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Objectives

- To optimize dietary protein to energy ratio (P/E ratio) for *Anabas testudineus*;
- To evaluate the effect of supplementation limiting amino acids in the formulated diets for commercially important fish species;
- To refine microalgae culture technique for using as fish feed ingredients
- To develop feed formulation and quality from conventional and non-conventional feed ingredients in this fish farming;
- To recommend the potential limiting amino acids as feed additives in the formulated diets;

Achievements

A series of feeding trials were conducted to develop quality feeds with supplementation of synthetic amino acids in plant protein based diets for *A. testudineus*. Two feeding trials on: investigate the optimum dietary protein to energy ratio (P/E ratio (trial-1) and supplementation of synthetic amino acids in plant protein based diets (trial-2) of *A. testudineus* were conducted in an indoor rearing system of Freshwater Station, BFRI, consisting a series of cylindrical fiber glass tanks (70-L each) for 6 weeks. The follow up feeding trial in pond conditions were conducted to develop and optimization of feeds with supplementation of synthetic amino acids in plant protein based diets of *A. testudineus* for 3 months (trial-4) was completed. Details of technical progress of the feeding trials are described below briefly.

Experiment 1. Optimizing dietary protein to energy ratio (P/E ratio) in *A. testudineus*

The feeding trial was carried out in a static indoor rearing system at Freshwater Station, BFRI, consists a series of cylindrical fibre glass tanks (70-L each) for 6 weeks. Same aged and uniform size of each fish fingerlings of *A. testudineus* were randomly distributed of 50 fish per 70-L fiberglass tank. Aeration was used to maintain an adequate level of dissolve oxygen in each test tank for the study. The fish were individually weighed at the start of the experiment and then weekly. Fish weight (fish sampling) was done weekly to adjust the daily feed ration for the following week. At the beginning of the experiment, 15 fish were randomly sacrificed and kept for analysis of whole body composition.

Six experimental diets were formulated to contain two levels of protein (35 and 40%), each with three levels of lipid (5, 10 and 15%), in order to produce a range of protein to energy ratios. Fish meal and mustard oil cake were used as protein source. As a lipid sources, soybean oil was used. Starch and wheat flour were used as sources of carbohydrate. Alphacellulose was used as filler and carboxymethyl cellulose was used 2% as a binder. Vitamin and mineral premix was added 0.20%. Formulated diets and calculated proximate compositions are shown in Table 1. The bite-sized (1.0-2.0 mm) pellet feeds was made with the help of hand pellet machine. Fish were offered the test diets two times daily at the rate of 12-5% of their body weight. Feeding rate was adjusted based on weekly sampling weights of fish. Standard methods were followed for the analysis of proximate composition of the dietary ingredients, experimental diets and fish samples according to AOAC (2003).

Table 1, Formulation and proximate composition of the experimental diets (% dry matter basis) for *A. testudineus*

Dietary Treatments						
Diet no: (Protein/Lipid), (%)	1 (35/5)	2 (35/10)	3 (35/15)	4 (40/5)	5 (40/10)	6 (40/15)
Ingredients:						
Fish meal	35.00	35.00	35.00	50.00	50.00	50.00
Soybean meal	28.00	28.00	28.00	20.00	20.00	20.00
Mustard oil cake	15.00	15.00	15.00	16.00	16.00	16.00
Rice bran (auto)	07.00	7.00	7.00	0.00	0.00	0.00
Starch	12.80	9.60	4.80	11.80	8.80	7.00
Soybean oil	0.00	3.20	8.00	0.00	3.00	4.80
Alpha cellulose	0.00	0.00	0.00	0.00	0.00	0.00
Binder	2.00	2.00	2.00	2.00	2.00	2.00
Vit. and minerals premix	0.20	0.20	0.20	0.20	0.20	0.20
Proximate composition						
Crude protein	35.06	30.05	30.05	35.03	35.04	35.03
Crude lipid	5.50	10.02	15.05	5.80	10.15	15.00
Ash	6.80	6.97	6.97	7.74	7.87	7.87
NFE	39.49	37.04	32.04	34.29	33.09	28.29
GE (kJ g ⁻¹)	17.00	17.43	18.54	17.70	17.97	19.04
P / E ratio	17.62	17.24	16.21	19.79	19.31	18.40

NFE = Nitrogen free extractives, calculated as 100 – (% protein + % Lipid + % Ash + % Fibre)

GE = Gross energy content

P / GE ratio = Protein to energy ratio in mg protein/ kJ⁻¹ GE

Growth performances in terms of final body weight, % weight gain, specific growth rate (SGR, % day) and protein utilization of fish fed the experimental diets were influenced by the levels of protein and energy as lipid (Table 2). Growth rates increased in response to higher dietary protein, but the highest dietary energy level in higher protein diet resulted in reduced weight gain (Table 2). On the basis of growth performance and protein utilization, it may be stated that the diet 2, containing 35% protein and 17.5 kJ/g gross energy performed best. This diet presumably contained the most appropriate P/E ratio 17.24 (16.62 mg protein/ kJ of GE) in *A. testudineus*. However, the optimum dietary protein to energy ratio (P/E ratio) found for 17.24 mg protein/kJ of GE, for a diet containing crude protein 35%, crude lipid 10% and gross energy 17.50 kJ/g.

Table 2. Mean growth performance and feed utilization of *A. testudineus* fed various P/E ratio for 6 weeks

Components	Dietary Treatments					
	1 (35/5)	2 (35/10)	3 (35/15)	4 (40/5)	5 (40/10)	6 (40/15)
Initial weight (g)	1.15 ± 0.07 ^a	1.11 ± 0.05 ^a	1.18 ± 0.03 ^a	1.16 ± 0.05 ^a	1.15 ± 0.04 ^a	1.15 ± 0.02 ^a
Final weight (g)	4.99 ± 0.15 ^d	5.22 ± 0.19 ^b	5.10 ± 0.16 ^c	5.37 ± 0.15 ^b	5.71 ± 0.17 ^a	5.52 ± 0.14 ^{ab}
Weight gain	3.84 ± 0.08 ^d	4.11 ± 0.07 ^{bc}	3.92 ± 0.13 ^{cd}	4.23 ± 0.11 ^c	4.56 ± 0.14 ^a	4.39 ± 0.12 ^b
% Weight gain	333.91 ± 2.54 ^d	370.27 ± 1.63 ^b	332.20 ± 3.05 ^d	364.65 ± 2.15 ^c	396.52 ± 1.67 ^a	388.50 ± 1.84 ^{ab}
Survival rate (%)	93.00 ± 2.00 ^c	94.33 ± 1.53 ^a	94.00 ± 2.00 ^b	92.67 ± 2.31 ^d	93.33 ± 1.15 ^{bc}	93.00 ± 1.73 ^c
FCR	3.28 ± 0.02 ^d	2.77 ± 0.03 ^b	2.82 ± 0.13 ^c	2.86 ± 0.08 ^c	2.61 ± 0.06 ^a	2.69 ± 0.03 ^{ab}
FER	0.31 ± 0.04 ^c	0.37 ± 0.03 ^a	0.35 ± 0.05 ^b	0.35 ± 0.19 ^b	0.38 ± 0.06 ^a	0.37 ± 0.12 ^a
PER	1.42 ± 0.25 ^b	0.75 ± 0.36 ^c	1.36 ± 0.41 ^d	1.55 ± 0.51 ^b	0.89 ± 0.27 ^c	1.84 ± 0.32 ^a
SGR (%/day)	2.62 ± 0.04 ^d	2.75 ± 0.02 ^b	2.65 ± 0.05 ^d	2.74 ± 0.06 ^c	2.86 ± 0.03 ^a	2.80 ± 0.05 ^b

Experiment 2. Effects of supplementation of synthetic amino acids in plant protein based formulated diets in *A. testudineus*

The follow up feeding trial was conducted with a series of cylindrical fibre glass tanks (70-L each) for 6 weeks at Freshwater Station, BFRI based on results from previous study (P/E ratio) in laboratory conditions. The same aged and uniform size of fingerlings of *A. testudineus* were randomly distributed into groups of 50 fish per fiberglass tank and two replicate tanks used for each test diet. Aeration was used to maintain an adequate level of dissolve oxygen in each test tank. Fish were individually weighed at the start and end of the experiment by weekly. Sampling weight of fish was done to adjust the daily feed ration for the following week. Water quality parameter such as temperature, pH, dissolve oxygen and total ammonia were monitored through weekly sampling. At the beginning of the experiment, 15 fishes were randomly sacrificed and kept for analysis of initial whole body composition. At the end of the feeding trial all fish were weighed and survival rate were determined. Five fishes were taken out from each tank for determination of whole body carcass composition.

Five experimental diets (iso-nitrogenous and iso-energetic) were formulated to contain 35% crude protein and around 17.50 kJg⁻¹ of gross energy. Feeds were prepared using locally available fish feed ingredients such as fish meal, soybean meal, mustard oil cake and rice bran in different combinations. Fish meal, soybean meal and mustard oil cake were used as protein sources. Rice bran and starch was used as sources of carbohydrate. Alpha-cellulose was used as filler and carboxymethyl cellulose was used 2% as a

binder. Vitamin and mineral premix was added 0.20%. The limiting amino acids: (i) Lysine and (ii) Methionine were added in the diets following the requirement of fish species. A control diet (diet-1, fish meal based) was prepared without adding amino acid, diets 2-3 were prepared fully and partially replace animal protein with plant protein without amino acids supplementation and diets 4-5 were prepared partially and fully replaced animal protein with plant protein and adding limiting amino acids of lysine and methionine as per requirement levels for thai koi (Table 3). The bite-sized (1.0-2.0 mm) pellet feeds were made with the help of hand pellet machine. The pelleted feeds were sun-dried or dried an oven at 40° C for two days. Each dietary treatment was conducted in duplicate tanks. The fish were offered the experimental and control diets, 2 times daily at the rate of 10-5% of their body weight and feeding rate was adjusted based on weekly sampling (fish weighing) of fish.

Standard methods were followed for the analysis of proximate composition of the dietary ingredients, experimental diets and fish samples according to AOAC (2003). Formulation and proximate composition of the experimental diets (% dry wt.) are shown in the following Table-3.

Table 3. Formulation and proximate composition of the experimental diets (% dry wt.) for *A. testudineus*

Ingredients:	Dietary Treatments				
	1	2	3	4	5
Fish meal	35.00	0.00	18.00	18.00	0.00
Soy bean meal	28.00	65.00	43.00	44.00	65.20
Mustard oil cake	20.00	25.00	20.80	20.00	25.00
Rice bran	11.60	2.80	13.00	11.50	4.00
Starch	0.00	0.00	0.00	0.00	0.00
Soy bean oil	3.20	5.00	3.00	3.00	1.00
Binder	2.00	2.00	2.00	2.00	2.00
Vit. and min.	0.20	0.20	0.20	0.20	0.20
Lysine	-	-	-	0.90	1.80
Methionine	-	-	-	0.40	0.80
Proximate composition					
Crude protein	35.07	35.03	35.00	35.08	35.00
Crude lipid	10.03	10.00	9.97	9.95	9.86
Ash	8.39	7.92	5.48	4.96	5.00
Fibre	8.36	9.89	8.96	8.40	6.70
NFE	40.97	53.70	33.40	32.80	36.15
GE (kjg ⁻¹)	17.57	17.29	17.28	17.16	17.16

NFE = Nitrogen free extractives, calculated as 100 – (% protein + % Lipid + % Ash + % Fibre)

GE = Gross energy content

Growth response parameters are shown in Table 4. The growth rate in terms of mean final body weight, percent weight gain of experimental fish fed diet 1 was higher than the other diets but there were no statistical different with diet 4. Fish fed diet 4 also showed good FCR value and better SGR with the control diet (Table 4).

Table 4. Mean growth performance and feed utilization of *A. testudineus* fed experimental diets for 6 weeks

Components	Dietary Treatments				
	1	2	3	4	5
Initial weight (g)	1.16 ±0.35 ^a	1.24 ±0.39 ^a	1.31 ±0.31 ^a	1.19 ±0.38 ^a	1.13 ±0.37 ^a
Final weight (g)	5.91 ±0.04 ^a	2.97 ± 0.02 ^d	4.73 ±0.05 ^b	5.42 ±0.06 ^a	3.59 ±0.05 ^c
Weight gain (g)	4.75 ±0.31 ^a	1.73 ±0.37 ^d	3.42 ±0.26 ^b	4.23 ±0.32 ^a	2.46 ±0.32 ^c
% Weight gain	457.54 ±0.36 ^a	139.52 ±0.35 ^d	261.06 ±0.48 ^c	355.46 ±0.32 ^b	217.69 ±0.29 ^c
Survival rate (%)	96.00 ±2.00 ^a	92.67 ±2.31 ^d	94.00 ±2.00 ^b	95.33 ±1.53 ^a	93.33 ±1.15 ^c
FCR	2.14 ±0.015 ^a	3.41 ±0.047 ^d	2.63 ±0.045 ^b	2.29 ±0.014 ^{ab}	3.00 ±0.048 ^c
FER	0.467 ±0.018 ^a	0.293 ±0.031 ^d	0.380 ±0.026 ^b	0.435 ±0.023 ^{ab}	0.335 ±0.028 ^c
PER	0.79 ± 0.012 ^a	1.76 ±0.005 ^d	1.37 ±0.013 ^b	0.84 ±0.021 ^a	1.51 ±0.004 ^c
SGR (%/day)	4.59 ±0.006 ^a	2.94 ±0.014 ^d	3.67 ±0.003 ^b	4.48 ±0.017 ^a	3.00 ±0.013 ^c

Experiment 3. Effects of supplementation of synthetic amino acids in plant protein based formulated diets in *A. testudineus*

The feeding trial was carried out in the pond complex of Freshwater Station, Bangladesh Fisheries Research Institute (BFRI), Mymensingh for a period of 12 weeks. Three experimental diets were formulated to contain 35% crude protein. Fish meal, mustard oil cake, soybean meal, wheat flour, vitamin and mineral premix were used as diet ingredients. Limiting amino acids: Lysine and Methionine was added in the diets and a control diet (diet-1; fish meal based) was prepared. Diet 2 was prepared partially replace animal protein with plant protein and Diet 3 was prepared fully plant protein based with adding limiting amino acids lysine and methionine. Pellet feeds (1.0-2.0 mm) made with hand pellet machine. The fish was offered the test diets two times daily at the rate of 20-3%. During experimental period water quality parameter and whole body composition was observed. Diets formulation and growth performance are shown the following Table 5 and 6, respectively. Growth response was observed monthly for the feed adjustment.

Table 5. Formulation and proximate composition of the diets (% dry weight basis) for *A. testudineus*

Ingredients	Dietary Treatments		
	Diet-1 (Control)	Diet-2	Diet-3
Fish meal	28.00	15.00	0.00
Soy bean meal	22.00	40.00	54.00
Mustard oil cake	18.00	20.00	25.00
Rice bran	23.80	15.45	10.10
Wheat flour	6.00	6.00	6.00
Binder	2.00	2.00	2.00
Vitamin and Minerals	0.20	0.20	0.20
Lysine	-	0.90	1.80
Methionine	-	0.45	0.90
Proximate composition			
Crude protein	33.01	33.10	33.00
Crude lipid	8.10	8.00	6.56
Ash	8.43	8.05	7.88
Fibre	5.84	5.65	5.56
NFE	33.85	36.70	38.06
GE (kjg ⁻¹)	16.64	16.28	16.10

Table 6. Mean growth performance and feed utilization of *A. testudineus* fed experimental diets in ponds for 12 weeks

Components	Dietary Treatments		
	Diet-1	Diet-2	Diet-3
Initial weight (g)	11.56 ± 1.02 ^a	11.36 ± 1.05 ^a	11.64 ± 1.11 ^a
Final weight (g)	82.32 ± 10.01 ^a	73.41 ± 6.03 ^b	51.37 ± 7.46 ^c
Weight gain (g)	70.76 ± 10.40 ^a	62.05 ± 12.00 ^b	39.73 ± 8.92 ^c
% Weight gain	612.11 ± 8.36 ^a	546.21 ± 5.35 ^b	341.32 ± 6.48 ^c
Survival rate (%)	91.00 ± 2.54 ^a	90.00 ± 3.03 ^a	88.00 ± 1.79 ^b
FCR	2.03 ± 0.12 ^a	2.20 ± 0.14 ^{ab}	3.23 ± 0.86 ^c
FER	0.49 ± 0.03 ^a	0.46 ± 0.03 ^b	0.31 ± 0.09 ^c
PER	1.87 ± 3.65 ^a	1.65 ± 2.07 ^b	1.26 ± 3.04 ^c
SGR (%/day)	2.18 ± 0.20 ^a	2.07 ± 0.31 ^b	1.65 ± 0.27 ^c

Table 7. Cost-benefit Analysis/ hectare/ 3 months

Components	Diet-1	Diet-2	Diet-3
Fingerlings (Tk)	18,574.00	18,574.00	18,574.00
Total feed (Kg)	9,667.46	9,094.63	8,381.81
Feed cost/ kg (Tk)	69.12	57.87	47.47
Total feed cost (Tk)	6,68,214.84	5,26,306.23	3,97,884.52
Total cost (Tk)	6,86,788.84	5,44,880.23	4,16,458.52
Total production (Kg)	5,532.03	4,998.09	3,351.36
Gross income (250.00 Tk/kg fish)	13,83,007.50	12,49,522.50	8,37,840.00
Net benefit (Tk)	6,96,218.66	7,04,642.27	4,21,381.48
BCR	1.01	1.29	1.00

From the results of this feeding trial, it is logical to conclude that fish meal based feed and partially replaced animal protein with plant protein with adding limiting amino acids lysine and methionine can be used as a fish feed additives in *A. testudineus* culture, to enhance better feed efficiency and growth performance.

Experiment 4. Refinement of microalgae culture technique for using as fish feed ingredients

The experiment was conducted on the rooftop of hatchery complex of Bangladesh Fisheries Research Institute, Freshwater Station, Mymensingh for 90 days from January to March, 2023. Three types of media viz. Kosaric medium (KM), papaya Skin Powder Medium (PSPM) and papaya Skin Powder Medium (PSPM) with baking soda were used for the culture of *S. platensis*. For two PSPM treatments each with 3 replications and for KM 3 replications were used. For both the culture media 12 days culture period was maintained.

Each plastic jar had 20 liter capacity where 15 liter water was taken. Treatment 1 was prepared by adding required amount of different chemicals with water. After mixing *S. platensis* was inoculated in the prepared media and then mixed well gently.

Papaya skin was dried in sun then dried in an oven at 50°C. Dried papaya skin was powdered with an electric blender and then sieved through a sieve (300µm). In treatment 2 and 3 papaya skin powder was added in each jar and fermented for fifteen days. Then chemicals were added and *S. platensis* inoculated. Sampling was done at every alternative day from each jar to observe *S. platensis* cell density and different water quality parameters of culture media. The pure stock of *S. platensis* in kosaric medium (KM) and papaya skin powder medium (PSPM) was being maintained in the laboratory.

Physico-chemical parameters of culture media

The physico-chemical parameters i.e. temperature were ranged 24.00-31.8°C, pH: 9.3-9.53, dissolved oxygen (DO): 4.27-6.58mgL⁻¹, measuring the voltage between a pH sensitive glass electrode (MVPH): 128.70-149.47, total dissolved solid (TDS): 1026.00-3875.00, electric conductivity (EC): 1501.00-2576.00, hectopascal pressure unit (hpa%): 1012.00-1476.00 and salinity: 0.60-4.32 were recorded. Different chemical comparison has been shown in table 8.

Table 8. Chemical required for different treatments to produce *Spirulina*.

T ₁ (KM)		T ₂ (PSPM)		T ₃ (PSPM with Baking soda)	
Chemical Composition	Quantity (gL ⁻¹)	Chemical Composition	Quantity (gL ⁻¹)	Chemical Composition	Quantity (gL ⁻¹)
NaHCO ₃ (Lab grade)	16.80	NaHCO ₃ (Lab grade)	16.80	NaHCO ₃ (Baking soda)	16.80
NaNO ₃	2.50	K ₂ HPO ₄	0.50	K ₂ HPO ₄	0.50
NaCl	1.00	Urea	0.67	Urea	0.67
Na-EDTA	0.08	PSP	0.50	PSP	0.50
CaCl ₂	0.04	-	-	-	-
FeSO ₄	0.01	-	-	-	-
MgSO ₄	0.20	-	-	-	-
K ₂ SO ₄	1.00	-	-	-	-
K ₂ HPO ₄	0.50	-	-	-	-

Table 9. Approximate chemical cost of different treatments (15.0L medium) to produce *Spirulina* for a period of 3 months

T ₁ (KM)			T ₂ (PSPM)			T ₃ (PSPM with Baking soda)		
Chemical composition	Quantity (g)	Cost (Tk)	Chemical composition	Quantity (g)	Cost (Tk)	Chemical composition	Quantity (g)	Cost (Tk)
NaHCO ₃	252.00	352.80	NaHCO ₃	252.00	352.80	NaHCO ₃	252.00	37.80
NaNO ₃	37.50	187.50	K ₂ HPO ₄	7.50	30.00	K ₂ HPO ₄	7.50	30.00
NaCl	15.00	15.00	Urea	10.05	0.15	Urea	10.05	0.15
Na-EDTA	1.20	1.20	PSP	7.50	-	PSP	7.50	-
CaCl ₂	0.60	0.60	-	-	-	-	-	-
FeSO ₄	0.15	0.15	-	-	-	-	-	-
MgSO ₄	3.00	3.60	-	-	-	-	-	-
K ₂ SO ₄	15.00	21.15	-	-	-	-	-	-
K ₂ HPO ₄	7.50	30.00	-	-	-	-	-	-
Total cost = 612.00			Total cost = 382.95			Total cost = 67.95		
Production								
T ₁ (KM)			T ₂ (PSPM)			T ₃ (PSPM with B.S)		
Wet wt. (g)	Dry wt. (g)		Wet wt. (g)	Dry wt. (g)		Wet wt. (g)	Dry wt. (g)	
700.00	70.0		650.00	65.00		595.00	59.50	

Subsequently harvesting was done in every 12 days. After each harvesting, chemical added partially. The growth of cells was varied in treatment 1, treatment 2 and treatment 3 found. The growth rate of *S. platensis* was higher in T₁ than T₂ and T₃ but there was no significant difference. Higher growth of cells was found due to the favorable water quality parameter and suitable amount of nutrients. In different treatments growth of *S. platensis* were observed and showed in Table 10.

Table 10. Cell weight of *S. platensis* between T₁ and T₂

Treatments	Initial weight (gL ⁻¹)	Final weight (gL ⁻¹)
T ₁	0.147 ± 0.009	1.036 ± 0.02
T ₂		1.021 ± 0.02
T ₃		1.001 ± 0.056

Production Performance of Hairy River Prawn (*Macrobrachium rude*) with Feed and Fertilizer in Pond Condition

Researchers

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Objectives

- To develop the poly-culture technique of Gura chingri, (*M. rude*), Subarno Rui (*L. rohita*), Catla (*L. catla*) and Silver carp (*H. molitrix*) fishes
- To analyze their cost-benefit ratio
- To produce improved quality post larvae (PLs) of *Macrobrachium rosenbergii*

Achievements

Experiment 1: Development of poly-culture technique of Gura chingri (*M.rude*), Subarno Rui (*L. rohita*), Catla (*C. catla*) and Silver carp (*H. molitrix*) fishes

The experiment was conducted with the treatments namely T₁, T₂ and T₃ each with three replications at freshwater station of BFRI, Mymensingh during a period of 06 months from February-2022 to July -2023. In T₁, the stocking density for small prawn, subarno rui, catla and silver carp fishes were 3 kg/decimal, 10, 3 and 9 nos per decimal, respectively. In T₂, these values were 4.5 kg/decimal, 10, 3 and 9 nos per decimal and were 6 kg/decimal, 10, 3 and 9 nos per decimal in T₃. The initial average weight for small prawn, rui, catla and silver carp were 0.14±0.07g, 15.05 ± 7.49g, 106.71±7.35g and 74.80±18.24g respectively in T₁; in T₂ these values were 0.12±0.04g, 12.99 ± 6.15g, 107.18±7.08g and 74.55±19.45g respectively and finally for T₃ they were 0.12±0.04g, 12.06 ± 4.82g, 104.41±7.47g and 74.33±18.94g respectively. The experimental designs are detailed in Table 1.

Table 1. Experimental layout of the poly-culture technique of small prawn, subarno rui, catla and silver carp fish in pond

Treatments	Replications	Prawn & fish species	Stocking density			
			Prawn (kg/dec.)	Subarno rui (nos./dec)	Catla (nos./dec)	Silver carp (nos./dec)
T ₁	3	Prawn+ Subarno rui+ Catla+ Silver carp	3	10	3	9
T ₂			4.5			
T ₃			6			

Pond preparation

The ponds were equal in size and shape, depth and basin configuration including water supply facilities. The size of each pond was 3 decimal each with an average depth of 1.5 m. The ponds were prepared by draining out the water. Lime was applied at the rate of 250 kg/ha. One week after lime application, the ponds were filled with water. To maintain water quality, the pond water was changed at regular intervals using water from a deep tube-well supply. Five days after fertilizer application, when the water turns green, small prawns were stocked. Providing root particules of bamboo trees at the bottom of the pond for sheltering of prawn. For increasing the primary productivity of water, 15 kg/ha.TSP and 25 kg/ha urea, MOC, and rice bran were applied at the fortnightly interval.

Collection of small prawns and fishes

Small prawns were collected from the old Brahmaputra River and various beels in Fulpure Upazila, while subarno rui, catla and silver carp fishes were collected from a hatchery in Mymensingh. To ensure their health and vitality, these small prawns and fishes were carefully collected and transported in oxy-polythene bags, subsequently undergoing an acclimatization period in cisterns. After collection, small prawns and fishes were transferred to the research ponds.

Feed and feeding

After stocking of prawns and fishes, Formulated feeds containing 30.53% protein were supplied with a mixture of raw materials such as fish meal (30%), mustard oil cake (20%), rice bran (20%), soya bean meal (25%), wheat bran (4%) and vitamin premix (1%) in all treatments at 05-03% of estimated body weight as per the experimental design.

Harvesting

First partial harvesting was done in April 2023 after three month of culture period and then one-month interval harvesting was conducted till six-month culture period. Final harvesting was done in July month by dewatering after completion of the experiment. The experimental ponds were harvested after 180 days of culture. To evaluate the fish growth performance weight gain (g), specific growth rate (SGR%/day), food conversion ratio, survival rate (%), individual and total production were measured after the end of the experiment.

Growth performance and production of fishes

The mean initial weight (g), final weight (g), weight gain (g), specific growth rate (SGR, % per day), food conversion ratio (FCR) and survival rate of fishes during the study period were recorded and presented in Table 2.

Table 2. Growth performances of prawn and fishes in different treatments over a culture period of six months

Parameters	Species	T ₁	T ₂	T ₃
Initial mean weight (g)	<i>M. rude</i>	0.14±0.07 ^a	0.12±0.04 ^a	0.12±0.04 ^a
	<i>L. rohita</i>	15.05±7.49 ^a	12.99±6.15 ^a	12.06±7.82 ^a
	<i>L. catla</i>	106.71±7.35 ^a	107.18±7.08 ^a	104.42±7.47 ^a
	<i>H. molitrix</i>	74.80±18.24 ^a	74.55±19.45 ^a	77.36±16.56 ^a
Final mean weight (g)	<i>M. rude</i>	0.95±0.6 ^c	1.10±0.10 ^a	1.03±0.94 ^b
	<i>L. rohita</i>	393.37±41.07 ^c	445.68±24.6 ^a	411.09±43.47 ^b
	<i>L. catla</i>	446.28±35.10 ^b	511.80±15.72 ^a	458.91±14.19 ^b
	<i>H. molitrix</i>	528.31±16.44 ^b	560.15±13.26 ^a	532.99±15.13 ^b
Mean weight gain (g)	<i>M. rude</i>	0.81±0.43 ^c	0.97±0.48 ^a	0.91±0.27 ^b
	<i>L. rohita</i>	378.32±40.47 ^b	432.69±26.53 ^a	399.03±42.0 ^b
	<i>L. catla</i>	339.57±32.12 ^b	404.62±13.92 ^a	354.50±16.41 ^b
	<i>H. molitrix</i>	453.51±28.04 ^b	485.59±27.81 ^a	455.63±18.85 ^b
Specific growth rate (%/day)	<i>M. rude</i>	0.95±0.35 ^c	1.13±0.36 ^a	1.10±0.27 ^b
	<i>L. rohita</i>	1.88±0.29 ^b	2.01±0.25 ^a	1.96±0.24 ^b
	<i>L. catla</i>	0.79±0.04 ^a	0.87±0.03 ^a	0.82±0.04 ^a
	<i>H. molitrix</i>	1.10±0.15 ^a	1.14±0.16 ^a	1.07±0.13 ^a
Survival rate (%)	<i>M. rude</i>	58.35±1.37 ^b	62.21±1.34 ^a	61.38±0.51 ^a
	<i>L. rohita</i>	98.26±0.34 ^a	98.7±0.41 ^a	98.8±0.52 ^a

Parameters	Species	T ₁	T ₂	T ₃
	<i>L. catla</i>	98.39±0.23 ^a	98.5±0.65 ^a	97.9 ±1.17 ^a
	<i>H.molitrix</i>	99.88±0.13 ^a	99.82±0.49 ^a	99.85±0.83 ^a
FCR		1.78±0.10 ^a	1.66±0.14 ^c	1.73±0.11 ^b
Species-wise Production (kg/ha/6 month)	<i>M. rude</i>	330.98±24.69 ^c	810.16±9.52 ^b	899.08±16.13 ^a
	<i>L. rohita</i>	973.18±21.16 ^c	1101.62±18.21 ^a	1015.17±13.51 ^b
	<i>L. catla</i>	343.33±7.56 ^a	333.45±9.32 ^a	340.86±10.24 ^a
	<i>H.molitrix</i>	1175.72±28.81 ^b	1244.88±31.65 ^a	1183.14±37.34 ^b
Total production (kg/ha/6 month)		2,824	3,491	3,438

Values in the same row having the same superscript are not significantly different ($p > 0.05$)

After 06 months of culture, the highest final mean weight of prawn, subarno rui, catla and silver carp fishes were found to be 1.10±0.10g, 445.68±24.61g, 511.80±15.72g and 561.15±13.26g respectively, in T₂ treatment. Subarno rui exhibited significantly lower growth performance in T₁ compared to T₁ and T₂. On the other hand, chingri showed significantly higher ($p < 0.05$) growth performance in T₂ than in T₁ and T₃. The food conversion ratio was significantly lowest in T₂ and highest in T₁. Furthermore, the highest specific growth rate (SGR) values were observed for prawn, subarno rui, catla and silver carp fishes at 1.13±0.36, 2.01±0.25, 0.87±0.03 and 1.14±0.16 in T₂ treatment, respectively.

At the end of the experiment, species-wise production of rui, catla and silver carp were not significantly different among the treatments except prawn and rui. The production of chingri recorded significantly higher ($p < 0.05$) in T₃ than in T₁ and T₂. The total highest productions of prawn and carp fishes were recorded in T₂ (3,491 kg/ha/6 months), followed by T₁ (2,824 kg/ha/6 months) and T₃ (3,438 kg/ha/6 months).

The economic benefit analysis of Poly-culture system

A simple cost-benefit analysis analysis in polyculture system of Gura chingri with carp fishes from one-hectare ponds over a culture period of 6 months was done to estimate the return against investment and profitability that had been generated proper combination and stocking densities in polyculture were summarized in Table 3. The total costs of farming (BDT/ha) were lower in T₁ (7, 38, 446) than those of T₂ (9, 86, 013) and T₃ (12, 30, 863). The net benefits were calculated from three treatments as BDT 2,56,866; 6,29, 838 and 4,57,708 per hectare for T₁, T₂ and T₃, respectively. The highest BCR was found to be 1.64 in T₂ treatment and lowest values were observed at 1.35 in T₁ treatment.

Water quality parameters

Physico-chemical parameters of pond water such as temperature, pH, transparency, alkalinity, and DO of all treatments were monitored at the fortnightly interval and recorded data were shown in the following table (4). Water temperature of different ponds was more or less same. The mean temperature was 30.59 ± 2.26 °C, 30.36 ± 2.11 °C and 30.17 ± 2.18 °C in T₁, T₂, and T₃ respectively. The mean values of pH were 7.94 ± 0.32, 8.21± 0.29 and 8.53± 0.34 in T₁, T₂ and T₃, respectively. The mean values of DO were 5.39 ± 0.57, 5.47 ± 0.51 and 5.64 ± 0.36 in T₁, T₂ and T₃, respectively. The highest mean values of alkalinity were recorded in T₂ (135.34 ± 3.16) and the lowest was T₁ (132.40 ± 3.21). The highest mean values of ammonia were recorded in T₂ (0.002±0.0015) and lowest was in T₃ in polyculture.

Table 3. Cost and benefits analysis of polyculture of prawn with Indian major carps fishes in one-hectare ponds over a 6 months culture period

Item wise expenditure / Operational costs		T ₁	T ₂	T ₃
A. Cost				
1. Pond lease value for 6 months		25,000	25,000	25,000
2. Price of fingerlings				
2.a	Prawn @ TK 600/kg	4,44,600	6,66,900	8,89,200
2.b	Bfri Subarno rui @ TK 4.00/piece	9,880	9,880	9,880
2.c	Catla @ TK 4.00/piece	2,964	2,964	2,964
2.d	Silver carp @ TK 3.00/piece	6,669	6,669	6,669
3. Feeds		2,16,333	2,41,600	2,64,150
4. Lime, fertilizer etc.		3,000	3,000	3,000
5. Human labor, Transport etc.		30,000	30,000	30,000
Total cost		7,38,446	9,86,013	12,30,863
B. Incomes				
Prawn (1200 tk/ kg)		3,97, 176	9,72,192	10,78,896
Bfri Subarno rui (260 tk/ kg)		2,53,027	2,86,422	2,63,945
Catla (250 tk/ kg)		86,450	83,363	85,250
Silver carp (220 tk/kg)		2,58,659	2,73,874	2,60,480
Total return		9,95,312	16,15,851	16,88,571
Net Profit (B-A)		2,56,866	6,29,838	4,57,708
BCR		1.35	1.64	1.37

Table 4. Water quality parameters of experimental ponds during February-July /2023

Water Temp. (°C)	30.59 ± 2.26 ^a	30.36 ± 2.11 ^a	30.17 ± 2.18 ^a
pH	7.94 ± 0.31 ^a	8.21 ± 0.29 ^a	8.53 ± 0.34 ^a
DO (mg/L)	5.39 ± 0.57 ^a	5.47 ± 0.51 ^a	5.64 ± 0.36 ^a
Total Alkalinity (mg/L)	132.40 ± 3.21 ^a	135.34 ± 3.16 ^a	134.62 ± 3.09 ^a
NH ₃ (mg/L)	0.019 ± 0.0012 ^a	0.002 ± 0.0015 ^a	0.0014 ± 0.00 ^a

*Figures in the same row having the same superscripts are not significantly different (p ≥ 0.05)

Production of post larvae (PLs) of *Macrobrachium rosenbergii* at the hatchery

Collection of brine water and Brood Golda: Brine water (180 ppt) was collected from pekua, Cox's Bazar. Twelve gravid females were selected and transferred to the hatching tank.

PL production: About ten thousand post-larvae were produced



Figure 4 (a): Brood Galda



Figure 4 (b): 30 days larvae



Figure 4(c): 55 days post-larvae

Development of YY GIFT Production using Marker-assisted Selection and Quality bi-sex Seed Production of GIFT Strain through Cohort Breeding

Researchers

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Objectives

- To develop MAS-selected YY super-males of GIFT
- To produce of quality mass seed of GIFT strain using Rotational Breeding

Achievements

Experiment 1: YY GIFT production using Marker-assisted selection

1. Pseudo female production

In 05 hapas having 2.0 m³ have been set up in pond and single pair of mature GIFT tilapia was stocked. Fertilized eggs were collected and kept in the hatching jar for incubation. After yolk sac absorption, the 500 offspring of 5 full sib families transferred in 05 mini cisterns. Diethylstilbestrol (DES) hormone was used @ 0.50g/kg and 1.0g/kg feed for 21 days. The hormone treated feeds provided to the fry thrice a day up to 21 days. A total of 500 offspring of 5 full sib families each also transferred in another 05 hapa as control groups. After completed of hormone treatment, both groups of fry have been transferred to hapas in pond condition. We harvested 1420 fish from the three groups (Table 1). In group one all individuals were female 77% and group two found 350 of the 500 individuals were phenotypically female. In contrast, the female rate was only 40% in the control group. Variable growth rates of tilapia were found after trails (Table 2). Highest final weight gain (g) was found at T₁ (group 1). The survival rates (%) of fish were 82, 78, and 74 in T₁, T₂ and T₃ respectively (Table 2).

Table 1. Summary information on Sex Reversal of Tilapia

Group	DES (g)/ feed (kg)	Individual number (n)	Female	Male	Intersex	Female rate (%)
T ₁	1	500	390	90	0	77
T ₂	0.5	500	350	120	0	70
Control (T ₃)	N/A	500	200	270	0	40
Total			1420			

2. Collection of Fin sample for DNA extraction

For pseudo female identification, 10 fin samples from hormone treated fry having mean weight 36±1.68g have been collected and kept in absolute ethanol for DNA extraction.

Table 2. Growth responses and survival of different treatments.

Sl no.	Treatment	Avrg. Length (cm)	Avrg. Weight (g)	% of Survival
1.	T1	12.22±0.91	32.26 ± 1.62	82
2.	T2	11.73±0.66	29.5±1.78	78
3.	T3	10.25±0.77	19.9±1.73	74

Hormone treatment completed for pseudo female production

Marker selection and PCR amplification

Sex determination (SD) marker closely linked to sex trait located on chrLG23 (forward primer: 50 - TCCCATTTAGACC ACCACACCTCAACAACA-30; reverse primer: 50 -GTCAGAAT GCACTTTA ACACAGAGATACCA-30; patent application no.: 2016107162044) are being used to genotype each individual. PCR amplifications are being performed and carried out in a 20- μ L volume using 2 \times PCR master mix, 1 ng genomic DNA and 0.5 μ mol/L forward and reverse primers in a thermal cycler. The following program was applied (one cycle of 3 min at 94 °C, 38 cycles of 30 s at 94 °C, 30 s at 55 °C and 30 s at 72 °C, followed by a final extension of 5 min at 72 °C). The resulting PCR products were initially detected by electrophoresis with 6% agarose gel. PCR amplification of individuals during MAS using the sex-linked marker SD is shown in figure 2.

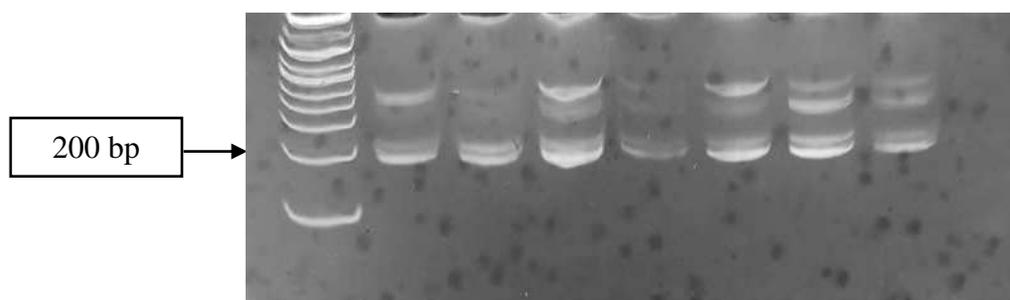


Figure 2. Confirmation of Pseudo female sex-linked marker SD, M: 1Kb: DNA ladder

Experiment 2. Cohort breeding program of GIFT strain for quality seed production

The F-13 generations of GIFT fingerlings with an mean weight of 7.25±2.41g have been stocked in September 2022 in four (75m²) separated hapa in a pond having an area of 1000m² area with an average depth of 1.25m for the period of five months. A total of 400 fingerlings have been stocked in each hapa for cohort breeding. The fish were fed with floating feed containing 30% crude protein at the rate of 4-8% based on body weight after stocking. After that, 200 male and 200 females will be selected from each hapa for breeding. About 3.25 lakh fry produced by Cohort breeding.

Breeding Biology of Commercially Important Freshwater Mollusk and Development of Culture Technique with Fish

Researchers

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Objectives

- To investigate breeding biology of commercially important mollusk (mussel and snail) available in Bangladesh
- To develop breeding technique and culture system of mollusk with fish in confined condition and pond ecosystem

Achievements

Experiment 1: Assessment of gametogenic stage of apple snail (*Pila globosa*)

Gonad maturation stages of snail (*Pila globosa*) were measured by following the standard procedure of histological process of mollusk. Pond were dried and limed at the rate of 1kg per decimal and filled with water. After pond preparation about 500-800 specimen of year-round collected snail from different aquatic habitat were stocked. Both organic manure and inorganic fertilizer and commercial feed were applied fortnightly for ensuring sufficient feeds for snail. Ten (10) samples were brought to laboratory monthly and processed for histological study within 24 hrs. Shell height, length and weight were measured with vernier calipers and electric balance and data were recorded. Sample specimen were dissected for gonadal tissue collection and fixed in Bouin fluid for 48 hrs. After that the sample were preserved in 70% ethyl alcohol until histological procedure. Following steps were followed for histological study: Step 1: Slicing, Step2: Dehydration, clearing and infiltration, Step3: Embedding, Step4: Trimming, Step5: Sectioning, Step6: Staining, Step7: Mounting, Step8: Microscopic observations



Figure 1. Pictorial view of sample collection, dissection and preservation

Developmental stages of male and female gametic cells were differentiated, as described by Peredo and Parada (1984), Tair-Abbaci, and Garric, (2012). Development of ova and spermatozoa were summarized as mentioned by Chatchavalvanich *et al.*, 2006, Gamarra-Luques *et al.*, 2013.

The beginning of the gametogenesis showed only female germinal cells, surrounding the hepatopancreatic epithelium which was wrapped in the secretion of the albumen gland. Spermatozoa and oocytes are both discharged by respectively the spermiduct and the oviduct in a junction where the secretion of the albumen gland is also deposited. Surrounded by the albumen secretions, the gametes continue their

journey in the gland of nidation where fertilization occurs; and so oocytes are fertilized and grouped in masses which were then discharged through the genital pore located on the head near the mouth. Spawning activity was highest in June for both male and female apple snail. Additionally, ripe and spawning stages ranged from March to July for both sexes. According to the histological study and gonadal developmental stages, it was confirming the occurrence of breeding time from March to July.

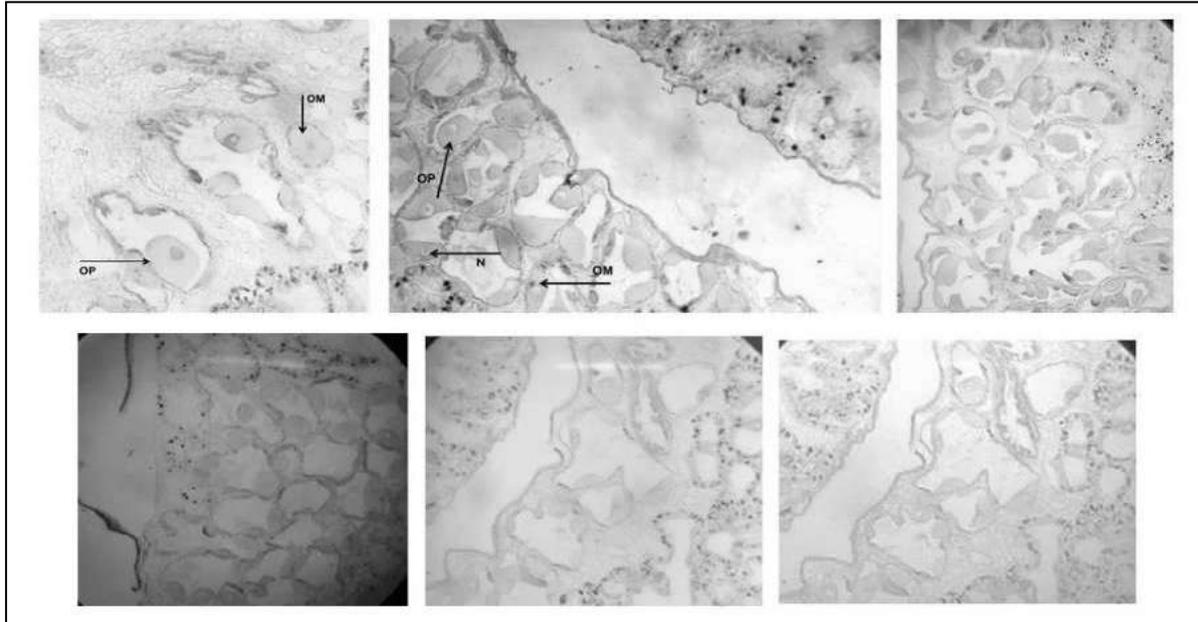


Figure 2. Female gonad development of *Pila globosa*

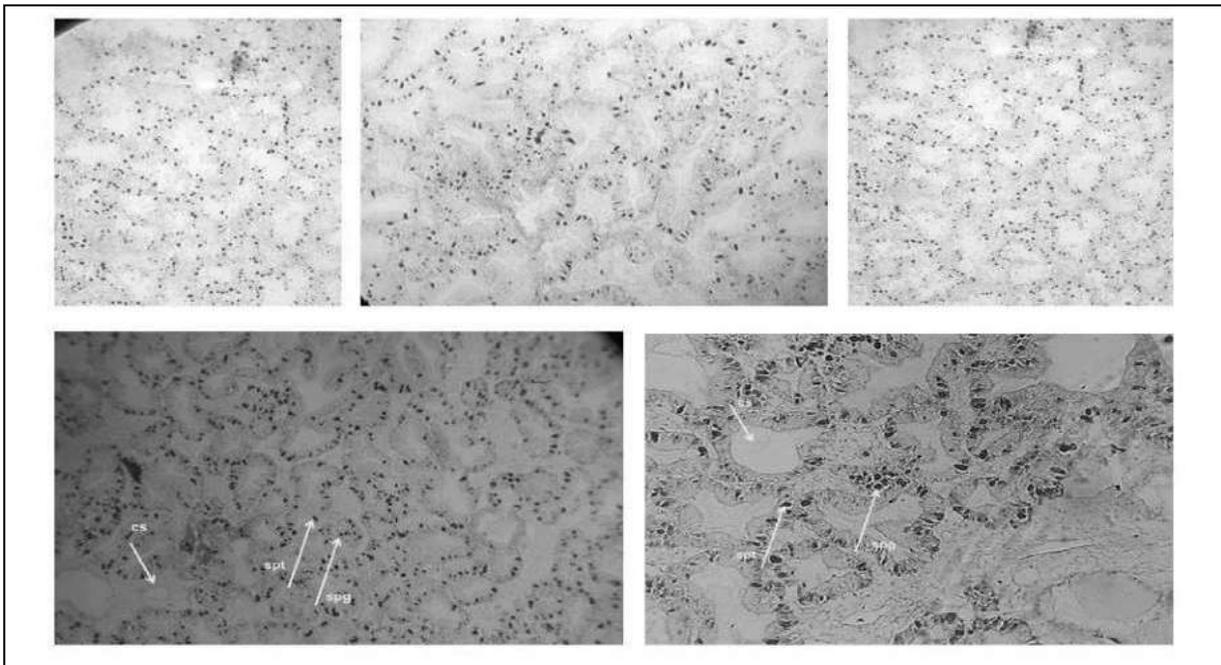


Figure 3. Male gonad development of *Pila globosa*

Table 1. Male Female ratio

Month	Sample	Male	Female
July	10	6	4
August	10	6	4
September	10	6	4
October	10	6	4
November	10	4	6
December	10	4	6
January	10	4	6
February	10	6	4
March	10	4	6
April	10	7	3
May	10	5	5
June	10	6	4

Male female ratio were found (1:1.14)

Experiment 2. Estimation of Condition Factor (CF) of apple snail (*Pila globosa*)

The condition factor (K) of the snails was determined from the relationship between the shell length and weight measurements using the equation (Gayaniilo and Pauly, 1997);
Condition Factor, $K = 100W/L^3$

Where, K = Fulton's condition factor, W = Weight of shell in grams (g), L = Total length of shell in centimeters (cm)

K value of less than 1 is an indication of a poor condition. But in this result from the table we can say that all the value are above one so the snail was in good condition. Mollusk condition strongly influenced by the condition of abiotic and biotic environment it was obtained and could be used as a tool to assess the ecosystem health.

Table 2. During the study period the estimated CF

Month	Total length of shell (cm)	Weight of shell (g)	Condition Factor (CF)
July	3.82±0.16	3.35±0.64	5.7±0.75
August	4.4±0.34	7.16±1.41	8.28±0.75
September	4.12±0.16	6.16±0.52	9.06±1.03
October	3.72±0.23	6.64 ±1.00	11.29±0.86
November	3.5±0.05	3.80±0.30	8.83±0.52
December	3.46±0.12	3.15±0.31	7.16±0.83
January	4.0±0.22	7.85±0.71	13.01±2.21
February	4.04±0.10	4.89±0.27	8.06±2.28
March	3.8±0.24	4.6±0.99	8.79±0.54
April	4.07±0.07	6.74±0.70	9.70±0.43
May	4.06±0.08	4.67±0.49	7.20±0.49
June	4.1±0.08	6.29±0.22	9.17±0.47

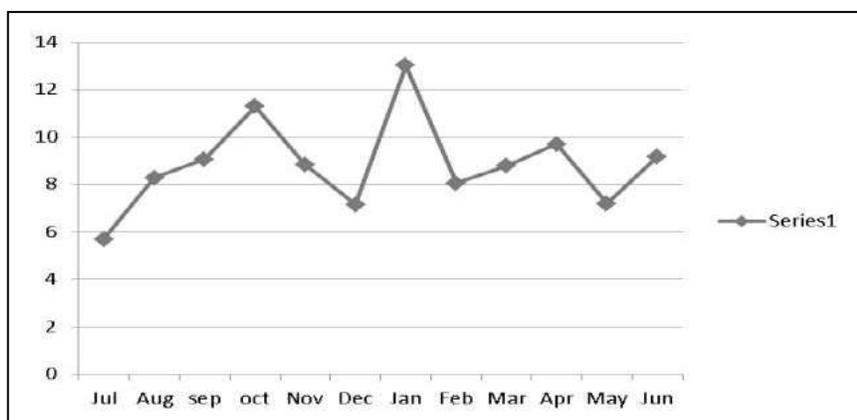


Figure 4. Condition Factor of *Pila globosa*

K value of less than 1 is an indication of a poor condition. But in this result from the above we can say that all the value are above one so the snail was in good condition. Mollusk condition strongly influenced by the condition of abiotic and biotic environment it was obtained and could be used as a tool to assess the ecosystem health.

Experiment 3. Nursing technique development of baby apple snail in Aquarium and hapa

Aquarium having a water exchange facility was used for the baby snail rearing after disinfected by KMnO4. The pond was organized following regular pond preparation procedures. The pond contained sandy soil, clean water, pollution free bottom were selected. Water from pond were totally drained out and dried. After drying, lime and salt were applied to the pond at the rate of 1kg/decimal to remove the insect and earthworm. After 6-7 days of liming, freshwater were supplied to the pond. Aquatic plants were planted. After the preparation baby snail were reared in different condition while the growth data recorded as below. After final collection data will be analyzed.

Table 3. Design of the experiment

Treatment	Nursing system	Stocking density	Feeding	Duration
T ₁	Aquarium; (23x18x3) inch ³	50 baby snails/L	1 leaf/ 50baby snail (Ricinus communis leaves) and commercial feed 3% per body weight	6 months
T ₂	Aquarium + mud; (23x18x3) inch ³			
T ₃	Hapa in pond; (23x18x3) inch ³			

Table 4. Survival rate and SGR (%) of snail

Treatment	Nursing system	Initial weight (g) (Mean±SE)	Final weight (g) (Mean±SE)	Survival rate (%)	SGR (%)
T ₁	Aquarium	0.017± 0.001	14.46±0.40	40	3.700±.025
T ₂	Aquarium+mud	0.016±0.001	17.71±0.52	42	3.85±0.029
T ₃	Hapa in pond	0.017± 0.001	21.15±0.46	48	3.92±0.028

From the above tabel we arrived to the following statement that, after 6 months of nursing of baby snails the survival rate was highest in T₃ that is in pond condition 48%, while minimum survival rate was found found in aquarium condition 40% in T₁. SGR (%) was more or less similar in each treatment.

Table 5. Water quality parameters

Parameter	T ₁	T ₂	T ₃
Temperature	28.6±1.00	29.1±1.00	28.71±1.26
pH	7.5±0.31	7.62±0.31	7.7±0.5
DO	5.29±0.73	5.21±0.24	5.49±0.46
Ammonia	0.02±0.00	0.02±0.0	0.02±0.0
Alkalinity	130±12.58	115±12.90	100±26.29

Water quality parameters were in optimum condition in each treatment

Expt. 4: Impact of glochidia on fish growth

These experiments were set to identify the impact of parasitic stage of freshwater mussel on fish growth. One control was taken which contains four treatments with different stocking density of mussel. Pond was prepared following the standard procedure (drying, liming and fertilization). After pond preparation mussels and multi-species of fish were stocked. Fish were fed with commercial feed at the rate of initially 10% and down to 3% of the total biomass of the fish twice daily (half ration morning and rest half evening). Organic and inorganic fertilizer was applied fortnightly at the rate of 1 kg 0.1 kg T.S.P and 0.1 kg urea per decimal. Lime was applied fortnightly at the rate of 0.5 kg/decimal. Water temperature, pH, and plankton growth, ammonia, DO and Ca²⁺ was recorded fortnightly. Growth and survival of the mussel and fishes was monitored monthly and at the end of the experiment data will be compiled and analyzed using appropriate statistic tools.

Table 6. Average present weight of fishes in different treatment

Treatment	Species combination				
	Density of Mussel (<i>Lamellidens jenkinsianus</i>)	Shing (<i>Heteropneustes fossilis</i>)		Pabda (<i>Ompok Pabo</i>)	
		Average Initial weight (g)	Average present weight (g)	Average Initial weight (g)	Average present weight (g)
T ₁	-	1.2±0.15	30.06±0.62	1.5±0.13	22±0.46
T ₂	150		30.66±0.57		20.26±0.49
T ₃	200		29.06±0.59		23.66±0.40
T ₄	250		30.13±0.58		20.4±0.50
T ₅	300		30.26±0.64		23.73±0.57

After 6 months of observation, from the above table it can be implies that, the average weight of Shing (*Heteropneustes fossilis*) were 30.06±0.62, 30.66±0.57, 29.06±0.59, 30.13±0.58 and 30.26±0.64. In terms of Pabda (*Ompok Pabo*) the average weight were 22±0.46, 20.26±0.49, 23.66±0.40, 20.4±0.50 and 23.73±0.57. There were no significant impact of glochidia on growth of fishes while cultured with mussels comparing with control treatments.

Table 7. Water quality parameters

↓ Parameter/ Months →	T₁	T₂	T₃	T₄	T₅
Temperature (°C)	26.05±3.74	28.55±1.33	29.51±2.37	28.15±1.47	29.11±2.37
pH	6.8±1.03	7.5±0.29	8.2±0.22	8.5±0.35	8.2±0.22
DO (mg/l)	5.16±0.52	4.78±0.28	5.35±0.42	4.9±0.51	5.30±0.42
Ammonia (mg/l)	0.04±0.0	0.04±0.0	0.02±0.0	0.04±0.0	0.02±0.0
Alkalinity (mg/l)	162.5±3.53	154±10.00	170±9.10	120±10.23	170±9.10

In each pond, water quality parameters were in optimum condition.

Development of Breeding Technique of Snakehead Fish

Researchers

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Objectives

- To refine the induced breeding technique of Striped Snakehead *Channa striata*
- To develop nursery rearing techniques of Striped Snakehead, *Channa striata*

Achievements

Experiment 1. Refinement of the induced breeding techniques of Striped Snakehead *Channa striata* Collection and stocking of fish

A total of 120 fishes were collected from the Haor of Netrokona and Kishoriganj district from October-December/2022. After transportation, fishes were acclimatized for 30 minutes in the selected pond. Then fishes were stocked in a pond having an area of 10 decimals. The mean initial length and weight of collected fish was recorded. The stocked fish was reared with live fish fry and commercial feed @ 5-3% BW twice daily.

Experimental design

Two types of hormones were administered in June 2023 to optimize the induced breeding technique of *C. striata*. For each hormone trail, there were three treatments (Table 1).

Table 1. Hormone doses for induced breeding of *C. striata*.

Hormones	Sex	Dose		Time interval
		1 st	2 nd	
PG (mg/kg)	F	20	20	6 hours
	M	-	20	
	F	20	30	
	M	-	25	
	F	20	40	
	M	-	30	
Buserelin (ml/kg)	F	0.40	-	-
	M	0.20		
	F	0.60		
	M	0.30		
	F	0.80		
	M	0.40		

Induced breeding

Mature and healthy fishes (600-1000g weight) were selected to optimize the induced breeding technique for *C. striata*. Mature male and female was stocked in cistern. The cistern was provided with all facilities including a continuous water supply. Water quality parameters (temperature, DO, pH and alkalinity etc.)

of the cistern was monitored. Induced breeding trials were carried out using different doses of hormone and several trials were made to optimize the doses of the hormone based on ovulation, fertilization, hatching and survival rates.

Injecting the PG extract into fish

Based on the body weight of the gravid female fish the required volume of extract was taken in a graduated 3.0ml hypodermic syringe. The selected brood fish was carefully taken for injecting the PG extract. The extract was injected intramuscularly into the fish on the dorsal side above the lateral line.

Response of different hormones on induction of spawning of *C. striata*

Three treatments were conducted for refinement of induced breeding of *C. striata* during June with a temperature around 28-30 °C. Data representing the effects of different hormones on ovulation of female and the rates of fertilization and hatching of eggs are presented in Table (2). For refining PG dose in female *C. striata*, three different doses of PG viz., 40, 50, and 60 mg kg⁻¹ body weight were applied in treatments T₁, T₂, and T₃, respectively in June. Buserelin were applied 0.50, 0.75 and 1.0 ml/kg BW of fish in T₁, T₂, and T₃, respectively. Fish showed minimum response with the 1st dose applied in T₁ but with 3rd doses applied in T₃ showed good response in consideration of ovulation, fertilization & hatching.

Table 2. Response of different hormones on induction of spawning of *C. striata*

Hormone	Treatment	Body weight (g)		Dosage of hormone/ (Kg)		Spawning period (hrs.)	Spawning rate (%)	Fertilization rate (%)	Hatching period (hrs.)	Hatching rate (%)	Incubation Temp. (°C)
		Female	Male	F	M						
PG	T ₁	621.2±63.2	478.9±54.5	40	20	22-24	30.7±3.5 ^c	55.5±3.89 ^c	32-35	30.1±2.9 ^c	28-31
	T ₂	586.5±66.5	492.3±59.1	50	25		59.6±4.7 ^b	75.6±4.73 ^b	32-35	49.9±4.1 ^b	
	T ₃	631.3±81.3	506.4±69.4	60	30		95.1±5.5 ^a	97.3±4.89 ^a	32-35	71.3±5.2 ^a	
Buserelin (ml/kg)	T ₁	537.2±82.2	466.9±57.5	0.50	0.25	24-28	29.5±4.1 ^c	48.5±5.99 ^c	32-36	20.8±4.9 ^c	28-31
	T ₂	519.5±56.5	452.3±43.1	0.75	0.35		45.9±4.7 ^b	70.6±5.33 ^b	32-36	37.1±4.5 ^b	
	T ₃	566.3±61.3	476.4±67.4	1.0	0.50		80.6±5.5 ^a	90.3±4.79 ^a	32-36	61.3±6.6 ^a	

** Figures with the same letter are not significantly (p<0.05) different.

When PG was used, the spawning rate showed noticeable differences in effectiveness among three doses in inducing ovulation. The spawning rate was recorded as 30.7%, 59.6% and 95.1% in the treatments of T₁, T₂, and T₃, respectively (Table 2). The time interval between the injection of PG extract and ovulation (latency period) varied between 22-24 hours of injection in all cases. Among three doses of PG in consideration of the spawning rate, T₃ showed the highest result followed by T₂ and T₁. The results from the ANOVA test indicated that there was a significant difference among the three doses of treatments whereas T₃ was significantly (p<0.05) higher than that of treatments T₁ and T₂ (Table 2). The spawning rate showed noticeable differences in effectiveness among three doses of Buserelin used for inducing ovulation. The spawning rate was recorded as 29.5%, 45.9% and 80.6% in the treatments of T₁, T₂, and T₃, respectively (Table 2). The time interval between the injection of Buserelin extract and ovulation

(latency period) varied between 24-28 hours of injection in all cases. Among three doses of Buserelin in consideration of the spawning rate, T₃ showed the highest result followed by T₂ and T₁. The results from the ANOVA test indicated that there was a significant difference among the three doses of treatments whereas T₃ was significantly ($p < 0.05$) higher than that of treatments T₁ and T₂ (Table 2). The average fertilization rate was recorded as 55.5%, 75.6% and 97.3% in treatments T₁, T₂ and T₃, respectively, for PG. The results from the ANOVA test indicated that there was a significant difference among the three doses of treatments whereas T₃ was significantly ($p < 0.05$) higher than that of treatments T₁ and T₂ (Table 2). The average fertilization rate was recorded as 48.5%, 70.6% and 90.3% in treatments T₁, T₂ and T₃, respectively, for Buserelin. The results from the ANOVA test indicated that there was a significant difference among the three doses of treatments whereas T₃ was significantly ($p < 0.05$) higher than that of treatments T₁ and T₂ (Table 2). Some little variation might be due to water quality, water temperature, brood management *etc.* The hatching rate was found at 30.1%, 49.9% and 71.3% in treatments of T₁, T₂ and T₃ respectively, when used PG. The highest hatching rate was recorded at 71.3% in T₃ and the lowest hatching rate was recorded at 30.1% in T₁. The result from the ANOVA test indicated that there was a significant difference between the three doses. It was found that the hatching rate in T₃ was significantly ($p < 0.05$) higher than that of T₁. When Buserelin was used, the hatching rate was found at 20.8%, 37.1% and 61.3% in treatments of T₁, T₂ and T₃ respectively (Table 2). The result from the ANOVA test indicated that there was a significant difference between the three doses.

Experiment 2. Development of the nursery rearing techniques of Striped Snakehead *Channa striata*

The experiment was carried out within the concrete tank in Freshwater Station, BFRI from October 2022 to December 2022 for 90 days. The present experiment was conducted with four treatments namely T₁, T₂, T₃ and T₄ each with three replications. The experimental designs are given below:

Table 3. Experimental design for the development of nursery-rearing techniques for *C. striata*.

Treatment	Feed	Stocking Density (nos./m ³)
T ₁	Formulated feed @ 40-10% BW	300
T ₂	Dry fish powder @ 30-10% BW	
T ₃	Dry fish powder and fish paste @ 30-10% BW	
T ₄	Fish paste @ 30-10% BW	

Table 4. Bi-weekly variation in growth of *C. striata* fry under different treatment.

Sampling date	Mean length (cm)				Mean weight (g)			
	T ₁	T ₂	T ₃	T ₄	T ₁	T ₂	T ₃	T ₄
Initial	1.08±	1.09±	1.09±	1.08±	0.01±	0.01±	0.01±	0.01±
02/10/22	0.08 ^a	0.08 ^a	0.07 ^a	0.09 ^a	0.001 ^a	0.002 ^a	0.002 ^a	0.001 ^a
1 st	1.86±	1.95±	1.84±	1.85±	0.07±	0.08±	0.07±	0.06±
16/10/22	0.13 ^b	0.14 ^a	0.10 ^b	0.11 ^b	0.004 ^b	0.006 ^a	0.006 ^b	0.005 ^c
2 nd	3.42±	3.95±	3.52±	3.31±	0.65±	0.77±	0.67±	0.61±
31/10/22	0.29 ^b	0.37 ^a	0.23 ^b	0.21 ^c	0.06 ^b	0.06 ^a	0.04 ^b	0.04 ^c
3 rd	5.02±	5.36±	5.06±	4.73±	1.70±	2.0±	1.71±	1.45±
15/11/22	0.51 ^b	0.57 ^a	0.47 ^b	0.36 ^c	0.32 ^b	0.29 ^a	0.44 ^b	0.21 ^c
4 th	6.65±	6.95±	6.61±	6.33±	3.45±	3.73±	3.44±	2.95±
30/11/22	0.59 ^b	0.64 ^a	0.72 ^b	0.49 ^c	0.29 ^b	0.47 ^a	0.31 ^b	0.35 ^c
5 th	8.43±	8.61±	8.54±	8.32±	6.14±	7.53±	6.36±	5.96±
15/12/22	0.85 ^{bc}	0.74 ^a	0.89 ^b	0.46 ^c	0.57 ^{bc}	0.77 ^a	0.83 ^b	0.74 ^c
6 th	10.6±	11.23±	10.71±	10.11±	11.42±	12.56±	11.54±	10.58±
30/12/22	1.19 ^b	1.38 ^a	0.98 ^b	1.37 ^c	1.23 ^b	1.41 ^a	0.99 ^b	1.13 ^c

Following 90 days of nursing, the fish were harvested. In the current experiment, feed had an impact on the final weight, survival, cannibalism, and FCR. The average initial weight (g) and length (cm) of *C. striata* fry were 0.01 ± 0.001 g and 1.08 ± 0.08 cm in T₁, 0.01 ± 0.002 g and 1.09 ± 0.08 cm in T₂, 0.01 ± 0.002 g and 1.09 ± 0.07 cm in T₃ and 0.01 ± 0.001 g and 1.08 ± 0.09 cm in T₄, respectively (Table. 4).

The average final lengths and weights of fry were 10.6 ± 1.19 cm and 11.42 g in T₁, 11.23 ± 1.38 cm and 12.56 g in T₂, 10.71 ± 0.98 cm and 11.54 g in T₃, and 10.11 ± 1.37 cm and 10.58 g in T₄, respectively. The ANOVA test results revealed that, in comparison to the T₁, T₃, and T₄ treatments, the fry from the T₂ treatment grew more rapidly and gained more weight. Among treatments, there was a significant difference ($p < 0.05$) in the SGR. Mean SGR for T₁, T₂, T₃, and T₄ were 7.78 ± 1.12 , 7.94 ± 1.01 , 7.80 ± 0.98 , and 7.71 ± 1.02 , respectively (Table 3). After 90 days of the trial period, it was noticed that the survival rates in T₁, T₂, T₃, and T₄ were 68.12 ± 3.72 , 79.83 ± 3.51 , 66.43 ± 3.14 , and 56.67 ± 4.08 respectively (Table 5). The survival rates varied significantly between the treatments ($p < 0.05$). Dry fish powders were more effective at bolstering survival rates. Lower survival rates, however, were related to the use of only fish paste (Table. 5). Among treatments, there were significant differences in cannibalism rates ($p < 0.05$). The amount of cannibalism was highest in T₄ where fish pastes were used, and lowest in T₂ where dry fish powders were used. At the end of the experiment, it was found that the FCR in T₁, T₂, T₃, and T₄ was 2.81 ± 0.07 , 2.38 ± 0.09 , 2.76 ± 0.08 , and 3.19 ± 0.07 , respectively. The FCR varied significantly among treatments ($p < 0.05$).

Table 5. Growth performance, survival (mean \pm SE), cannibalism and FCR of *C. striata* fry

Parameters	Treatments			
	T ₁	T ₂	T ₃	T ₄
Initial weight (g)	0.01 ± 0.001^a	0.01 ± 0.002^a	0.01 ± 0.002^a	0.01 ± 0.001^a
Initial length (cm)	1.08 ± 0.08^a	1.09 ± 0.08^a	1.09 ± 0.07^a	1.08 ± 0.09^a
Final weight (g)	11.22 ± 1.23^b	12.56 ± 1.41^a	11.54 ± 0.99^b	10.58 ± 1.13^c
Final length (cm)	10.6 ± 1.19^b	11.23 ± 1.38^a	10.71 ± 0.98^b	10.11 ± 1.37^c
Av. daily weight gain (g)/day	0.124 ± 0.002^b	0.139 ± 0.003^a	0.127 ± 0.002^b	0.117 ± 0.001^c
Weight gain	11.21 ± 1.22^b	12.55 ± 1.40^a	11.53 ± 0.98^b	10.57 ± 1.11^c
SGR (%/day)	7.78 ± 1.12^b	7.94 ± 1.01^a	7.80 ± 0.98^b	7.71 ± 1.02^c
FCR	2.81 ± 0.07^b	2.38 ± 0.09^b	2.76 ± 0.08^b	3.19 ± 0.07^c
Survival (%)	68.12 ± 3.72^b	79.83 ± 3.51^a	66.43 ± 3.14^b	56.67 ± 4.08^c
Cannibalism	14.73 ± 1.76^b	07 ± 0.98^a	16.03 ± 2.04^b	22.57 ± 2.36^c

Water parameters such as temperature ($^{\circ}$ C), pH, DO, ammonia, and total alkalinity (mg/l) were measured at biweekly intervals. Table (6) displays the results of the water quality parameters. The results show that the water quality parameter that was observed was extremely favorable for fish growth. Water temperature and total alkalinity did not differ significantly ($p > 0.05$) among treatments (Table 6). However, significant variations in pH, DO, and NH₃ between the treatments were found ($p < 0.05$).

Table 6. Mean values of the water parameters during the experiment (Oct-Dec 2022)

Parameters	Treatments			
	T ₁	T ₂	T ₃	T ₄
Water temperature ($^{\circ}$ C)	26.43 ± 1.53^a	26.53 ± 1.18^a	26.30 ± 1.33^a	26.38 ± 1.42^a
pH	7.82 ± 0.14^a	7.67 ± 0.11^b	7.79 ± 0.16^a	7.72 ± 0.10^b
DO (mg/L)	5.29 ± 0.39^b	5.18 ± 0.47^c	5.32 ± 0.51^b	5.41 ± 0.44^a
Total Alkalinity (mg/L)	117.40 ± 5.8^a	116.70 ± 4.52^a	116.90 ± 4.7^a	118.10 ± 4.77^a
NH ₃ (mg/L)	0.028 ± 0.008^a	0.019 ± 0.005^c	0.022 ± 0.007^b	0.03 ± 0.009^a

Improved Germplasm Production of Carps, White Pangas and Pure-line Breeding of Kalibaus (*Labeo calbasu*)

Researchers

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Objectives

- To upgrade and produce quality seeds of Indian major carps, BFRI Shuborno Rui, Catfishes, and distribute among the farmers and/or hatchery owners.
- To develop live gene bank with quality brood stocks through implementation of effective breeding plan.
- To produce improved stocks of Kalibaus through cross breeding and mass selection techniques
- To evaluate the growth performance of selected breeds with non-selected breeds of Kalibaus (generation to generation).

Achievement

Production of F₂ Generation of Kalibaus (Both Pure And Cross Breed Line) through Genetic Selection

Both pure and cross breed lines of F₁ generation of Kalibaus were reared in separate earthen ponds of the Pond complex in Freshwater Station. After completion of primary and secondary nursing, about 20% fingerlings from each line were selected based on individual growth performance. The selected fingerlings were reared in the separate ponds in order to developing broods so that we could use them for the development of F₂ generation of Kalibaus. Primary and secondary sexual characteristics were observed monthly to evaluate the status of maturity of Kalibaus. Like the other Indian major carps, the peak breeding season of Kalibaus is monsoon period. Observation of sexual characteristics during the monsoon indicated that the fish were not mature enough to breed. So, the production of F₂ generation of Kalibaus was not possible.

Evaluation of Growth Performance of Cross Breeds and Pure Lines of F₁ Generation of Kalibaus

Experimental Site

The experiment was conducted at the pond complex in Freshwater Station, BFRI, Mymensingh over 150 days from October 2022 to February 2023. The trial was conducted in ponds. At first the pond was completely drained, and all aquatic vegetation was manually removed. The pond was fenced with a synthetic net and surrounded by dykes for protection against unwater animals. Bottom racking was performed to remove toxic gases from the pond bottom. Diluted lime (CaCO₃) was applied on the pond surface at the rate of 250 Kg ha⁻¹. The ponds were filled with water from deep tube-well at the pond complex one day prior to stocking. Four ponds were used which were further divided into three parts with the help of synthetic net in such a way that the area of each part was one decimal.

Experimental Design

The experiment was designed to evaluate the growth performance of four groups viz., Group-1 [F₁ Male (Meghna) × F₁ Female (Meghna)], Group-2 [F₁ Male (Haor) × F₁ Female (Haor)], Group-3 [F₁ Male (Meghna) × F₁ Female (Haor)], and Group-4 [F₁ Male (Haor) × F₁ Female (Meghna)] of F₁ Kalibaus in

captive condition. Several 100 fingerlings were stocked in ponds with an area of one decimal. After stocking, fingerlings were fed 28% protein rich feed prepared with locally available ingredients (rice bran, wheat bran, fish meal, mustard oil cake etc.) at the rate of 10-3% body weight (Table 1).

Table 1. Design of experiments to evaluate growth performance of F₁ Kalibaus.

	Groups of F ₁ Kalibaus			
	G-1	G-2	G-3	G-4
Descriptions	F ₁ Male (Meghna) × F ₁ Female (Meghna)	F ₁ Male (Haor) × F ₁ Female (Haor)	F ₁ Male (Meghna) × F ₁ Female (Haor)	F ₁ Male (Haor) × F ₁ Female (Meghna)
Stocking density (Fingerlings/decimal)	100			
Feeding (% protein)	28			
Feeding rate (%)	10-3			
Period of trial (day)	150			

*G indicates group

Growth Performance

Initial length and weight of fish did not differ significantly ($p > 0.05$) among the four groups of F₁ Kalibaus, whereas final length, final weight, length gain, weight gain, average daily weight gain, and specific growth rate differ significantly ($p > 0.05$) among the four groups of F₁ generations (Table 2). Group-3 [F₁ Male (Meghna) × F₁ Female (Haor)] showed highest weight gain (100.28 ± 2.28) g, length gain (19.44 ± 1.20) cm, average daily weight gain (0.67 ± 0.02) g, and specific growth rate (0.95 ± 0.04) followed by Group-4 [F₁ Male (Haor) × F₁ Female (Meghna)], group-1[F₁ Male (Meghna) × F₁ Female (Meghna)], and Group-2 [F₁ Male (Haor) × F₁ Female (Haor)], respectively (Table 2).

Table 2. Growth performance of F₁ generation of Kalibaus (*L. calbasu*) over 150 days trial

Growth parameters	Groups of F ₁ Kalibaus			
	Group-1	Group-2	Group-3	Group-4
Mean initial length (cm)	3.51±0.53 ^a	3.47±0.47 ^a	3.46±0.40 ^a	3.39±0.34 ^a
Mean final length (cm)	19.03±1.19 ^b	17.95±1.22 ^c	22.90±1.18 ^a	18.72±0.95 ^b
Length gain (cm)	15.53±1.41 ^b	14.48±1.21 ^c	19.44±1.20 ^a	15.33±0.94 ^b
Mean initial weight (g)	3.90±0.61 ^a	3.91±0.50 ^a	3.94±0.48 ^a	3.97±0.42 ^a
Mean final weight (g)	95.73±2.24 ^b	89.92±2.53 ^c	104.57±2.25 ^a	95.52±2.22 ^b
Weight gain (g)	91.82±2.21 ^b	86.01±2.54 ^c	100.63±2.28 ^a	91.55±2.33 ^b
Average daily weight gain (g)	0.61±0.01 ^b	0.57±0.02 ^c	0.67±0.02 ^a	0.61±0.02 ^b
Specific growth rate (%bw/day)	0.93±0.04 ^b	0.91±0.04 ^c	0.95±0.04 ^a	0.90±0.03 ^b

*Values in the same row having different superscripts indicate significant difference at $p < 0.05$

Water quality parameters

Water quality parameters were monitored fortnightly. Water quality parameters such as temperature ranged between 30.38 ± 0.64 to 30.47 ± 0.64 °C, DO 6.09 ± 0.36 to 6.31 ± 0.22 ppm, pH ranged between

7.32±0.39 to 7.50±0.25, and ammonia ranged between 0.015±0.001 to 0.027±0.002 ppm in experimental units among the four groups of F₁ Kalibaus (Table 3). Water quality parameters were not varied significantly ($p > 0.05$) among the experimental units (Table 3). Water quality parameters in all experimental units were within the suitable ranges for fish growth.

Table 3. Water quality parameters of the experimental units.

Parameters	Experimental units of four groups of Kalibaus			
	Group-1	Group-2	Group-3	Group-4
Temperature (°C)	30.43±0.80 ^a	30.47±0.64 ^a	30.38±0.64 ^a	30.44±0.93 ^a
D. O. (ppm)	6.15±0.20 ^a	6.21±0.29 ^a	6.09±0.36 ^a	6.31±0.22 ^a
pH	7.32±0.39 ^a	7.36±0.33 ^a	7.50±0.25 ^a	7.46±0.31 ^a
Ammonia (ppm)	0.015±0.002 ^a	0.015±0.001 ^a	0.021±0.003 ^a	0.027±0.002 ^a

*Values in the same row having different superscripts indicate significant difference at $p > 0.05$

Production and distribution of quality mass seeds of Indian major carps (Rui, Catla, Mrigal, Kalibaus), Chinese carps (Silver carp, Bighead carp), Silver Barbs (Rajpunti), and Catfish (White pangas)

Keeping in line with production target, carp hatchery of Freshwater Station running under the project produced about 616.100 Kg of spawn comprising of Indian major carps, Chinese carps, Silver barbs, and White Pangas (Table 4). Major contributions in total production of spawn came from the Indian major carps while Kalibaus contributed least.

Table 4. Production of Improved Germplasm of Carps, Barbs and Catfish.

Species	Production		Breeding period
	Spawn (kg)	Fry/Fingerlings (Nos)	
BFRI Shuborno Rui	54.250	-	April-July
BFRI Rui	240.975	60,000	April-July
Catla	68.350	-	April-June
Mrigal	63.875	-	April-July
Kalibaus	1.625	50,000	April-July
Silver carp	37.950	-	March-July
Bighead carp	3.250	-	March-July
Silver barb (Rajpunti)	132.325	20,000	March-July
White Pangas	13.500	-	April-July
Total	616.100	1,30,000	

The produced spawn was distributed and disseminated among the fish farmers, hatchery and nursery owners throughout the country. Along with spawn, a number of 1,30,000 fingerlings were produced which are used for further brood development or research purposes.

Culture of Indigenous Small Fishes in Biofloc Aquaculture System (Comp. A)

Researchers

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Objectives

- To evaluate the growth and production of Striped Snakehead (*Channa striata*) in the Biofloc system
- To evaluate the growth and production of Striped Dwarf Catfish (*Mystus tengara*) in the Biofloc system

Achievements

Experiment 1. Evaluation of the growth and production of Striped Snakehead (*Channa striata*) in the Biofloc system

The experiment was started at the Freshwater Station of Bangladesh Fisheries Research Institute in three plastic indoor tanks with a volume of 8000L where water capacity is 6000L for the period of 06 months. The design of the experiment is given below:

Table 1. Experimental design for *C. striata* in Biofloc aquaculture system

Treatment	Stocking density (Nos./6000L)
T ₁	2000
T ₂	4000
T ₃	6000

Fish stocking and tank management

The *C. striata* was stocked according to the design of the experiment mentioned in the previous Table (1). After stocking, commercial feed (45-40% crude protein) was applied twice a day @ 10-03% body weight. For maintaining the C/N ratio, probiotics and molasses were added to tanks. Following six months of rearing, the fishes were harvested. In the current experiment, stocking density had an impact on the final weight, survival, and FCR. The average initial weight (g) and length (cm) of *C. striata* fry were 25.52±3.68g and 14.07±0.82cm in T₁, 25.46±3.71g and 14.03±0.78 cm in T₂, and 24.48±3.36g and 13.97±0.77cm in T₃, respectively (Figure 1).

The average final lengths and weights of fry were 30.1±2.41cm and 254.27±10.48g in T₁, 28.2±2.30cm and 213.60±9.42g in T₂, and 27.26±1.42cm and 175.7±8.44g in T₃, respectively (Figure 1). The ANOVA test results revealed that, in comparison to the T₂ and T₃ treatments, fish from the T₁ treatment grew more rapidly and gained more weight. Among treatments, there was a significant difference (p<0.05) in the SGR. Mean SGR for T₁, T₂, and T₃ were 1.39±0.08, 1.29±0.05, and 1.18±0.06, respectively (Table 2). It was noticed that the survival rates in T₁, T₂ and T₃ were 65.0±1.82, 57.5±1.99, and 54.2±2.79, respectively (Table 2). The survival rates varied significantly between the treatments (p<0.05). At the end of the experiment, it was found that the FCR in T₁, T₂, and T₃ were 1.50±0.08, 1.53±0.11, and 1.52±0.14, respectively. The FCR did not varied significantly among treatments (p>0.05). Water parameters such as temperature (°C), pH, DO, ammonia, and total alkalinity (mg/l) were measured at biweekly intervals. Table (3) displays the results of the water quality parameters. The results show that the water quality parameter that was observed was extremely favorable for fish growth. Water temperature, DO, pH, flock

density and total alkalinity did not differ significantly ($p>0.05$) among treatments (Table 3). However, significant variations in TAN among the treatments were found ($p< 0.05$). Several variable costs like stocking cost, chemical cost, labour and electricity cost were estimated during the period of farming. There were some fixed costs such as land rent, pond preparation as well. Cost and return analysis were performed on both variable and total cost bases. To achieve the objectives of the experiment a simple tabular analysis was done (Table 4). The benefit cost ratios were estimated as 1.28, 1.15 and 1.08 in T₁, T₂ and T₃, respectively.

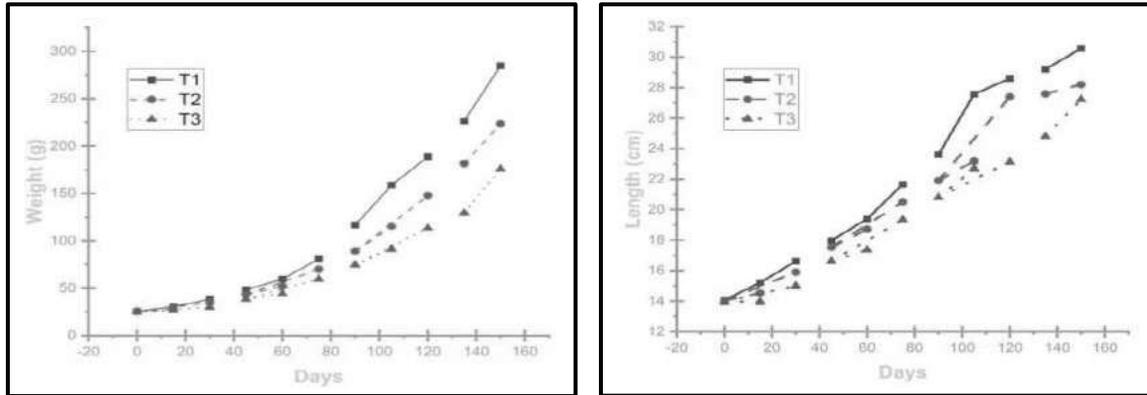


Figure 1. Bi-weekly variation in growth of *C. striata* under different treatments

Table 2. Growth performance of *C. striata* in biofloc system.

Parameters	T ₁	T ₂	T ₃
Initial weight (g)	25.52±3.68 ^a	25.46±3.71 ^a	24.48±3.36 ^a
Initial length (cm)	14.07±0.82 ^a	14.03±0.78 ^a	13.97±0.77 ^a
Final weight (g)	254.27±10.48 ^a	213.60±9.42 ^b	175.7±8.44 ^c
Final length (cm)	30.1±2.41 ^a	28.2±2.30 ^b	27.26±1.42 ^c
Weight gain (%)	896.35±8.57 ^a	738.96±9.98 ^b	617.73±11.41 ^c
Daily growth rate (%)	1.38±0.04 ^a	1.14±0.06 ^b	0.92±0.05 ^c
SGR	1.39±0.03 ^a	1.29±0.05 ^b	1.18±0.06 ^c
Survival rate (%)	65.0±1.82 ^a	57.5±1.99 ^b	54.5±2.79 ^b
FCR	1.50±0.08 ^a	1.53±0.11 ^a	1.52±0.14 ^a
Production (kg)	148.68±6.98	214.47±9.49	247.24±10.18

Table 3. Mean values of the water parameters during the experiment (Dec 22-May 23)

Parameters	T 1	T 2	T 3	Suitable range
Water temp. (°C)	a 26.85±3.14 (31.2-20.8)	a 27.02±2.97 (31.1-20.7)	a 26.97±3.11 (31.1-20.8)	° 26-32 C
pH	a 7.78±0.53 (8.36-7.10)	a 7.90±0.66 (8.45-6.90)	a 7.97±0.63 (8.5-6.91)	7.50-8.50
DO (mg/L)	a 5.87±0.2 (7.47-5.10)	a 5.95±0.2 (7.47-5.10)	a 6.01±0.2 (7.47-5.10)	>4 mg/l
Alkalinity (mg/L)	a 117.23±2.45 (135-105)	a 117.41±2.45 (135-105)	a 117.26±2.45 (135-105)	50-150 mg/l
TAN (mg/l)	b 0.06±0.01 (0.04-0.08)	0.09±0.02 ^{ab} (0.04-0.09)	a 0.11±0.06 (0.03-0.08)	0.00-0.50 mg/l
Floc density (mg/l)	a 16.07±0.11 (13-19)	a 15.99±0.10 (12-18)	a 15.96±0.12 (12.5-19)	5-30 mg/l

Table 4. Benefit cost ratio analysis for *C. striata* in biofloc system

Inputs	T 1		T 2		T 3	
	Qty.	Cost (Tk.)	Qty.	Cost (Tk.)	Qty.	Cost (Tk.)
Fingerling	1000	9000	2000	18000	3000	27000
Feed (Kg)	222	19980	328	29520	375.5	32795
Molasses	35kg	1400	42kg	1570	46 kg	1675
Probiotics	3.5 kg	3500	4.5 kg	4500	5.30 kg	5300
Electricity	170KW	1093	170KW	1093	170KW	1093
Construction	-	2000	-	2000		2000
Total cost	-	35973	-	55683	-	68863
Sell price	148.68kg @ 310 tk/kg	46090	214.47 kg @ 300 tk/kg	64343	247.24 kg @ 270 tk/kg	74172
Net benefit		10117		8660		5309
BCR		1.28		1.15		1.08

Experiment 2. Evaluation of the growth and production of Striped Dwarf Catfish *Mystus tengara* in the Biofloc system

The experiment was started at the Freshwater Station of Bangladesh Fisheries Research Institute in plastic indoor tanks with a volume of 8000L where water capacity is 6000L for the period of 06 months' culture period. The design of the experiment is given in Table 5.

Fish stocking and tank management

M. tengara was stocked according to the design of the experiment mentioned in previous Table (4). After stocking fish, commercial feed (37-30% crude protein) was applied twice a day @ 10-2% of estimated body weight. For maintaining the C/N ratio, probiotics and molasses were added to tanks.

Table 5. Experimental design for *M. tengara* in Biofloc aquaculture system

Treatment	Stocking density (Nos./6000L)
T ₁	12000
T ₂	24000
T ₃	36000

Following 06 months of rearing, the fishes were harvested. In the current experiment, stocking density had an impact on the final weight, survival and FCR. The average initial weight (g) and length (cm) of *M. tengara* fry were 0.60 ± 0.01 g and 4.16 ± 0.01 cm in T₁, 0.59 ± 0.01 g and 4.15 ± 0.01 cm in T₂, and 0.60 ± 0.01 g and 4.17 ± 0.01 cm in T₃, respectively (Figure 2). The average final lengths and weights of fry were 8.23 ± 0.41 cm and 5.07 ± 0.48 g in T₁, 8.08 ± 0.39 cm and 4.83 ± 0.42 g in T₂, and 7.76 ± 0.42 cm and 4.18 ± 0.44 g in T₃, respectively (Figure 2). The ANOVA test results revealed that, in comparison to the T₂ and T₃ treatments, fish from the T₁ treatment grew more rapidly and gained more weight. Among treatments, there was a significant difference ($p < 0.05$) in the SGR. Mean SGR for T₁, T₂, and T₃ were 1.29 ± 0.03 , 1.27 ± 0.05 , and 1.18 ± 0.06 , respectively (Table 6). It was noticed that the survival rates in T₁, T₂, and T₃ were 91.3 ± 1.80 , 85.39 ± 1.93 , and 76.3 ± 2.89 , respectively (Table 5).

The survival rates varied significantly between the treatments ($p < 0.05$). At the end of the experiment, it was found that the FCR in T₁, T₂, and T₃ were 1.02 ± 0.08 , 1.18 ± 0.11 , and 1.27 ± 0.14 , respectively. The FCR varied significantly among treatments ($p < 0.05$).

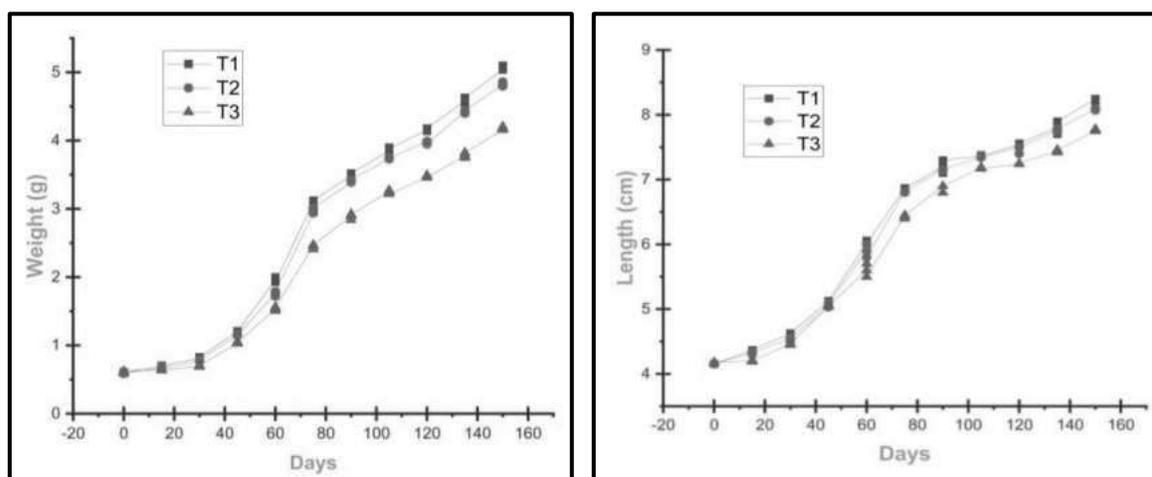


Figure 2. Bi-weekly variation in growth of *M. tengara* under different treatments

Water parameters such as temperature ($^{\circ}\text{C}$), pH, DO, ammonia, and total alkalinity (mg/l) were measured at biweekly intervals. Table (7) displays the results of the water quality parameters. The results show that the water quality parameter that was observed was extremely favorable for fish growth. Water temperature, pH, DO, flock density and total alkalinity did not differ significantly ($p > 0.05$) among treatments (Table 7). However, significant variations in TAN between the treatments was found ($p < 0.05$). Several variable costs like stocking cost, chemical cost, labour and electricity cost were estimated during the period of farming. There were some fixed costs such as land rent, pond preparation as well.

Cost and return analysis were performed on both variable and total cost bases. To achieve the objectives of the experiment a simple tabular analysis was done (Table 8). The benefit cost ratios were estimated as 1.23, 1.14 and 1.05 in T₁, T₂ and T₃, respectively.

Table 6. Growth performance of *M. tengara* in biofloc system

Parameters	T ₁	T ₂	T ₃
Initial weight (g)	0.60±0.01 ^a	0.59±0.01 ^a	0.60±0.01 ^a
Initial length (cm)	4.16±0.01 ^a	4.15±0.01 ^a	4.17±0.01 ^a
Final weight (g)	5.07±0.48 ^a	4.83±0.42 ^b	4.18±0.44 ^c
Final length (cm)	8.23±0.41 ^a	8.08±0.39 ^b	7.76±0.42 ^c
Weight gain (%)	745.1±8.57 ^a	718.64±9.98 ^b	596.67±11.41 ^c
Daily growth rate (%)	2.72±0.04 ^a	2.57±0.06 ^b	2.17±0.05 ^c
SGR	1.29±0.03 ^a	1.27±0.05 ^{ab}	1.18±0.06 ^b
Survival rate (%)	91.3±1.80 ^a	85.39±1.93 ^b	76.3±2.89 ^c
FCR	1.02±0.08 ^a	1.18±0.11 ^b	1.27±0.14 ^c
Production (kg)	56.55±6.98 ^c	97.93±9.49 ^b	117.69±10.18 ^a

Table 7. Mean values of the water parameters during the experiment (Dec 22-May 23)

Parameters	T ₁	T ₂	T ₃	Suitable range
Water temp. (°C)	27.45±3.14a (31.2-20.8)	27.29±2.97a (31.1-20.7)	27.34±3.11a (31.1-20.8)	26-32 C
pH	7.78±0.53a (8.36-7.10)	7.90±0.66a (8.45-6.90)	7.97±0.63a (8.5-6.91)	7.50-8.50
DO (mg/L)	6.07±0.2a (7.47-5.10)	6.07±0.2a (7.47-5.10)	6.07±0.2a (7.47-5.10)	>4 mg/l
Alkalinity (mg/L)	116.23±2.45a (135-105)	116.23±2.45a (135-105)	116.23±2.45a (135-105)	50-150 mg/l
TAN (mg/l)	0.06±0.01b	0.07±0.02b	0.11±0.06b	0.00-0.50 mg/l
Floc density (mg/l)	16.17±0.12a	15.89±0.10a	15.92±0.13a	5-30 mg/l

Table 8. Benefit cost ratio analysis for *M. tengara* in biofloc system

Inputs	T ₁		T ₂		T ₃	
	Qty.	Cost (Tk.)	Qty.	Cost (Tk.)	Qty.	Cost (Tk.)
Fingerling	12000	6000	24000	12000	36000	18000
Feed (Kg)	39.5	2765	105	6090	103.5	6003
Molasses	40kg	1400	42kg	1470	45 kg	1575
Probiotics	3.0 kg	3000	3.8 kg	3800	5.20 kg	5200
Electricity	170KW	1093	170KW	1093	170KW	1093
Construction	-	2000	-	2000	-	2000
Total cost	-	15758	-	26453	-	33068
Sell price	56.5 kg @ 400 tk/kg	22600	94 kg @ 320 tk/kg	30080	108 kg @ 320 tk/kg	34560
Net benefit	6842		3627		1492	
BCR	1.23		1.14		1.05	

Upgradation of Pearl Quality Using Different Techniques in Freshwater Mussel

Researchers

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Objectives

- To improve pearl quality by using different techniques in lab condition
- To reduce mortality rate of operated freshwater mussel by using different treatment
- To expand the technology through field trial of image pearl culture

Achievements

Experiment 1: Post harvest treatment of cultured pearl to increase the pearl quality

Different image pearls were cleaned with 10% ethanol and then dried. Then pearls were placed in vessels of hydrogen peroxide of different concentrations (5%, 15%, 25%, 35%, 45%). The dried pearls were kept 99% alcohol for 20h and then again kept in new 99% alcohol for another next 20 hours. After that a liquid solvent mixture of ethanol, methanol, distilled water (6:3:1) at 0.15mg/ml were mixed with 0.5ml of Tween 80 and Potassium iodide (KI) mixture in a vial with 4 replication (Treatment 1). After mixing the chemicals, crystal violet were mixed with 0.10mg/ml (Treatment 2). This two kind of mixture were placed under strong fluorescent lights (1,700-11,900 lumens) where they were kept for as long as 7-10 days at 33-40°C under intense light and controlled temperature. Temperature was checked.

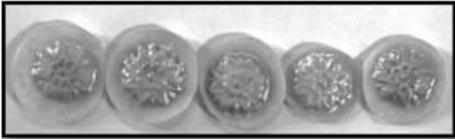
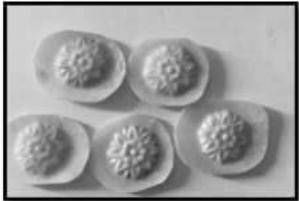
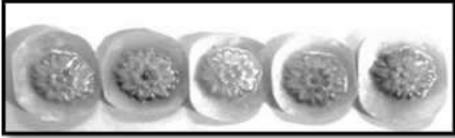
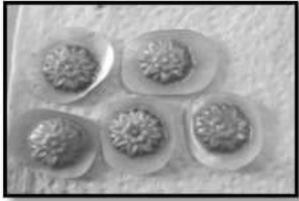
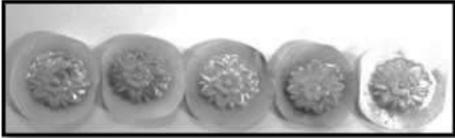
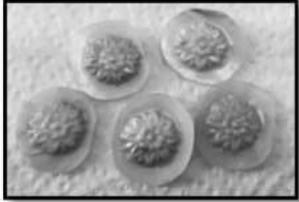
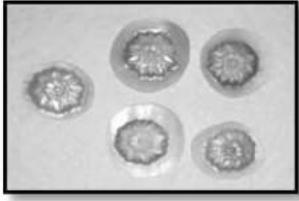
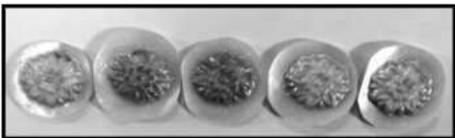


Figure 1. Measuring lux by light meter



Treatment chamber

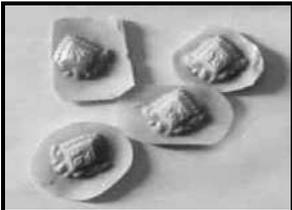
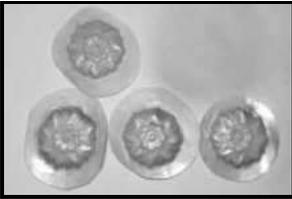
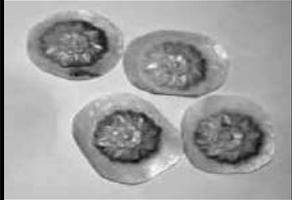
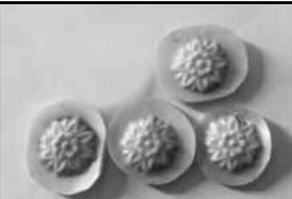
Table 1. Different lux parameters of image pearl in treatment 1.

H_2O_2 concentration (%)	Initial Lux (Mean±SE)	Final Lux (Mean±SE)
5%	 21±0.41	 41±0.86
15%	 22±0.32	 44±0.78
25%	 20±0.42	 46±0.56
35%	 20±0.35	 52±0.81
45%	 22±0.39	 55±0.87

The average lux of image pearl was 21 initially. That means, pearl was grade less. Here is the different concentration of H_2O_2 where pearl placed for 20 hrs. After 6 months of treatment, by naked eye and light

meter we observed that, the pearls have become shiny while H₂O₂ concentration was 45% than another concentration. The highest lux was found 55.

Table 2. Different lux parameters of image pearl in treatment 2.

H ₂ O ₂ concentration (%)	Initial Lux (Mean±SE)	Final Lux (Mean±SE)
5%	 21±0.31	 43±0.86
15%	 22±0.34	 46±0.78
25%	 22±0.41	 48±0.56
35%	 23±0.34	 55±0.81
45%	 22±0.32	 58±0.87

In treatment 2 average lux of image pearl was 22. After 6 months we found that, when pearl was placed in 45% H₂O₂ concentration for 20 hours the pearl getting absorbed violet color than another concentration. The highest lux was found 58.

Experiment 2. Organic and inorganic medicinal treatment to increase the survival rate of operated mussel during pearl culture

Pond was selected for stocking and rearing of collected mussels. Pond was prepared by following standard procedure. The pond was totally drained out and dried. After drying, lime and salt were applied at the rate of 1kg and 0.25kg per decimal to remove the insect and earthworm. After 6-7 days of liming, the pond was filled with water. After pond preparation, mussels were collected from different freshwater habitats in Bangladesh. Collected mussels were reared in stocking pond with food and fertilizers. After one month of rearing, the reared mussels were brought to the laboratory before two hours of operation, and then mussels were operated for pearl culture. In this experiment, *Lamellidens marginalis* and acrylic made powder made image were used. Species were collected from different freshwater regions. Image preparation and operation method were followed by the experiment number one.

Medicine treatment

After the operation, mussels were treated for 14 days with different medicinal treatments in the aquarium with a stocking density of 1 mussels/L. Medicine was used twice a day, and water was changed regularly. After 14 days of treatment, the operated mussels were transferred to the culture pond.

Culture Method

Operated mussel were cultured in pond under net bag hanging method, stocking density of mussels were 120 mussel/decimal. Net bag hanging method is a method where net bag hanged from a rope into 30-35cm depth with float. The rope stretched across the pond in the surface of water. The distance between adjacent two bags were 25-30cm and two hanging rope were 1.5m. For stimulating and maintaining the growth of natural plankton, organic, inorganic and fertilizers were applied fortnightly to the pond at the rate of 5kg organic manure, 0.125kg T.S.P. and 0.1kg urea per decimal respectively. Lime/CaCO₃ powder was applied 0.5kg per decimal respectively. Water depth was kept more than 1-1.5 meter. Water temperature, pH, NH₄-N, DO and Ca²⁺ parameters were monitored fortnightly.

Table 3. Survival rate of operated mussel after organic and inorganic medicinal treatment

Treatment	Medicinal ingredient		No. of operated mussels	Survival rate of operated mussel	Comment
T ₁	Turmeric Powder Dose: 0.05gm/L		100	93	Experiment going on
			100	91	
			100	88	
T ₂	Chlortetracycline Hydrochloride (Antibiotic); 0.05ml/L		100	87	
			100	90	
			100	89	
T ₃	Povisep (antiseptic) 0.05ml/L		100	88	
			100	87	
			100	86	

After 6 months of observation in culture pond it stated that, the survival rate in T₁ was maximum 93% than another medicinal treatment T₂ and T₃ . Experiment going on.

Experiment 3. Field trial of BFRI image pearl production techniques in farmer level

Image pearl production technology was developed at 3 different regions of Bangladesh. At the end of the experiment produced pearl will be collected. After collection complete data will be recorded. Total yield will be given to the farmers. The details of demo farms are given below:

a) Purbadhola Upazila, Netrokona

- About 400 operated mussels were given to the farm
- Single acrylic image were inserted in each mussel
- Water quality parameters and operated mussels were observed monthly
- Pearl quality will be observed after final harvest

b) Mymensingh sadar upazila, Mymensingh

- About 400 operated mussels were given to the farm
- Single acrylic image were inserted in each mussel
- Water quality parameters and operated mussels were observed monthly
- Pearl quality will be observed after final harvest

c) Hossainpur upazila, Kishoreganj

- About 400 operated mussels were given to the farm
- Single acrylic image were inserted in each mussel
- Water quality parameters and operated mussels were observed monthly
- Pearl quality will be observed after final harvest

Table 4. Survival rate of operated mussels in different region

SL	Farmer's name and address	Culture period	Survival rate	Comment
1	Abdullah Al Noman Vill: Jaoani Upazilla: Purbo Dhola District: Netrokona	11 Months (Starting date: 01 March 2023) Pearl quality will be observed after final harvest	88%	Experiment going on
2	Md. Kawsar Hossain Vill: Parail Upazilla: Mymensingh sadar District: Mymensingh		85.5%	
3	Muslim Uddin Upazilla: Kishorganj sadar District: Kishorganj		81%	

So far, maximum survival rate of mussels were 88% in Netrokona region and minimum in Kishoreganj region 81%. In mymensingh sadar, survival rate was 85.5%. Experiment going on

Table 5. Water quality parameters in Netrokona region

Month	Temp (⁰ C)	DO (mg/l)	pH	Ammonia (mg/l)	Alkalinity (mg/l)
Apr	27.53±0.12	4.66±0.26	7.32±0.37	0.09±0.08	180.00±26.46
May	26.53±0.65	4.54±0.35	7.16±0.36	0.02±0.04	190.00±10.00
Jun	26.77±0.50	4.63±0.31	7.39±0.10	0.00±0.00	190.00±10.00
Jul	26.53±0.25	4.74±0.16	7.28±0.07	0.05±0.08	176.67±15.28
Aug	25.97±0.57	5.86±0.07	7.40±0.43	0.04±0.03	170.00±10.00
Sep	26.80±0.26	5.91±0.10	7.57±0.12	0.03±0.01	190.00±10.00

Table 6. Water quality parameters in Churkhai, Mymensingh sadar region

Month	Temp (⁰ C)	DO (mg/l)	pH	Ammonia (mg/l)	Alkalinity (mg/l)
Apr	28.83±0.61	4.77±0.03	7.56±0.02	0.08±0.11	180.00±10.00
May	24.47±2.59	4.87±0.15	7.38±0.33	0.03±0.01	150.00±10.00
Jun	26.50±1.15	4.50±0.31	7.14±0.21	0.00±0.00	130.00±10.00
Jul	27.17±0.51	4.70±0.10	7.32±0.26	0.00±0.00	150.00±10.00
Aug	26.90±0.36	5.90±0.10	7.77±0.18	0.03±0.01	190.00±10.00
Sep	26.90±0.3	5.20±0.10	7.30±0.20	0.03±0.03	146.7±11.5

Table 7. Water quality parameters in Hossainpur, Kishorganj region

Month	Temp (⁰ C)	DO (mg/l)	pH	Ammonia (mg/l)	Alkalinity (mg/l)
Apr	27.2±0.6	5.4±0.2	7.3±0.1	0.023±0.032	133.3±20.8
May	27.3±0.6	5.2±0.1	7.4±0.1	0.003±0.002	136.7±30.6
Jun	26.9±0.3	5.2±0.1	8.3±0.2	0.030±0.030	146.7±11.5
Jul	26.6±0.6	5.2±0.1	7.5±0.1	0.033±0.012	133.3±15.3
Aug	26.5±0.3	5.3±0.2	8.4±0.1	0.030±0.030	123.3±15.3
Sep	25.7±2.59	4.7±0.1	7.8±0.3	0.030±0.010	150.0±10.00

Water quality parameters if different area were in optimum range during study period.

Ecological assessment of inland open water fisheries population with bio-physicochemical properties to frame EBFM approach (Comp. B. FSS)

Researchers

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Objectives

- To estimate population ecology and diet composition of some commercially significant inland open water fishes (especially Haor and Beel resident fishes)
- To assess bio-physicochemical properties of some selected inland water bodies (Haor and Beel) including seasonal variation and impact assessment of agro-chemicals level
- To assess stock and biomass of some important ecological fish group si.e. Planktivores /Herbivores, Detrivores, Carnivores & Omnivores based on catch and CPUE data
- To formulate ecosystem based management approach of some major inland open water bodies (especially Haor and Beel) with emphasizing to increase productivity, stock enhancement and conservation of the fisheries resources

Achievements

Study Areas

- Gumani River at Chalan Beel
- Atrai River at Chalan Beel

Study 1. Sampling of Bio-Physicochemical properties of inland open waters

Collection of Hydrological Data

Water quality parameter such as transparency, temperature, dissolved oxygen, pH, CO₂, alkalinity, hardness, conductivity, and TDS of sampling sites were recorded monthly basis.

Water quality of Gumani River at Chalan Beel

Surface water temperature ranged from 17°C to 30°C in Gumani River during the study period. The pH ranged from 7.1 to 7.7 in Gumani River during the study period. The pH value remained in the optimum range although it was fluctuating irrespective of the months.

In the present study, DO ranged from 4.5 to 5.3 mg/l in Gumani River at Chalan Beel. Maximum DO was observed in the month of May. CO₂ content ranged from 9 mg/l to 17 mg/l in Gumani River. It was minimum in May and maximum in March. Free carbon dioxide was found to be least in winter months due to greater utilization of it for photosynthetic activity by the phytoplankton. Transparency ranged from 18 cm to 22 cm in Gumani River.

Total alkalinity content ranged from 41 mg/l to 54 mg/l in Gumani River during the study period. In the present study, the lower alkalinity values were recorded during March which may be due to dilution effect. Total hardness refers to the concentration of calcium and magnesium. It ranged between 51 mg/l to

61 mg/l in Gumani River which indicated that water is soft and is suitable for drinking and irrigation purpose after the treatment (Figure 1).

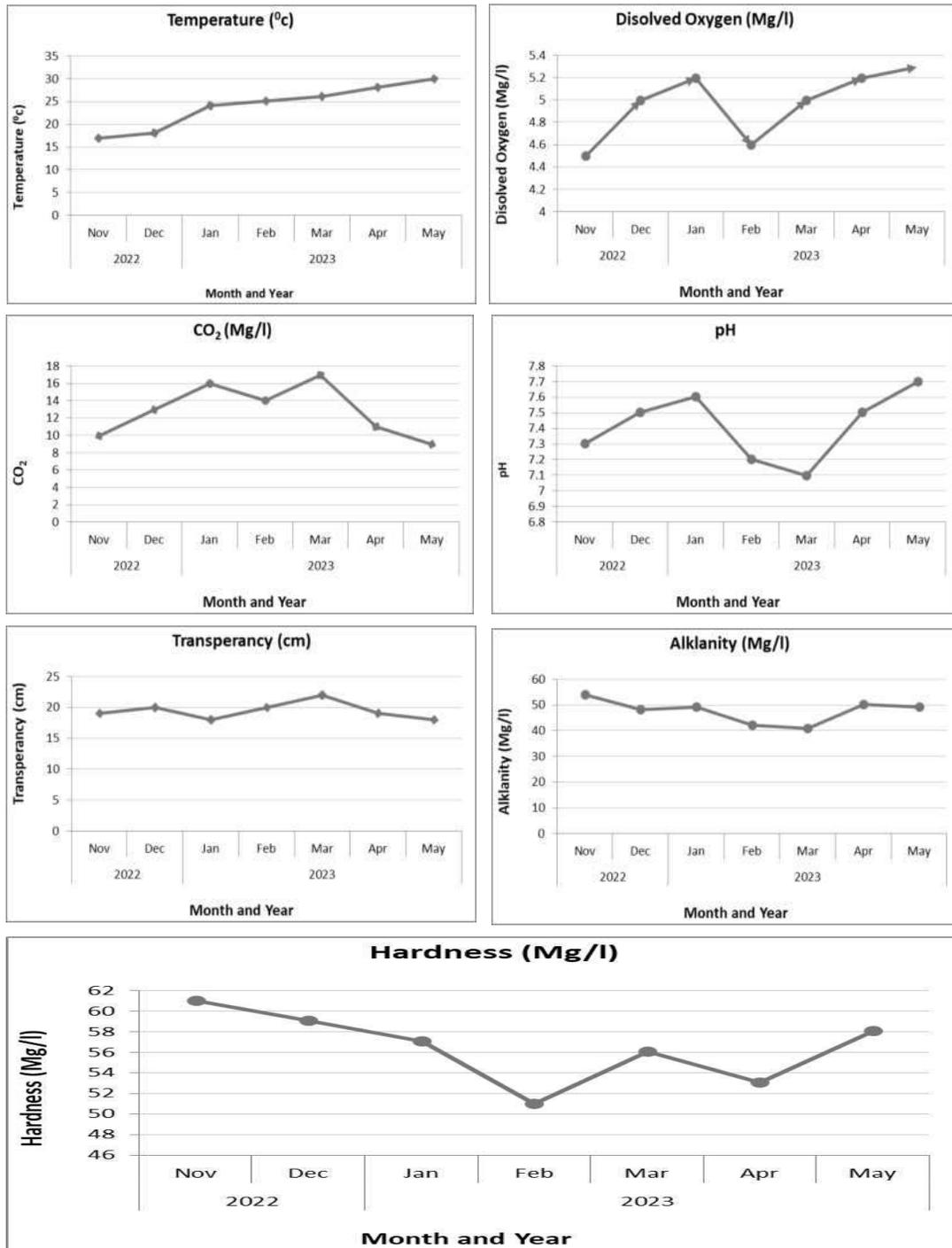


Figure 1. Water quality parameters of Gumani River.

Water Quality Standard

Almost all water quality parameters were within acceptable range for fish according to Bangladesh standard. Which is suitable for the fish and other aquatic animals.(Table 1)

Table 1. Water Quality Standard (Bangladesh).

Sl. No.	Parameters	BD Standard	Source
1	Water Temperature (°C)	30	EQs, 1997
2	Dissolved Oxygen (mg/l)	6.5	DoE, 2001
3	Carbon-di-oxide(mg/l)	23	EPAUS, 1976
4	pH	8.5	EQs, 1997
5	Transparency (cm)	45	BARC/Hossain, 2011
6	Total Alkalinity (mg/l)	100-200	Boyd & Tucker, 1998
7	Total Hardness (mg/l)	500	DoE, 1997
8	TDS (mg/l)	1000	DPHE, BD Online

Plankton Identification

Gumani River

A total of 4 groups (21 genera) of phytoplankton and 3 groups (7 genera) of zooplankton were identified of which Chlorophyceae in phytoplankton population and Rotifera in zooplankton population were dominant.

Atrai River

A total of 5 groups (18 genera) of phytoplankton and 3 groups (4 genera) of zooplankton were identified of which Chlorophyceae in phytoplankton population and Copepoda in zooplankton population were dominant.

The phytoplankton and zooplankton ratios in Gumani and Atrai River of Chalan Beel were 75: 25 and 81: 9, respectively. Groupwise list of different plankton species and No./L of two sampling site has given on Table: 2, 3 and 4.

Table 2. Group wise list of different plankton Species of Gumani River at Chalan Beel.

Plankton Type	Plankton Groups	Genus
Phytoplankton	Bacillariophyceae	<i>Asterionella sp. Coscinodiscus sp. Navicula sp. Nitzsehia sp. Synedra sp.</i>
	Cyanophyceae	<i>Spirulina sp. Anabaena sp. Aphanocapsa sp. Coelosphaerium sp. Polycystis sp. Microcystis sp. Oscillatoria sp. Spirulina sp.</i>
	Euglenophyceae	<i>Euglena sp. Phacus sp.</i>
	Chlorophyceae	<i>Pediastrum sp. Spirogyra sp. Pandorina sp. Closterium sp. Volvox sp. Ankistrodesmus sp.</i>
Zooplankton	Copepoda	<i>Cyclops sp. Nauplius sp.</i>
	Rotifera	<i>Lecane sp., Brachionus sp. Keratella sp.</i>
	Branchiopoda	<i>Bosmina sp. Moina sp.</i>

Table 3. Group wise list of different plankton Species of Atrai River at Chalan Beel.

Plankton Type	Plankton Groups	Genus
Phytoplankton	Bacillariophyceae	<i>Asterionella sp. Cyclotella sp. Navicula sp. Synedra sp. Coscinodiscus sp.</i>
	Cyanophyceae	<i>Spirulina sp. Microcystis sp. Nostoc sp. Anabaena sp. Aphanocapsa sp.</i>
	Coscinodiscophyceae	<i>Coscinodiscus sp.</i>
	Euglenophyceae	<i>Euglena sp. Phacus sp.</i>
	Chlorophyceae	<i>Spirogyra sp. Ankistrodesmus sp. Pandorina sp. Pediastrum sp. Scenedesmus sp.</i>
Zooplankton	Copepoda	<i>Cyclops sp. Nauplius sp.</i>
	Rotifera	<i>Brachionus sp.</i>
	Branchiopoda	<i>Bosmina sp.</i>

Table 4. Assessment of Plankton Distribution.

Sampling Points	Total Plankton (No./L)	Phytoplankton (No./L)	Zooplankton (No./L)	Ratio (Phyto : Zoo)	Remarks
Gumani River	69×10^2	50×10^2	19×10^2	75 : 25	Phytoplankton dominant
Atrai River	72×10^2	59×10^2	13×10^2	81 : 9	Phytoplankton dominant

Study 2. Field data collection for estimating population ecology of commercially significant haor and beel resident fishes

Length Weight Range

Length-weight range of different fish species was described under the following table according to the Fishing gear/ trap operated in study area. This length-weight range will be varied according to seasonal fluctuations (Table 5 and 6).

Table 5. Length-weight range of different fish species at Gumani River of Chalan Beel.

	Bele	Baim	Punti	Koi	Kholisha	Veda	Shing	Taki	Tengra	Chanda	Mola	Shol
Length (cm)	6.5	9	4.5	8	8.8	7	6.2	21	7.5	2.5	4.1	5
	-	-	-	-	-	-	-	-	-	-	-	-
	7.9	16	8.7	14	10	16	20	25	10	4.5	6.5	14
Weight (g)	2	2.9	1.5	8.9	11	9.3	6	79	4.5	2.5	0.9	1
	-	-	-	-	-	-	-	-	-	-	-	-
	3.5	11	1.2	22	14	62	55	166	7.5	1.7	2.5	21.5

Gear Study

Major gear used in those Rivers: Various types of fishing gear/ trap used in this study area. Type of gear used according to the fisherman benefit. Gill net, Trap Net, Seine Net, Cast net, Lift Net, Push Net, Drag Net, Setbag Net, Fish trap and seasonal trap of different mesh sizes are common in Gumani and Atrai River area. Use of different fishing gear and traps can also serve as a rough indicator of the availability of different fish species. We observe that Vadai net used widely during the sampling period in those study areas (Table 7).

Fish eggs, larvae and small fry are caught indiscriminately with these nets. Vadai, Setbag and Trap Net are harmful nets. Besides, seasonal traps are a threat to aquatic biodiversity.

Table 6. Length-weight range of different fish species at Atrai River of Chalan Beel.

	Punti	Kholisha	Baim	Bele	Koi	Shing	Mola	Veda	Tengra	Taki	Chanda
Length (cm)	4.5	7.5	7	6.5	7.2	6.2	3	6.3	6.5	13.5	2.1
	-	-	-	-	-	-	-	-	-	-	-
	9	8	18	8	14	20	7	17	12	22	4.6
Weight (g)	1.4	10.2	2.2	2.3	8.3	6.3	0.5	10.5	4.1	45	3
	-	-	-	-	-	-	-	-	-	-	-
	10	14	10	3.7	25	51	2.9	69	7.9	171	2

Table 7. Location wise net list.

Sl. No.	Location	Net name and type		
1	Gumani River	Net (7)	Fish trap (6)	Seasonal Trap (2)
		Fash/Current Jal (Gill net),	Khoilsun, Polo, Dhahair,	Brush Shelter
		China Doari Jal (Trap Net),	Vara,	Kua
		Vadai/Ber jal, (Seine Net)	Chai,	
		Jhaki/Khepla jal (Cast net)	Darki	
		Veshal Jal Dharma Jal (Lift Net)		
		Thela Jal (Push Net)		
		Moi Jal (Drag Net)		
		Suti-bindi Jal (Setbag Net)		
2	Atrai River	Net (8)	Fish trap (7)	Seasonal Trap (2)
		Fash/Current Jal (Gill net)	Khoilsun	Brush Shelter
		China Doari Jal (Trap Net)	Vara,	Kua
		Vadai/Ber jal, (Seine Net)	Ucha	
		Jhaki/Khepla jal (Cast net)	Polo,	
		Veshal Jal Dharma Jal (Lift Net)	Chai,	
		Thela Jal (Push Net)	Dhahair,	
		Moi Jal (Drag Net)	Darki	
		Suti-bindi Jal (Setbag Net)		

Study 3. Assessment of Stock or Biomass of Commercially Significant Inland Open Water Fishes as well as Water Bodies

CPUE of different type of fishing gear

Use of different fishing gear and traps can also serve as a rough indicator of the availability of different fish species. Some gear is species selective such as gill nets, traps. We observe that Vadai net used widely during the sampling period in those study areas. CPUE of Seine net was the highest in Gumani River. The CPUE was 22-23 kg in August to October.

Table 8. Monthly Gear-wise Average CPUE (Catch Per Unit Effort) of Gumani River at Chalan Beel [Kg/Hour/100 m Net].

Net Name	Month Name												Total	Avg. (kg)
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun		
Vadai jal/Berjal (Seine net)	18	23	22	22	13	8	7	7	5	5	7	6	143	11.92
Jhaki jal (Cast net)	1.5	1.3	1	1.4	0.8	0.9	0.7	1.6	1.5	1.5	1	2	15.2	1.27
Fash/Current Jal (Gill net)	2.5	3	7	5	3	2.5	1	1	1	0.9	0.8	1.5	29.2	2.43
Veshal net (Lift Net)	2	3.5	3	2	2	1	1	1	1	1.3	1.4	1	20.2	1.68
Thela Jal (Push Net)	0.3	0.5	1	1	1	0.5	0.3	0.4	0.5	1	1	1	8.5	0.71
Moi Jal (Drag Net)	0.5	1	1	1	1	0.9	0.6	0.7	0.5	1	1	1	10.2	0.85
Suti-bindi Jal (Setbag Net)	3	4	7	8	10	4	4	5	5	6	5	6	67	5.58
Fish trap	2.5	2.5	3	2	2	2	1.7	1.7	2	1.5	1	1.7	23.6	1.97
Brush Shelter and Kua (Seasonal)													300	300
Total													617	

Brush shelters and Kua (season-based fishing techniques) are set up during the rainy season of the year; after the rainwater subsides, fish are caught in brush shelter and Kuas. Brush shelters and Kua exist in Gumani and Atrai rivers. Although season-based fishing techniques, fish production here is more visible. CPUE of Brush shelters and Kua of Gumani river is 300 kg and net catch CPUE is 317 kg. In case of Atrai River, CPUE of Brush shelters and Kua is 320 kg and Net CPUE is 313 kg.

The CPUE in the Seine net at Atrai River was higher level. It was 20-26 kg in August to October. CPUE of different type of fishing gear is presented in the following table according to monthly basis (Table 8 and 9).

Table 9. Monthly Gear-wise Average CPUE (Catch Per Unit Effort) of Atrai River [kg/Hour/100 m Net].

Net Name	Month Name											Total	Avg. (kg)
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May		
Vadai jal/Berjal (Seine net)	20	20	21	26	21	12	7	6	5	4	3	145	24.17
Jhaki jal (Cast net)	1	1.7	1.4	2	1	1	1	1.5	2	1.5	1.2	15.3	2.55
Fash/Current Jal (Gill net)	5	4	4	5	4	3	1	1	1	1	1	30	5
Veshal net (Lift Net)	1	3	3	4	3	2	1	1	3	3	2	26	4.33
Thela Jal (Push Net)	0.3	0.5	0.7	1	1	0.5	0.4	0.5	0.5	1	1	7.4	1.23
Moi Jal (Drag Net)	0.5	1	1.2	1	1	0.9	0.6	0.6	0.5	1	1	9.3	1.55
Suti-bindi Jal (Setbag Net)	3	4	6	7	9	4	5	4	5	6	5	58	9.67
Fish trap	2.5	3	3.5	2.5	2	1.5	1.7	1.2	1	1.5	1.6	22	3.67
Brush Shelter and Kua (Seasonal)								320				320	320
Total												633	

Development of Induced Breeding and Culture Techniques of Gangetic Endangered Fish Species

Researchers

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Objectives

- Refinement of induced breeding techniques of Batashi and Pialy fish.
- Development of the induced breeding technique of Kajuli (*A. coila*) fish.
- Development of nursing and culture techniques of Batashi and Pialy fish.

Achievements

Experiment 1. Refinement of induced breeding techniques of the Batashi and Pialy

Collection of brood fishes

The sexually matured, strong, and diseased free broods were collected from the River Jamuna, River Atrai & Roktodaho Beel of Sirajgonj, Naogoan, and Bogura districts of Bangladesh and were stocked in the ponds at the rate of 200-250 brood/decimal averaging 3-4 g each for domestication for breeding purposes.

The results in the present experiment indicated that induced breeding of *N. atherinoides* was successful by using different doses of PG extract and among all trials, comparatively better performances in terms of ovulation, fertilization, and hatching rates were found in treatment T₃ in the month of July when 14 mg PG/ Kg body weight was applied.

The results in the present experiment indicated that induced spawning of *A. jaya* was successful by using different doses of PG extract and among all trials, comparatively better performances in terms of ovulation, fertilization, and hatching rates were found in T₃ treatment in the month of July when we used 12 mg PG/ kg body weight.

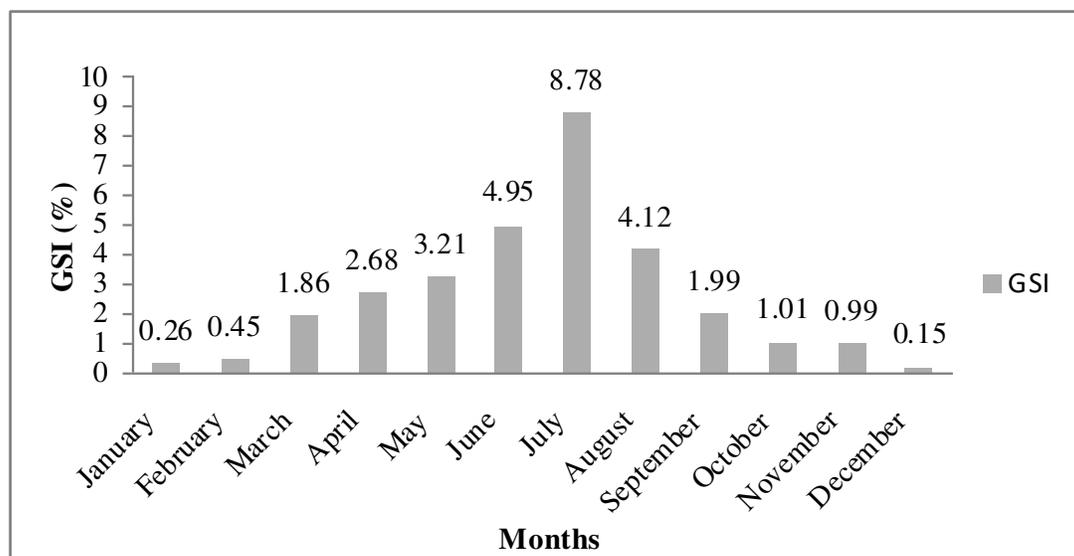


Figure 1. Monthly mean values of gonado-somatic index (GSI) of female *A. coila*.

Fecundity and Ova Diameter Range of *A. Coila*

Table 3. Fecundity and Ova diameter range of *A. coila*.

Month	Fecundity range	Mean Fecundity (nos.) (Mean±SD)	Ova diameter (mm) (Mean±SD)
April	715-985	850±135	0.12±0.03
May	1070-1800	1435±365	0.15±0.05
June	1640-2620	2130±490	0.25±0.06
July	1880-3020	2450±570	0.38±0.07
August	1236-2194	1715±479	0.27±0.05
September	785-1015	900±115	0.15±0.02

Histological Observation of *Ailia Coila*

Based on the oocyte prevalence percentage, classification of ovarian developmental phases are given below. The immature stage oocytes were found in February and March. A rapid development of oocytes with the shifting towards maturing stage was observed between April and May where the average oocyte diameter was found to be 0.12 mm and 0.15 mm, respectively (Table 3). There was a significant mature stage oocyte observed in June, July and August with average oocyte diameter of 0.25 mm, 0.38 mm and 0.27 mm, respectively (Table 3). The immature stage oocytes was found to be minimal from May to August while the maximum number of maturing stage and mature stage oocytes were present in May and July, respectively. The highest percentage of spent stage of ovary was observed in September. In the current study, the macroscopic and histological observations of the gonads, GSI, fecundity, and oocyte diameter showed a good agreement that the spawning season of *A. coila* extends from June to August with the major peak in July.

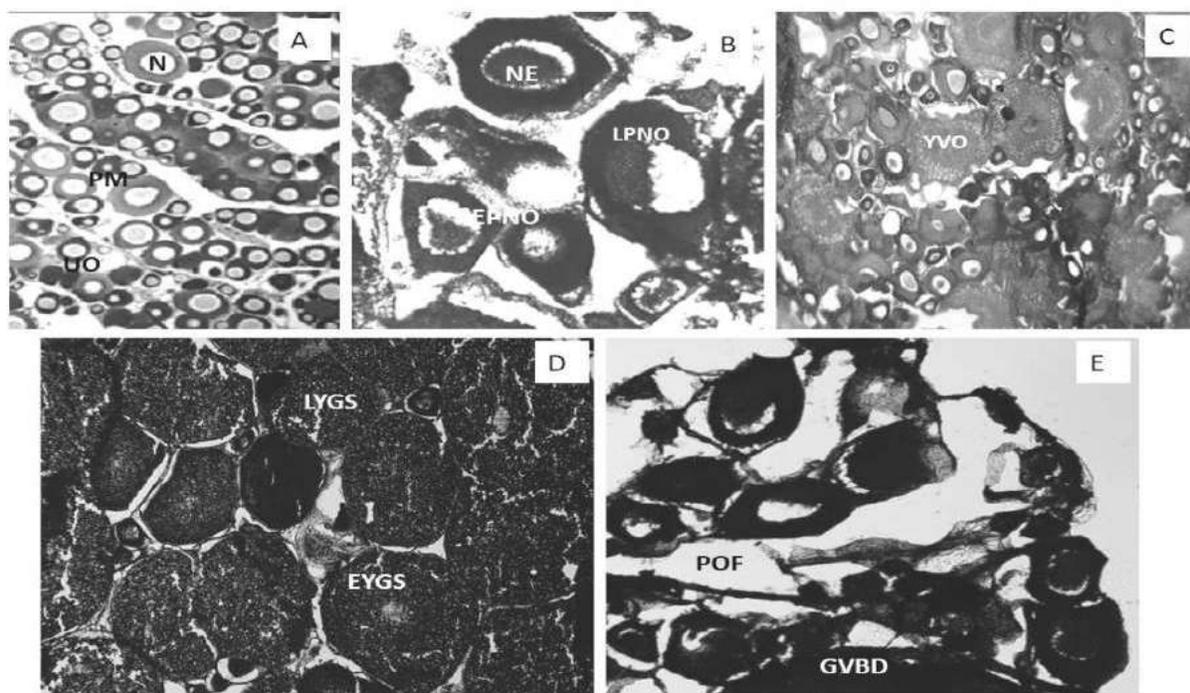


Figure 2. (A) Chromatin nuclear stage (N= Nucleoli; UO= Undeveloped oocyte; PM= Premature oocyte), (B) Perinucleolar stage (NE= Nucleolus; EPNO= Early perinucleolar oocyte, LPNO= Late perinucleolar oocyte), (C)Yolk vesicle stage (YVO= Yolk vesicle oocyte, (D) Yolk granular stage (EYVO= Early yolk vesicle stage oocyte, LYGO= Late yolk granule stage oocyte, (E) Spent (GVBD= Germinal vesicle breakdown; POF= Post ovulatory follicle.

Table 4: Trial for induced breeding of Kajuli (*A. coila*) by applying PG doses.

Trial	Treatment	Weight of brood fish (g)		PG dose (mg/kg BW)		Ovulation
		Female	Male	Female	Male	
Trial 1 (May)	T1	5.22±0.18	4.53±0.24	2	1	
	T2	5.33±0.29	4.34±0.21	4	2	No ovulation
	T3	5.18±0.24	4.93±0.23	6	3	
Trial 2 (June)	T1	6.20±0.16	5.83±0.21	7	3.5	
	T2	6.53±0.20	5.39±0.29	8	4	No ovulation
	T3	6.78±0.21	5.97±0.33	9	4.5	

For the development of induced breeding techniques of Kajuli fish, two trials were conducted during the months of May and June of 2023. There were three treatments in each trial with three replications each. During the month of May, 2, 4 and 6 mg PG/Kg BW were injected to female but none of the fish was ovulated. Another trial was conducted during the month of June where 7, 8 and 9 mg PG/kg BW of female were injected but none of the fish was ovulated.

Experiment. 3. Development of Nursing And Culture Techniques of Batashi And Pialy

Experiment 3.1. Development of Nursing Techniques of Batashi And Pialy

After breeding the five days old spawn of Pialy and Batashi were stocked in the nursery pond at a stocking density of 10,000 spawn/decimal and the nursing period was 40 days. The size of the each pond was 20 decimal. The feeding schedule during the experimental period was shown in Table 05.

Table 5. Feeding chart of 100 g spawn are given below.

Spawn/Fry age (Days)	Feed	Feeding rate	Feeding frequency (times/day)
1-3	Boiled egg yolk	2 egg	3
4-7	Boiled egg yolk + Flour mixing	50 g	3
8-15	Nursery feed (38-40 % protein)	100 g	3
16-30	Nursery feed (35 % protein)	200 g	3
31-40	Nursery feed (32 % protein)	300 g	3

Table 6. Water quality parameters during the nursing period.

Water quality parameters	Values	
	Mean \pm SD	Range
Water Temperature ($^{\circ}$ C)	29.91 \pm 1.55	28.36 - 31.46
pH	7.82 \pm 0.11	7.71 - 7.93
DO (mg/l)	5.53 \pm 0.38	5.15 - 5.91
Transparency (cm)	29.12 \pm 1.22	27.9 - 30.34
Free CO ₂ (mg/ l)	0.30 \pm 0.06	0.24 - 0.36
Total ammonia (mg/l)	0.11 \pm 0.05	0.06 - 0.16

Table 7. Growth performance of Pialy and Batashi after 40 days of nursing period

Parameters	Batashi	Pialy
Stocking density (spawn/dec)	10000	10000
Final length (cm)	2.52 \pm 0.10	2.82 \pm 0.15
Final weight (g)	0.99 \pm 0.07	1.02 \pm 0.06
Survival rate (%)	73.19 \pm 1.05	78.08 \pm 0.66

Experiment. 3.2. Effects of Different Stocking Density on the Growth and Production of the

Genetic Endangered Fish Species in Earthen Pond

The trial was set up in a Completely Randomized Design (CRD) with three treatments (stocking density) having three replicates each.

Table 8. Stocking ratio of Batashi and Pialy.

Species	Stocking density (Fry/dec)			Replication
	T1	T2	T3	
<i>N. atherinoides</i>	500	750	1000	3
<i>A. jaya</i>	500	750	1000	
Total	1000	1500	2000	

Water Quality Parameters

Table 9. Mean± SD and range values of water quality parameters measured during the experimental period of 120 days.

Water quality	T1	T2	T3
Water Temperature (°C)	28.40 ± 1.30a (27.10-29.70)	28.40 ± 1.30a (27.10-29.70)	28.40 ± 1.30a (27.10-29.70)
pH	7.50±0.20a (7.30-7.70)	7.40 ± 0.20ab (7.40-7.60)	7.10 ± 0.40b (6.70-7.50)
DO (mg l ⁻¹)	5.40 ± 0.50a (4.90-5.90)	5.30 ± 0.50a (4.80-5.80)	5.10 ± 0.60a (4.50-5.70)
Transparency (cm)	33.10 ± 2.10a (31.00-35.20)	33.10 ± 2.40a (30.70-35.50)	33.30 ± 2.30a (31.00-35.60)
Total ammonia (mg l ⁻¹)	0.10 ± 0.02a (0.08-0.12)	0.14 ± 0.04a (0.10-0.18)	0.17 ± 0.06a (0.11-0.23)

Growth and production performance

Table 10. The growth and production performance of Batashi and Paly in polyculture are given below during the experimental period of 120 days.

Parameters	Species	Treatment		
		T ₁	T ₂	T ₃
Initial Length (cm)	<i>N.atherinoides</i>	2.52±0.10 a	2.54±0.08 a	2.56±0.17 a
	<i>A.jaya</i>	2.82±0.15 a	2.44±0.78 a	2.66±0.19 a
Final Length (cm)	<i>N.atherinoides</i>	8.63±0.30 a	8.85±0.07 a	8.99±0.11 a
	<i>A.jaya</i>	8.93±0.31 a	8.75±0.57 a	8.89±0.16 a
Initial Weight (g)	<i>N.atherinoides</i>	0.99±0.07 a	1.00±0.11 a	1.01±0.12 a
	<i>A.jaya</i>	1.02±0.06 a	1.10±0.11 a	1.01±0.12 a
Final Weight (g)	<i>N.atherinoides</i>	7.20±0.07a	7.44±0.11a	7.69±0.14a
	<i>A.jaya</i>	8.28±0.24 a	8.22±0.20 a	8.15±0.17 a
Weight Gain (g)	<i>N.atherinoides</i>	6.21±0.03 a	6.44±0.19 a	6.68±0.11 a
	<i>A.jaya</i>	7.29±0.20 a	7.22±0.19 a	7.14±0.11 a
SGR (% day ⁻¹)	<i>N.atherinoides</i>	1.66±0.05 a	1.68±0.10a	1.70±0.10 a
	<i>A.jaya</i>	1.77±0.05 a	1.76±0.10 a	1.74±0.12 a
ADWG (g)	<i>N.atherinoides</i>	0.05±0.00a	0.05±0.00a	0.06±0.00a
	<i>A.jaya</i>	0.06±0.00 a	0.06±0.00 a	0.06±0.00 a
Survival (%)	<i>N.atherinoides</i>	87.30±6.60 a	85.71±4.70 a	84.95±5.40 a
	<i>A.jaya</i>	84.78±4.22 a	84.65±3.25 a	83.47±3.48 a
Gross Production (Kg/dec)	<i>N.atherinoides</i>	3.14±0.27 c	4.78±0.20 b	6.53±0.53 a
	<i>A.jaya</i>	3.51±0.10 c	5.21±0.08 b	6.80±0.35 a
Total Production (Kg/dec)		6.65±0.26 c	9.99±0.30 b	13.33±0.19 a
FCR		2.23±0.06a	2.17±0.02a	2.09±0.06a

Results of the present study demonstrated that, no significant differences were observed among the treatments in weight gain, SGR, and survival rates. A significantly higher ($p < 0.05$) gross production of 13.33±0.19 Kg/ dec in 120 days was obtained in T₃ (2000 nos/ dec) treatment compared to T₂ and T₁. The results demonstrate that the polyculture of Batashi and Paly at 2000 nos/dec stocking density may be suitable for higher growth, survival and production.

Table 1. Details of induced breeding of Batashi (*N. atherinoides*) by applying PG doses.

Trial	Treatment	Weight of brood fish (g)		PG dose (mg/kg BW)		Latency period (h)	Ovulation rate (%)	Fertilization rate (%)	Incubation period (h)	Hatching rate (%)
		Female	Male	Female	Male					
Trial 1 (May)	T ₁	5.4±0.26	4.1±0.19	10	5		38.13±1.11 c	45.34±1.22 c		52.44±2.21 c
	T ₂	5.2±0.21	4.9±0.18	12	6	12 to 15	45.21±2.13 b	51.36±1.31 b	23 to 26	59.64±1.62 b
	T ₃	5.6±0.25	5.3±0.20	14	7		52.12±1.21 a	59.24±1.12 a		65.54±2.11 a
Trial 2 (June)	T ₁	7.2±0.16	5.5±0.24	10	5	12 to 15	61.12±1.21 b	59.24±1.12 b	23 to 26	75.54±2.11 b
	T ₂	6.5±0.20	5.3±0.21	12	6		63.21±2.13 ab	61.37±1.31 ab		79.64±1.62 ab
	T ₃	7.7±0.21	5.7±0.23	14	7		67.14±1.59 a	62.35±1.21 a		80.33±1.10 a
Trial 3 (July)	T ₁	8.2±0.17	6.6±0.24	10	5	12 to 15	64.13±1.23 b	62.27±1.12 b	23 to 26	76.55±2.13 b
	T ₂	7.4±0.22	7.1±0.22	12	6		66.22±2.15 ab	64.39±1.31 ab		80.65±1.64 ab
	T ₃	7.9±0.23	6.9±0.20	14	7		70.15±1.61 a	65.37±1.21 a		81.34±1.12 a

Table 2. Details of induced breeding of Pialy (*A. jaya*) by applying PG doses.

Trial	Treatment	Weight of brood fish (g)		PG dose (mg/kg BW)		Latency period (h)	Ovulation rate (%)	Fertilization rate (%)	Incubation period (h)	Hatching rate (%)
		Female	Male	Female	Male					
Trial 1 (June)	T ₁	7.20±0.16	6.53±0.24	8	5		51.12±1.21 c	57.24±1.12 c		70.54±2.11c
	T ₂	7.53±0.20	7.34±0.21	10	6	6 to 8	56.21±1.13b	63.36±1.01b	20 to 22	74.64±1.62b
	T ₃	7.78±0.21	6.93±0.23	12	7		60.14±1.09a	67.34±1.21a		79.33±1.10a
Trial 2 (July)	T ₁	8.94±0.24	8.10±0.20	8	5	6 to 8	67.23±1.62c	69.85±1.30c	20 to 22	78.89±1.30c
	T ₂	8.79±0.26	8.36±0.29	10	6		72.59±1.80b	74.74±1.51b		82.48±1.12b
	T ₃	8.84±0.25	8.74±0.23	12	7		78.87±1.71a	79.39±1.40a		86.98±1.20a
Trial 3 (January)	T ₁	9.14±0.24	8.99±0.66	8	5	6 to 8	59.12±1.11 c	52.24±1.22 c	20 to 22	58.54±2.21c
	T ₂	8.99±0.26	8.76±0.49	10	6		61.21±1.23b	57.36±1.11b		62.64±1.32b
	T ₃	9.21±0.25	8.94±0.33	12	7		65.14±1.39a	62.34±1.31a		66.33±1.40a

Species Availability and Develop a Suitable Technology of Fermented Dried Fish Product (Shidol) in Floodplain Region of Bangladesh

Researchers

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Objectives

- Refinement of suitable technology for good quality Shidol.
- To observe the shelf life of Shidol in vacuum packaging by examining biochemical and microbiological test.
- To evaluate the sensory test of Shidol

Achievements

Survey of the Available SIS Species and Ingredients Used in *Shidol* Preparation

We visited several local fish markets to know the availability of different SIS found in the floodplain region for the preparation of *Shidol*. Some locally available fish species are given below:

- Puti
- Taki
- Kholisha
- Mola
- Chanda
- Chela
- Batashi
- Dhela

Among them Puti was most available and cheap SIS. For development of suitable technology of *Shidol* Puti was used. In this experiment three different types of *Shidol* samples (BFRI-1, BFRI-2 and BFRI-3) was prepared by using different amount of ingredients and their special characters has been showed in Table 1.

ii) **Materials and Methods of *Shidol* Processing**

The equipment required for *Shidol* processing are: Smoking Kiln, Ring Tunnel Fish Drier, Net Covered Drying Basket. The pictures of these equipment are given below:

iii) **Collection of Raw Materials**

Raw materials (SIS) were collected from local fish market.

iv) **Dressing, Cutting, Gutting**

After collection, raw materials (SIS) were gutted immediately. Generally, women workers are involve in dressing, cutting and gutting.

v) **Salting**

After gutting fish salting were done to protect fish from fly, insect, or their larval infestation. Sometime salts were used to get extra weight of fish. Generally, 125 g salt was used for 1 kg of fish.

vi) The Smoking Kiln

The smoking kiln made with steel as a rectangular box of 105×75×45 cm³ size. Horizontally, the chamber divided into two equal parts by placing a horizontal perforated iron net-frame and the bottom portion used as base for burning saw dust wooden logs/chips as smoke source. The temperature (external of Kiln) was maintained at 50-55⁰C manually by controlling the outlet of the smoking chamber. During smoking operation fishes were turned over in the middle period.



Figure 1. Smoking of salted fish in Smoking Kiln.

vii) Sun drying in ring tunnel

After Smoking fishes were sun dried (4-6 days) in ring tunnel fish dryer and net covered drying basket. Each fish turned over 8-10 times/day.



Figure 2. Sun drying of smoked fishes.

viii) Processing of *Shidol*

At first mankochur data pulp mixed with dried Mola, Putti, Taki fish powder as required amount to make paste. After mixing, the paste was rubbed with turmeric and mustard oil and made the paste into round shaped by hand. To protect it from birds or flies during drying under sun for 8-10 days, the baskets were covered with nets.

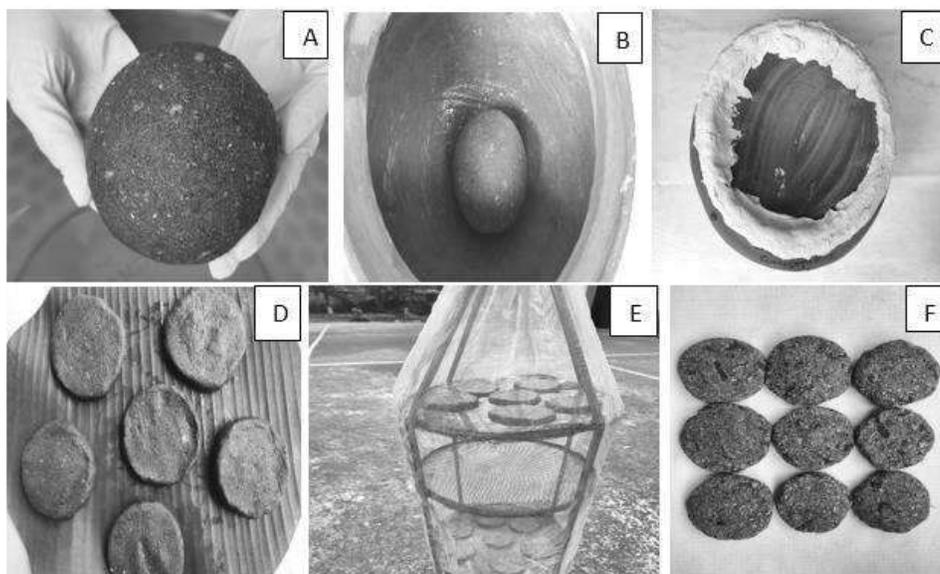


Figure 3. Processing of *Shidol*.

Table 1. Materials used in processing of *Shidol*.

Sample name	Origin/ District	Materials	Special Characters
BFRI made Shidol	New	Aram green (57%), Dry SIS (28%), Salt (1.99%), Salt (1.99%), Garlic (7.2%), Ginger (3.6%), Turmeric powder (0.7%), Mustard oil (7.2%)	Salting, Smoking, sun drying
Traditional	Rangpur, Nilphamari, Kurigram, Dinajpur, Gaibanda, Lalmonirhat, Panchagarh	Aram green (70%), Dry SIS (17.54%), Salt (3.50%), Garlic (7.01%), Ginger (0.70%), Turmeric powder (0.35%), Mustard oil (0.70%)	Sun drying

Vacuum Packaging

After preparation of Shidol, we sealed the Shidol in vacuum machine with polythene bags and stored at atmospheric temperature (15-34⁰C). The biochemical and microbiological test of Shidol samples have already been examined to assess the shelf life of packaged Shidol. All samples were tested at BCSIR lab, Rajshahi.



Figure 4. Vacuum packaging of Shilol.

Table 2. Proximate composition (% dry weight) of *Shidol* samples.

Parameters	Initial value		Value after 60 days of preservation in vacuum packaging	
	BFRI made Shidol	Traditional	BFRI made Shidol	Traditional
Moisture (%)	19.73±2.21	27.72±3.68	16.63±2.55	26.62±4.10
Crude lipid (%)	20.18±1.59	13.28±0.98	19.38±1.52	14.28±1.10
Crude protein (%)	37.15±3.21	31.66±1.58	39.15±3.65	28.58±1.25
Ash (%)	14.90±1.25	14.82±2.24	15.10±1.98	16.12±2.95
Crude fiber (%)	5.84±1.45	7.50±2.10	7.84±1.69	10.58±1.95
Carbohydrate (%)	2.20±0.54	5.02±1.21	1.90±0.44	3.82±1.65

Table 3. Results of Biochemical and microbiological test after 60 days of preservation period of *Shidol*.

Days	pH (27°C)		Total viable count (log CFU/g)		Total yeast mold (log CFU/g)		Total coliform count (log CFU/g)		TVBN (mg/100gm)		Peroxide value (meq O ₂ /kg)	
	A	B	A	B	A	B	A	B	A	B	A	B
0	6.19	7.31	2.8	8.8	1.1	3.56	0	0.1663	20.1	176.21	2.1	7.1
15	6.25	7.45	1.3	7.4	2.1	5.34	0	0.2499	26.25	198.6	4.2	10.2
30	6.4	7.76	1.8	6.4	2.3	6.5	0	0.2499	33.15	225.69	7.2	15.2
45	6.26	7.26	1.4	5.5	2.8	6.7	0	0.4978	37.25	249.62	7.4	20.4
60	6.3	7.71	1.29	5.7	3.1	7.4	0	0.6367	41.21	268.3	8.6	27.6

A= BFRI made *Shidol* and B= traditionally made *Shidol*

Assessment of Existing Hatchery Management Practices and Dissemination of BFRI Evolved Improved Germplasm in Jashore Region

Researchers

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Objectives

- To assess the present status of fish seed production and hatchery management practices in Jashore;
- To identify the major problems and constraints in fish hatchery and nursery management;
- To evaluate the role of value chain actors and their functions for producing quality fish seed;
- To improve the existing brood stock in Jashore region through dissemination of BFRI evolved improved germplasm;
- To standardize the fish seed production, marketing system and value chain in Jashore.

Achievements

Name of the Study: Assessment of the Present Status of Fish Seed Production and its Marketing Channel in Jashore

In the course of present time period some survey work has been carried out under experiment no1. Preliminary survey site has been selected in different hatcheries in Jashore region. Prior to do the survey work, a questionnaire was developed regarding existing hatchery management practices. Surveys have been conducted using the formulated questionnaire in respective hatcheries (Figure 1). Fry production practices including application of different inputs by the hatchery technicians were observed closely and recorded. Brood management technique including brood source and brood exchange techniques were observed and data were recorded. Data on total fry production in different hatcheries including production cost and return achieved were being collected (Figure 1). About 38 hatcheries were surveyed in the Jashore region till reporting. Among them 34 hatcheries (89%) was running and 4 hatcheries (11%) stopped their fry production.

In Jashore region, total three types of hatcheries were observed which are Carp, Carp and Catfish and Carp, Catfish and Tilapia. Among the observed hatcheries Carp, Catfish and Tilapia contributed 70% of the total fish seed production and carp hatcheries contributed only 5% (Figure 2).



Figure 1. Focus group discussion and data collection.

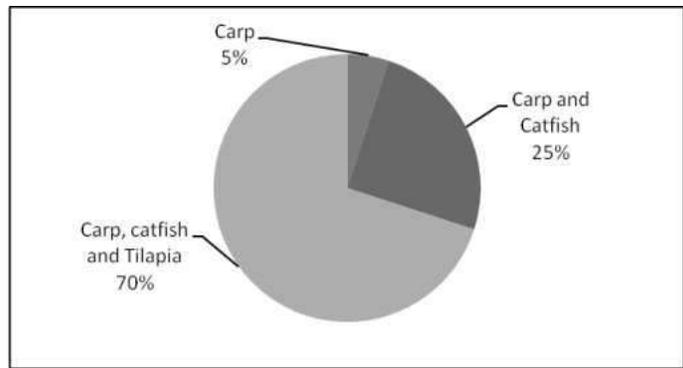


Figure 2. Percentage of fish seed producing hatchery in Jashore region.

Source of Brood

After observations three types of brood sources were found. Fifty percent (50%) of the hatcheries have own source of broods, thirty percent (30%) use broods from other ponds and twenty percent (20%) of hatcheries use broods from natural sources (Figure 3).

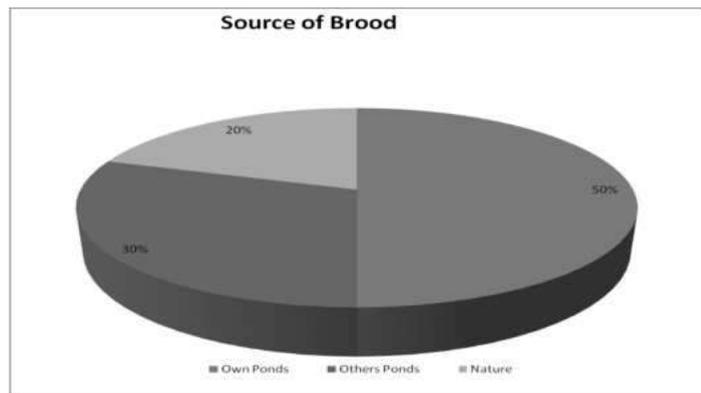


Figure 3. Percentage of brood sources for hatcheries in the study region

Hatchling Production

Hatcheries of Jashore district produce three types of hatchlings; mainly Indian Major Carps (IMCs), Exotic carps and other species. Among the produced hatchlings, IMCs were produced by 48% hatcheries, exotic carp hatchlings were by 43% of hatcheries and only 9% hatchery produce other species hatchlings (Figure 4).

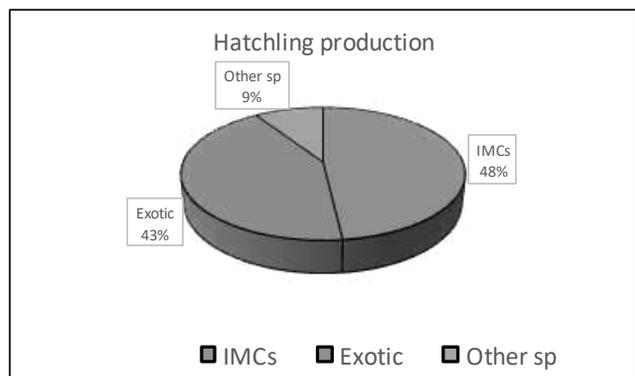


Figure 4. Percentage of hatchling production in hatcheries in the research area.

From Jashore region’s hatcheries, the produced hatchlings were distributed mostly all over Bangladesh where 46% of hatchlings are distributed in south-west region, 19% distributed in south-east region, 18% in north-west region and only 17% in north-east region (Figure 5).

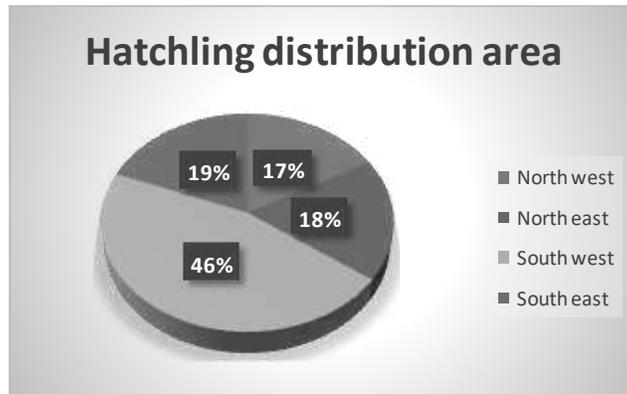


Figure 5. Percentage of hatchling distribution from hatcheries in the research area.

In case of lab facilities, almost 90% of the hatcheries do not have any lab facilities where only 10% have that (Figure 6).

About 38 hatcheries were surveyed during the study period. Among them 34 hatcheries (89%) were running and 4 hatcheries (11%) stopped their production due to several constraints (Figure 7).

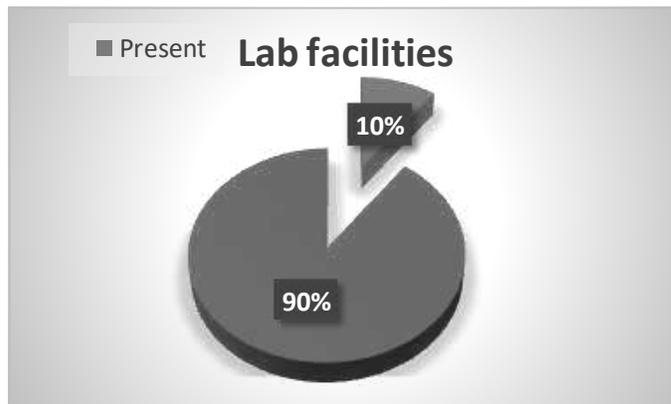


Figure 6. Percentage of lab facilities of hatcheries in the research area.

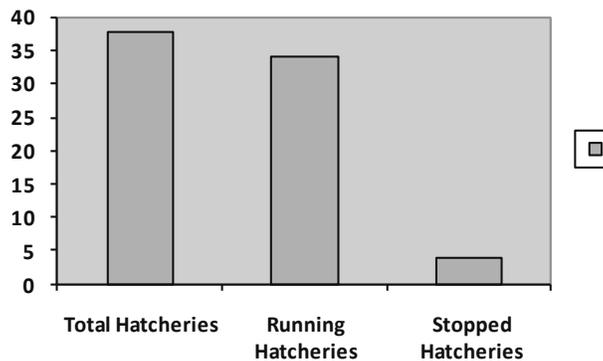


Figure 7. Hatcheries in the research area.

Name of the Experiment/Study: Improved Germplasm (Suborno Rui) Collection, Rearing and Distribution.

The experiment was conducted in the selected pond of BFRI, FSS Jashore. Bottom sludge from all the experimental ponds was removed after sun dried completely. Dike of the ponds were repaired. Liming was done@1kg/dec. Fertilization with organic fertilizers were done@ 100g/dec Urea & 75g/dec TSP. Improved germplasm of Subono Rui fingerlings were collected from BFRI Freshwater Station, Mymensingh. The Suborno Rui fingerlings were stocked at 8/dec. Fishes were being fed with formulated feed and supplementary feed @ 10% to 3% bodyweight concurrently daily. Growth performance parameters were calculated monthly basis (Table 1).

Table 1. Growth performance of Suborno Rui.

Months	Initial Body Weight (g)	Average Body Length (cm)	Average Body Weight (g)
November/22	2.1±0.19	11.25±0.34	45.23±0.21
December/22		17.48±0.27	98.06±0.13
January/23		23.5±0.18	186.8±3.37
February/23		27.56±0.21	327.26±2.34
Mar/23		32.28± 1.66	446±4.62
April/23		32.95± 3.12	516.1±6.51
May/23		35.05± 2.07	602.5±8.72
June/23		36.27± 3.11	709.2±5.33

Water quality parameters (temperature, DO, pH, alkalinity, ammonia, hardness) data were monitored monthly (Table 2).

Table 2. Water quality parameter till reporting.

Parameters	Nov/22	Dec/22	Jan/23	Feb/23	Mar/23	Apr/23	May/23	June/23
Temp (°c)	28.45 ±0.07	23.25±0.21	20.85 ±0.63	23.75±0.28	24.2 ±0.14	24.6 ±0.14	25.5± 0.07	26.65±1.7
DO (mg/l)	4.7±0.14	4.85±0.07	4.55±.07	4.65±.07	4.55 ±0.07	4.5 ±0.14	4.4± 0.14	5.0±0.24
pH	7.6±0.14	7.65±0.14	7.85±.07	7.75±.03	7.6 ±0.14	7.8 ±0.14	7.9 ±0.28	7.5±0.18
Ammonia (mg/l)	0.08 ±0.03	0.1±0.07	0.02±.03	0.02±.07	0.02± 0.07	0.01± 0.03	0.02± 0.03	0.03±0.02
Alk. (mg/l)	165.5 ±2.12	165.5 ±0.70	166±.70	167.5±1.41	167.5 ±2.12	169.5± 0.70	171± 1.41	165±2.22
Hardness	170.5 ±0.70	169.5±0.70	171.5±.07	170.5±.07	171 ±1.41	171.5± 0.70	170± 1.41	169±2.11

Name of the Experiment/Study: Improved Germplasm (BFRI GIFT Tilapia) Collection, Rearing and Distribution.

The experiment was conducted in the selected ponds of BFRI, FSS Jashore. Bottom sludge from all the experimental ponds was removed after sun dried completely. Dike of the ponds were repaired. Liming was done@1kg/dec. Fertilization with organic fertilizers were done@ 100g/dec Urea & 75g/dec TSP. Fingerlings and sub adults of BFRI GIFT fish was collected from Freshwater Station, Mymensingh. The BFRI GIFT fingerlings were stocked @ 60 /dec. Fishes are being fed with formulated feed and supplementary feed @ 8% to 2% bodyweight concurrently daily. Water quality parameters (temperature, DO, pH, alkalinity, ammonia, hardness) data were monitored monthly (Table 3). Growth performance

parameters were calculated monthly. The growth performances of Tilapia in rearing ponds has been shown in Table 4 and Figure 9.

Table 3. Water quality parameters till reporting.

Months	Temperature (°c)	DO (mg/l)	pH	Ammonia (mg/l)	Alkalinity (mg/l)	Hardness
November/22	28.35 ±0.07	4.7±0.14	7.6±0.14	0.18±0.03	164.5±2.12	170.5±0.70
December/22	23.35±0.21	4.85±0.07	7.75±0.14	0.17±0.03	165.5±0.70	170.5±0.07
Jan/23	20.85±0.63	4.55±0.07	7.85±0.07	0.012±0.03	166±0.70	171.5±0.07
Feb/23	23.75±0.28	4.65±0.07	7.75±0.03	0.02±0.07	167.5±1.41	170.5±0.07
Mar/23	24.3± 0.14	4.6± 0.14	7.65± 0.07	0.02± 0.14	166± 1.41	171± 0.03
Apr/23	24.6 ±0.14	4.5 ±0.14	7.8 ±0.14	0.01± 0.03	169.5± 0.70	171.5± 0.70
May/23	25.5± 0.07	4.4± 0.14	7.9 ±0.28	0.02± 0.03	171± 1.41	170± 1.41
June/23	26.65± 1.7	5.0± 0.24	7.5 ±0.18	0.03± 0.02	165± 2.22	169± 2.00

Table 4. Growth performance of BFRI GIFT Tilapia

Months	Initial body weight(g)	Average Body Length (cm)	Average Body Weight (g)
November/22	0.25±0.06	4.32±0.31	4.25±0.28
December/22		9.18±.09	18.06±0.34
January/23		14.02±.37	56.24±.17
February/23		16.08±.28	102.04±.56
Mar/23		18.46± 1.82	136.6± 1.29
April/23		18.68± 0.96	161.33± 2.12
May/23		21.2± 1.63	188.85± 1.37
June/23		20.27±1.2	190.18± 2.22

Development of Breeding and Culture Technique of Needle Fish and River Catfish

Researchers

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Objectives

- To optimize the dose for breeding and larval rearing technique of Kakila fish in captive condition
- To develop breeding and larval rearing technique of Bacha fish in captive condition
- To develop culture technique of Kakila and Bacha fish in captive condition
- To study the histology of the gonadal development during breeding season of Kakila and Bacha fish

Achievements

Experiment 1. To optimize the dose for breeding of Kakila fish in captive condition

The study was conducted to optimize the hormone doses for induced breeding of Kakila (*X. cancila*). The length-weight data were collected monthly basis for the Kakila (*Xenentodon cancila*) fishes to observe their growth performances. Randomly five Kakila fishes were collected monthly by netting from the Kakila fish pond of the FSS, Jashore and dissected them to estimate gonado-somatic index (GSI) (Table-1). The highest gonado somatic indexes (GSI) were found at the month of August.

Refinement was done by injecting same doses of PG extracts to optimize the hormone doses 2 times in the breeding season (August/22). Water quality data were also collected fortnightly in every month to observe water quality parameters of the Kakila fish pond (Table-3). All the water quality parameters were found in suitable ranges of fish culture.

Table 1: Mean length-weight data of Kakila fish and gonad of pond at FSS, Jashore

Months	Average Length (cm)	Average Body Weight (g)	Average Gonad weight (g)	Gonado Somatic Index (GSI) (%)
July/2022	22.14±2.90	23.28±6.21	1.10±0.55	4.72
August/2022	22.89±1.87	26.0±2.12	1.31±0.37	5.03
September/2022	22.23±2.04	25.84±1.72	1.16±0.20	4.49
October/2022	23.81±1.62	27.24±1.68	0.94±0.10	3.40
November/2022	23.42±1.50	27.16±1.55	0.80±0.06	2.94
December/2022	18.47±1.06	15.64±1.51	0.44±0.05	2.81
January/2023	18.38± 1.31	14.61± 3.50	0.24± .08	1.62
February/2023	19.53 ±1.26	15.86 ±3.25	0.28± 0.07	1.79
March/2023	18.98±1.15	13.91±2.51	0.40±0.06	2.89
April/2023	18.44±1.13	15.57±1.66	0.46±0.05	2.95
May/2023	19.17± 2.05	18.05± 3.97	0.54± 0.14	2.99
June/2023	21.18±2.57	21.11± 5.48	0.69 ± 0.12	3.27

Table 2: Induced breeding trial of Kakila fish in FSS, Jashore

Trial No.	No. of Pairs	Dose No.	Hormone Dose carp PG (mg/kg)		Hormone dose Ovotide/ One time (ml/kg)		Observations
			Female	Male	Female	Male	
01 (August 2022)	10	1	6.0	2.0	-	-	Ovulation and hatching success occurred
02 (August 2022)	12	1	6.0	2.0	-	-	

The eggs were about 3.5 mm (0.14 in) in diameter and were attached to plant roots, stems, leaves and hapas wall. The eggs took 4-5 days to hatch while needle fish larvae were 12-15 mm. After hatching, broods were transferred to another tank immediately. First feeding was started 72 hours of hatching while yolk sac became absorbed. Egg yolk meshed were supplied as first feed @ 40% of body weight. Zooplankton collected from research ponds were supplied to hatchling with chick egg meshed simultaneously up to 7 days. Brine shrimp flakes were provided as supplementary feed with zooplankton. At the age of 6/7 days, fries were graded according to their size and shifted to another tank for avoiding cannibalism. After 15 days, those graded fingerlings were shifted to different hapas in the earthen pond.

Table 3: Monthly average water quality parameters of Kakila fish pond water of FSS, Jashore

	2022						2023					
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Temp. (°C)	30.1 ±0.14	30.7 ±0.14	30.75 ±0.35	31.35 ±0.21	25.75± 0.35	20.4 ±1.97	19.6 ±0.56	21.3 ±0.14	28 ±1.41	31.5 ±2.12	31 ± 1.41	32.05±0 .21
DO (mg/l)	5.0±0 .28	5.0± 0.14	5.0± 0.28	5.0± 0.14	4.45± 0.07	4.5± 0.14	5±0.1 4	5.7± 0.14	4.65± 0.07	4.85± 0.21	4.79± 0.07	4.95± 0.21
pH	8.0±0	7.95	7.82 ±0.11	8.0	7.75	7.5 ±0.20	7.4 ±0.20	7.5±0	8.0±0	7.70 ±0.20	7.95 ± 0.07	7.75± 0.07
Alk. (mg/l)	169± 1.41	165.5 ±0.7	167± 1.41	164.5 ±0.70	163.5± 0.70	159.5 ±0.7	160.5 ± 0.70	161.5 ±0.70	164.5± 0.70	166±0	163.5± 0.70	165 ±1.41
Hard. (mg/l)	175± 1.41	172.5 ±0.7	174.5 ±0.70	173.5 ±0.70	171.5± 0.70	167±1 .41	164.5 ± 0.70	165.5 ±0.70	173±1. 41	174.5± 0.70	172.5± 0.70	172.5 ±3.54
NH ₃ (mg/l)	0.08± 0.05	0.05± 0.02	0.06± 0.02	0.10± 0.05	0.12±0 .02	0.11± 0.05	0.14± 0.02	0.17± 0.04	0.15±0. 06	0.12±0. 05	0.11±0 .02	0.11±0. 04

Experiment 2. Collection and Domestication of Bacha fish in captive condition

The length-weight data of Bacha (*Eutropiichthys vacha*) were recorded monthly to observe their growth (Table-4) and water quality parameters (temperature, DO, pH, alkalinity, ammonia, hardness) were monitored fortnightly (Table-5). All the water quality parameters were found in suitable ranges of fish culture.

Table 4: Mean length-weight data of Bacha fish of pond at FSS, Jashore

Months	Length (cm)	Weight (g)
July/2022	11.30±1.26	12.05±1.92
August/2022	11.3±1.84	13.18±1.60
Sep/2022	13.2±0.82	15.93±0.92
Octo/2022	13.81±0.90	16.73±1.01
Nov/2022	15.45±0.30	20.55±2.41
Dec/2022	16.98±2.17	27.83±7.20
Jan/2023	17.23± 0.93	35.66± 10.81
Feb/2023	19.03± 2.87	52.83 ±19.34
March/2023	19.17± 4.83	54.37± 2.36
April/2023	19.31± 1.76	56.32± 6.71
May/2023	19.37 ±1.78	57.69± 8.71
June/2023	19.45± 0.93	59.86± 10.81

Table 5. Monthly average water quality parameters of Bacha fish pond water of FSS, Jashore.

	2022						2023					
	Jul	Aug	Jul	Aug	Jul	Aug	Jul	Aug	Jul	Aug	Jul	Aug
Temp. (°C)	30.4 ±0.28	29.55 ±0.77	30.4 ±0.14	29.65 ±0.63	28.2 ±0.28	21.7 ±0.56	21.01 ± 1.92	23.5 ±0.42	24.14± .07	24.35± 0.07	25.25± 0.21	31.4±0. 07
DO (mg/l)	5.05± 0.07	4.6±0. 14	4.7±0 .14	4.65± 0.07	4.7±0. 14	4.65± 0.07	4.55± 0.07	4.55± 0.07	4.6 ±0.14	4.5± 0.14	4.45 ±0.07	5.00±0. 07
pH	7.87± 0.17	7.45± 0.07	7.9±0 .14	7.72± 0.03	7.85±0 .07	7.9±0. 14	7.95± 0.07	7.75± 0.07	7.7± 0.14	7.9± 0.14	7.8± 0.14	7.75±0. 17
Alk. (mg/l)	164.5 ±0.70	165±0	167.5 ±0.70	165±0	166.5± 0.70	165.5 ±0.7	170.5 ±2.12	170.5 ± 0.70	163.5± 3.53	172.5± 0.70	173.5± 2.12	166.5±0 .70
Hard. (mg/l)	171.5 ±2.12	174±1 .41	171± 1.41	171.5 ±2.12	172.5± 0.70	170.5 ±0.70	166± 2.82	164.5 ± 0.70	169.5± 0.70	167.5 ±2.12	169.5± 3.53	172.5±2 .12
NH ₃ (mg/l)	0.07± 0.03	0.017 ±0.03	0.015 ±0.07	0.025 ±0	0.037± 0.17	0.01±. 07	0.012 ±0.03	0.012 ±0.03	0.012± 0.035	0.012± 0.035	0.015 ±0.07	0.01±0. 03

Experiment 3. Histology of the gonadal development during breeding season of Kakila and Bacha fish

Fishes were collected from both wild and captive source. Gonado Somatic Index (GSI) of Kakila and Bacha fish were estimated monthly. Collected Gonad were preserved and send to BFRI Shrimp Research Station, Bagerhat for histological study.

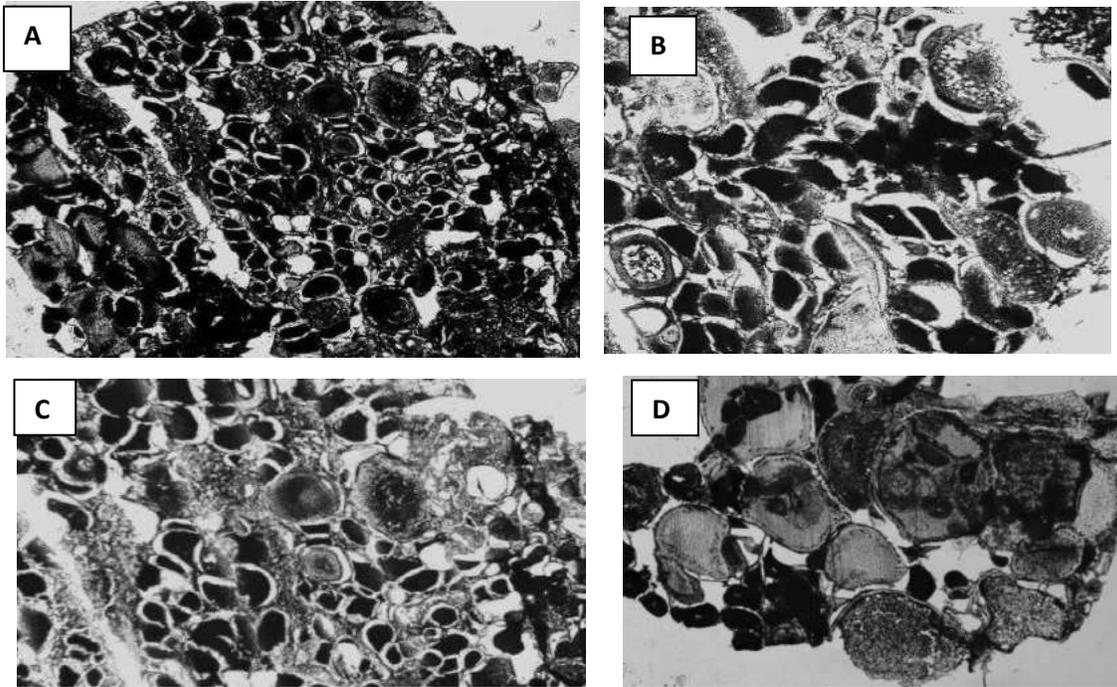


Figure 1: Transverse sections through ovaries of *E. vacha* illustrating oogenesis: (A) oogonia and chromatin nucleolar stage oocytes in April; (B) early perinucleolar stage oocytes in early May; (C) late perinucleolar stage oocytes in late May; (D) yolk vesicle stage oocyte in June.

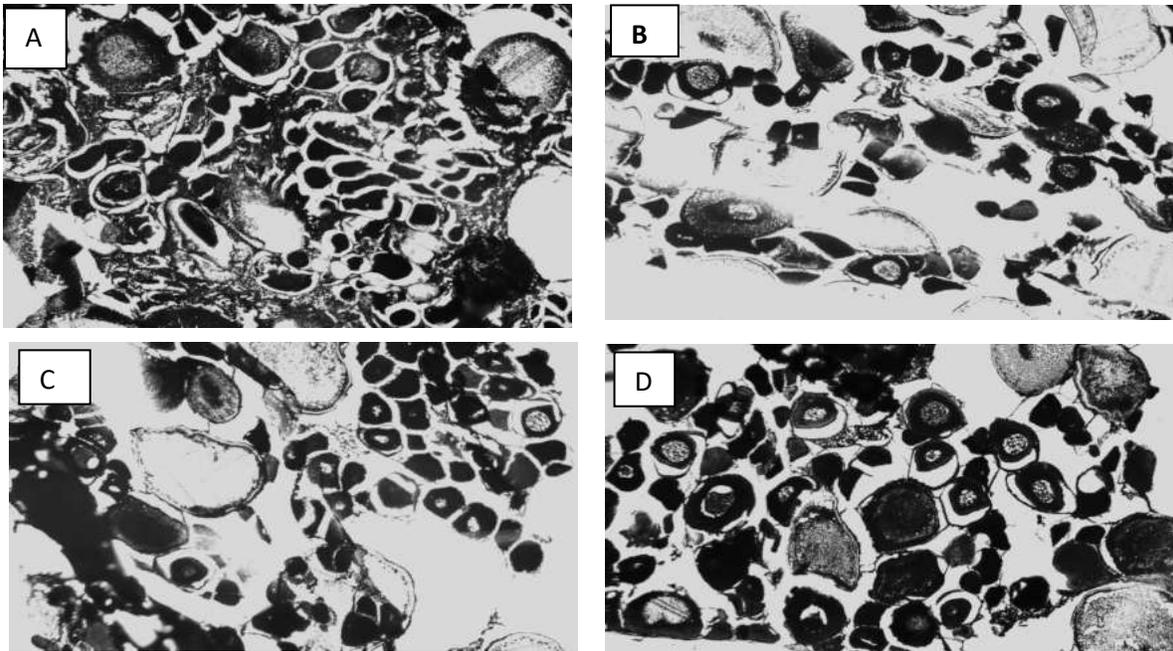


Figure 2. Transverse sections through ovaries of *X. cancila* illustrating oogenesis: A) oogonia and chromatin nucleolar stage oocytes in April; (B) early perinucleolar stage oocytes in May; (C) late perinucleolar stage oocytes in late May; (D) yolk vesicle stage oocyte in June.

Ecological Assessment of Open water Fisheries (Baor) Population with Bio-Physicochemical Properties to Frame EBFM Approach (Comp.-C)

Researchers

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Objectives

- To estimate population ecology and diet composition of some commercially significant inland open water fishes (especially Baor resident fishes)
- To assess bio-physicochemical properties of some selected Baor including seasonal variation and agro-chemicals impact level
- To assess stock of some important ecological fish groups i.e., Planktivores/Herbivores, Detrivores, Carnivores & Omnivores based on catch and CPUE data
- To assist for framing or formulating ecosystem-based management approach of some commercially significant inland open water bodies with emphasizing to increase productivity, stock enhancement and conservation of the fisheries resources

Achievements

Experiment 1. Sampling of bio-physicochemical properties of Baors

All the water quality parameters were found within suitable ranges for fish culture in the Boluhar, sostar, nosti and bergobindapur Baor (Table 1, 2, 3 and 4). The phytoplankton and zooplankton genera identified of following Baor are similar and belonging from seven groups and three groups respectively (Table. 5, 6 and 7).

Table 1. Monthly average water quality parameters of Boluhor Baor.

Parameters	2022						2023					
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Temperature (°C)	30.7	31.3	31.1	29.9	29.7	23.3	20.5	22.3	24.7	25.1	25.5	32.7
Transparency (cm)	37	36	38	38	39	39	38	40	36	37	39	41
DO (mg/l)	5.6	5.7	5.6	4.9	5.1	4.6	4.4	4.5	4.8	5.1	5.2	5.6
pH	7.5	7.6	7.5	8	8.2	7.8	8.1	7.7	7.9	7.8	7.7	7.8
NH ₃ (mg/l)	0.1	0.05	0.15	0.05	0.15	0.25	0.3	0.25	.20	.30	.25	.15
Total Alkalinity (mg/l)	164	166	165	164	166	167	168	166	162	160	164	159
Total Hardness (mg/l)	170	172	169	167	170	171	172	170	168	165	169	167

Table 2. Monthly average water quality parameters of Nosti Baor.

Parameters	2022						2023					
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Temperature (°C)	30.5	31.7	31.3	29.7	29.4	23.2	21.5	23.2	25.2	26.1	26.3	28.9
Transparency (cm)	38	35	37	36	38	37	37	39	37	35	37	40
DO (mg/l)	5.5	5.6	5.7	5.1	5.2	4.7	4.6	4.7	4.9	5.0	5.2	5.7
pH	7.5	7.7	7.5	7.9	8.1	7.8	8.0	7.7	7.8	7.6	7.7	7.8
NH ₃ (mg/l)	0.1	0.05	0.1	0.05	0.15	0.25	0.25	0.25	.20	.20	.15	.25
Total Alkalinity (mg/l)	165	166	164	165	166	167	168	166	164	162	164	160
Total Hardness (mg/l)	170	171	169	165	170	171	169	170	168	165	168	167

Table 3. Monthly average water quality parameters of Sostar Baor.

Parameters	2022						2023					
	Jul	Aug										
Temperature (°C)	31.7	31.5	32.1	29.9	29.7	23.4	21.5	22.3	24.7	25.1	25.5	32.7
Transparency (cm)	38	37	39	38	37	39	38	41	37	38	39	41
DO (mg/l)	5.6	5.7	5.6	4.9	5.1	4.6	4.4	4.5	4.8	5.1	5.2	5.6
pH	7.4	7.6	7.5	7.7	8.1	7.8	7.9	7.8	7.7	7.9	7.7	7.8
NH ₃ (mg/l)	0.1	0.05	0.1	0.05	0.15	0.25	0.3	0.25	.05	.25	.25	.15
Total Alkalinity (mg/l)	166	167	165	164	166	167	168	164	162	160	164	159
Total Hardness (mg/l)	172	170	169	168	170	172	171	169	167	165	169	167

Table 4. Monthly average water quality parameters Bergobindapur Baor.

Parameters	2022						2023					
	Jul	Aug										
Temperature (°C)	30.6	31.2	31.2	30.9	29.7	23.5	21.5	22.7	24.5	25.5	26.5	31.7
Transparency (cm)	38	37	36	37	38	37	38	40	36	37	39	41
DO (mg/l)	5.5	5.7	5.6	5.0	5.1	4.9	4.6	4.5	4.9	5.2	5.3	5.6
pH	7.5	7.6	7.5	8.0	8.2	7.8	8.1	7.7	7.9	7.8	7.7	7.8
NH ₃ (mg/l)	0.1	0.05	0.25	0.05	0.15	0.25	0.25	0.05	.20	.25	.25	.05
Total Alkalinity (mg/l)	165	167	166	165	167	168	168	166	162	160	164	159
Total Hardness (mg/l)	171	172	169	170	171	172	171	169	168	167	169	170

Experiment 2. Assessment of plankton community dynamics

The abundance of phytoplankton and zooplankton were found in Boluhar Baor within the ranges from lowest in the month of January 2022 (158×10^2) and December 2021 (42×10^2) and highest in June 23 (168×10^2) and July/22 (53×10^2) respectively (Table-6). The abundance of phytoplankton and

zooplankton were found in Nosti, sostar and bergobindapur Baor within the ranges from lowest in the month of January 2023 (162×10^2) and August/22 (28×10^2); Feb/23 (158×10^2) and July/22 (41×10^2) and Dec/22 (135×10^2) and Dec/22 (34×10^2) and highest in June/23 (189×10^2) and (43×10^2); June/23 (170×10^2) and Feb/23 (53×10^2); June/23 (179×10^2) and May/23 (43×10^2), respectively (Table-6). Chlorophyta and Copepoda species were most dominant phytoplankton and zooplankton group in waterbody.

Table 5. Phytoplankton and zooplankton genera found in Boluhor, Nosti, Soshtar and Bergobindapur Baor.

Group	Phytoplankton Genera	Total
Bacillariaophyceae	<i>Diatoma, Navicula, Nitzschia, Chaetoceros, Asterionella, Amphora, Gyrosigma, Synedra, Bacillaria, Fragilaria</i>	09
Chlorophyceae	<i>Chlorella, Volvox, Eudorina, Gomphosphaeria, Pleodorina, Anabaena, Oedogonium, Microcystis, Ankistrodesmus, Oocystis, Chlamydomonas, Coelastrum</i>	11
Cyanophyceae	<i>Spirogyra, Anacystis, Ploycystis, Ulothrix, Volvox, Spirulina, Chlorella, Pediastrum, Microspora, Scenedesmus</i>	10
Zygnematophyceae	<i>Zygnema</i>	01
Group	Zooplankton Genera	Total
Rotifera	<i>Brachionus, Keratella, Filinia, Asplanchna</i>	04
Cladocera	<i>Moina, Daphnia, Bosmina, Diaphanosoma</i>	04
Copepoda	<i>Cyclops, Mesocyclops, Macrocyclus, Diaptomus, Pseudodiaptomus, Nauplius</i>	06

Table 6. Phyto and Zoo Plankton abundance in Different Baors.

Baor name	Plankton	2022						2023					
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Boluhor	Phyto (No./L)	168 x 10 ²	165 x 10 ²	164 x 10 ²	163 x 10 ²	161 x 10 ²	159 x 10 ²	158 x 10 ²	160 x 10 ²	165 x 10 ²	168 x 10 ²	171 x 10 ²	172 x 10 ²
	Zoo (No./L)	53 x 10 ²	52 x 10 ²	49 x 10 ²	46 x 10 ²	45 x 10 ²	42 x 10 ²	44 x 10 ²	46 x 10 ²	44 x 10 ²	45 x 10 ²	47 x 10 ²	46 x 10 ²
Nosti	Phyto (No./L)	178 x 10 ²	174 x 10 ²	173 x 10 ²	169 x 10 ²	167 x 10 ²	163 x 10 ²	162 x 10 ²	163 x 10 ²	176 x 10 ²	181 x 10 ²	185 x 10 ²	189 x 10 ²
	Zoo (No./L)	32 x 10 ²	28 x 10 ²	29 x 10 ²	31 x 10 ²	32 x 10 ²	35 x 10 ²	38 x 10 ²	40 x 10 ²	41 x 10 ²	42 x 10 ²	43 x 10 ²	43 x 10 ²
Soshtar	Phyto (No./L)	165 x 10 ²	163 x 10 ²	161 x 10 ²	167 x 10 ²	162 x 10 ²	161 x 10 ²	162 x 10 ²	158 x 10 ²	167 x 10 ²	168 x 10 ²	169 x 10 ²	170 x 10 ²
	Zoo (No./L)	41 x 10 ²	43 x 10 ²	45 x 10 ²	46 x 10 ²	47 x 10 ²	49 x 10 ²	50 x 10 ²	53 x 10 ²	45 x 10 ²	47 x 10 ²	49 x 10 ²	51 x 10 ²
Bergobindapur	Phyto (No./L)	144 x 10 ²	143 x 10 ²	139 x 10 ²	141 x 10 ²	137 x 10 ²	135 x 10 ²	137 x 10 ²	136 x 10 ²	167 x 10 ²	172 x 10 ²	178 x 10 ²	179 x 10 ²
	Zoo (No./L)	40 x 10 ²	38 x 10 ²	36 x 10 ²	37 x 10 ²	36 x 10 ²	34 x 10 ²	36 x 10 ²	37 x 10 ²	44 x 10 ²	45 x 10 ²	47 x 10 ²	46 x 10 ²

Table 7. Plankton distribution in different Baors.

Soshtar		Nosti		Boluhor		Bergobindopur	
Phyto (%)	Zoo (%)	Phyto (%)	Zoo (%)	Phyto (%)	Zoo (%)	Phyto (%)	Zoo (%)
80	20	78	22	80	20	78	22

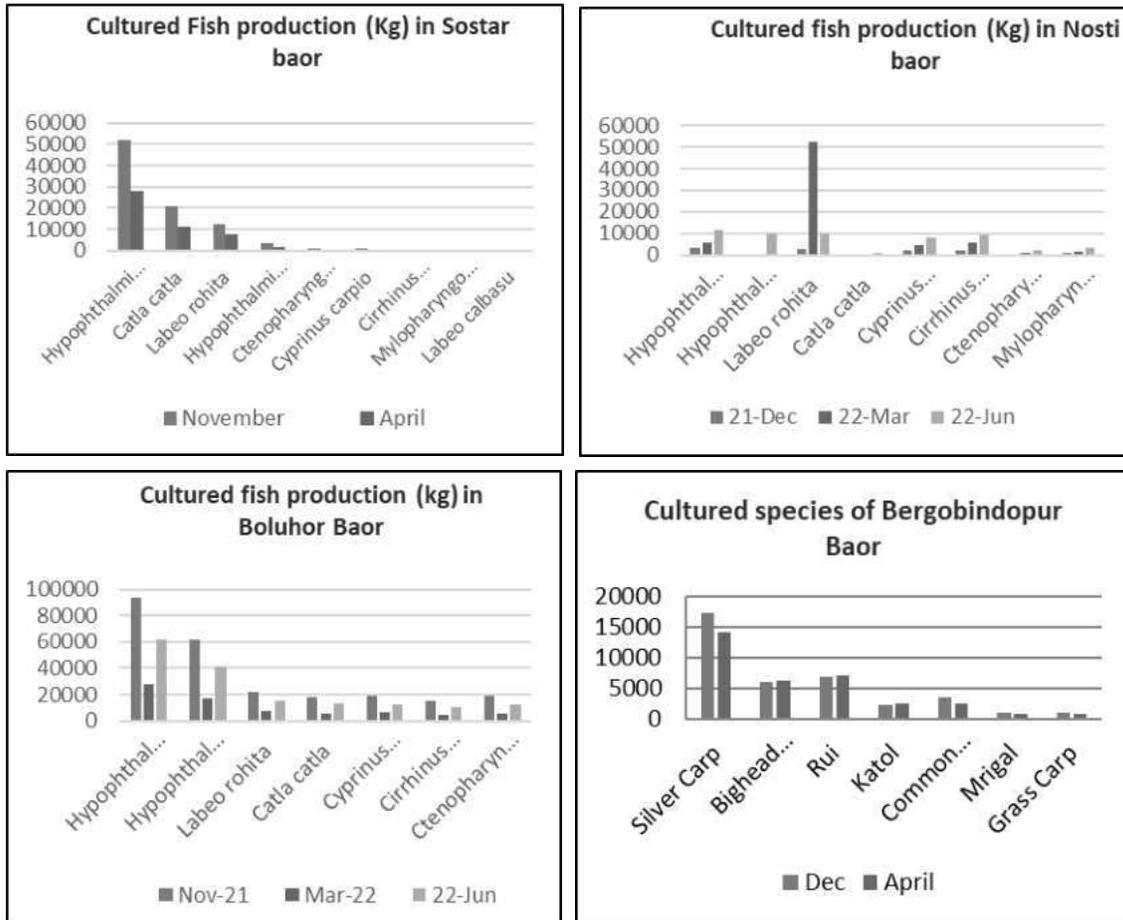
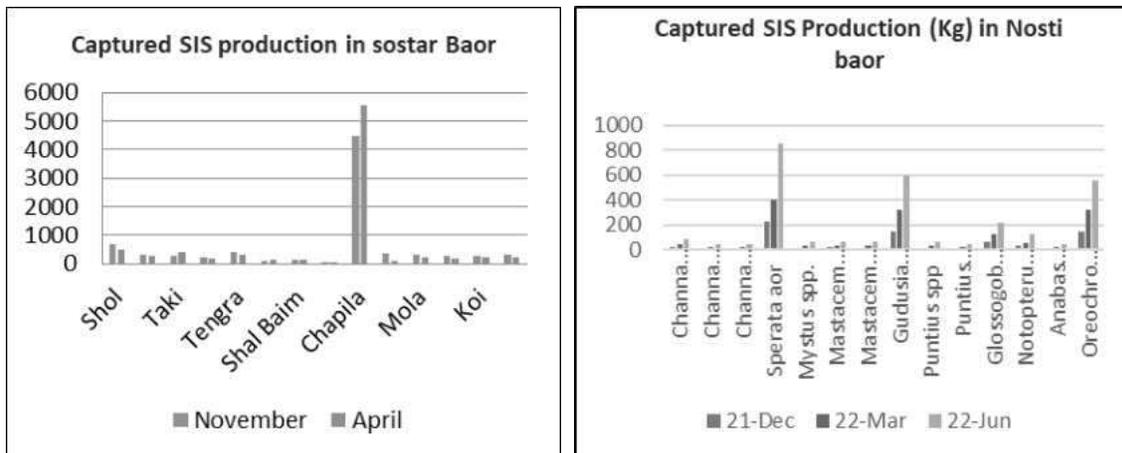


Figure 2. Cultured fish production in bergobindopur, boluhor, sostar and nosti baor



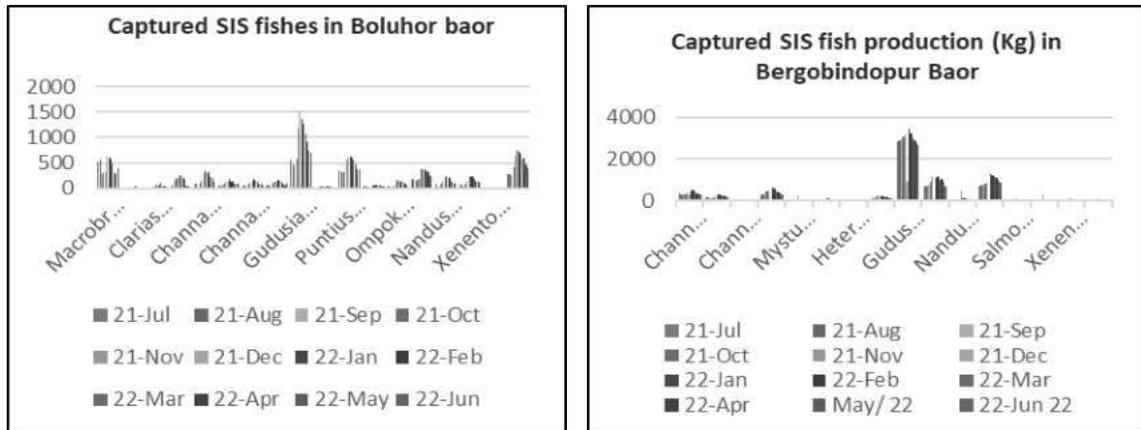


Figure 3. Captured SIS fish production in bergobindopur, boluher, sostar and nosti baor

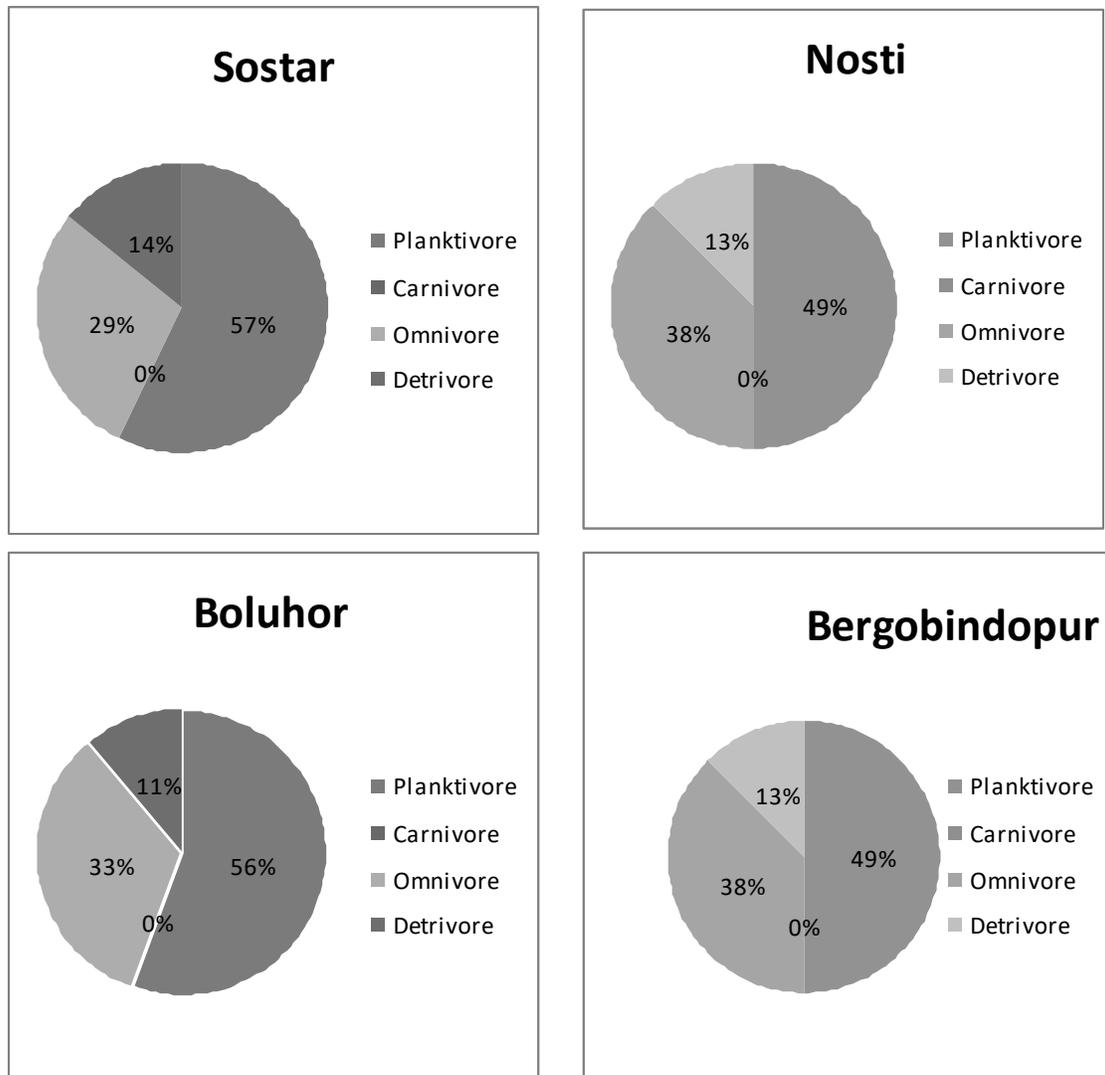


Figure 4. Cultured fish classification according to their food habit in Boluher, Nosti, Sostar and Bergobindopur Baor

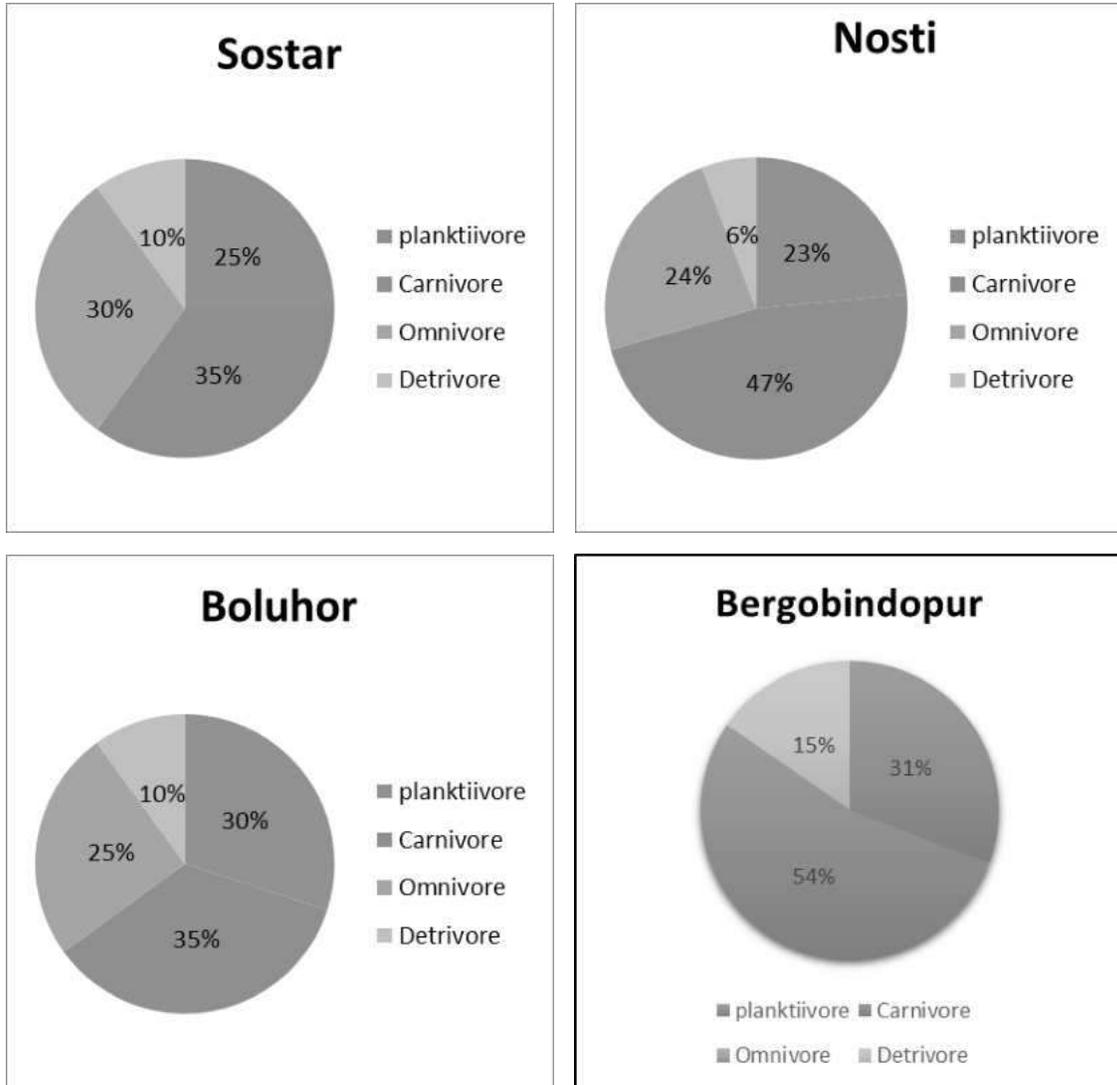


Figure 5. Captured fish classification according to their food habit in Boluhor, Nosti, Sostar and Bergobindopur Baor

Study on the Present Status of Aquatic Biodiversity of Teesta and Its Adjacent Rivers

Researchers

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Objectives

- To assess aquatic biodiversity of Teesta and its adjacent rivers;
- To determine spatio-temporal variability of biodiversity status of Teesta and its adjacent rivers;
- Complete cataloging of fish species of Teesta and its adjacent rivers.

Achievements

Site Selection

The study was carried out in six sampling sites of Teesta and its adjacent rivers which are located across four districts. These are-1. Teesta Barrage, Hatibanda, Lalmonirhat 2. Belka, Sundarganj, Gaibanda 3. Tapa Madhupur, Kaunia, Rangpur 4. Kolkonda, Gangachara, Rangpur 5. Dalia, Joldhaka, Nilphamari and 6. Betgari, Gangachara, Rangpur.

Water Quality Parameter Observation

During this research period water quality parameters of Teesta and its adjacent rivers were recorded monthly. Water quality parameters such as water temperature ($^{\circ}\text{C}$), water pH, and dissolved oxygen (DO) (mg/L), ammonia (mg/L), alkalinity (mg/L), total dissolved solids (mg/L) and hardness (mg/L) of the sampling sites were collected and recorded on data book. Maximum data was collected by using Hanna digital multiparameter. Data are presented in the Table 1.

The range of water temperature varied between 20.02 and 31.84 $^{\circ}\text{C}$ in dry and wet seasons. Lowest temperature was recorded in the month of February (20.02 $^{\circ}\text{C}$) and highest was recorded in the month of August (31.84 $^{\circ}\text{C}$). In case of river water temperature, the standard for sustaining aquatic life is within 20 to 30 $^{\circ}\text{C}$ both in wet and dry season (Bhaumik *et al.*, 2006). The pH was 7.93, 7.64 and 7.18 in Teesta, Buri Teesta and Ghaghat rivers, respectively. Islam *et al.* (2014) also found the average pH values in wet and dry seasons 7.73 and 8.03, respectively where the standard value is 6.5 to 8.5 for open water capture fishery. Adequate DO is necessary for good water quality, more than 5 ppm is required for fish habitat (Rahman *et al.*, 2012). DO was within range in the Teesta and its adjacent rivers. Total dissolved solids was found 63.42, 73.72 and 82.52 (mgL⁻¹) in Teesta, Buri Teesta and Ghaghat rivers, respectively. The average values of TDS in wet and dry seasons were found 53.7 and 73.87 mg L⁻¹ in the Teesta River at Kaunia point stated by Islam *et al.*, 2014. The average alkalinity values of wet and dry seasons were found 44.94 and 62.57 mgL⁻¹, respectively (Table 1), where the standard value for aquatic life is 100 mgL⁻¹ (EQS, 1997). So comparison between average values of alkalinity in Teesta and its adjacent river's water which is within the permissible limit suitable for aquatic life. The average values of hardness in wet and dry seasons were found 99.53 and 116.46 mgL⁻¹, respectively (Table 1). The standard value is 60-120 mgL⁻¹ for aquatic life (Rahman *et al.*, 2012).

Table 9. Fishing nets operating in Baors

Type of fishing	Gear		Description/Size		Mesh (cm)	Materials Used	Nature of gear	Fishing period	Fishermen (FM) and boat required	Comments
	English name	Local name	Length (m)	Breadth (m)						
Kochal	Scine net	Ber jal	80-110	15-20	8-10	Nylon twine	Selective	Oct-Dec Feb-mar May-Jun	12-14 FM	Most widely used
Komar	Drag net	Komar jal	300-400	9-10	3-4	Nylon twine	Selective	Oct-Dec Feb-mar May-Jun	FM depends on Komar size and group 2 boats	Most widely used
Chak	Lift net	Chak jal	8-10	7-8 (round diameter)	4-5	Cod twine with bamboo frame	Selective	Oct-Dec Feb-mar May-Jun	FM depends on Komar size	Minimum use
Cast	Cast net	Jhaki jal	8-10	8-10 (round diameter)	0.5-1.4	Nylon twine	Non-Selective	Round the year	2 FM and 1 boat	Minimum use
Lift	Lift net	Veshal jal	12-15	10-12	0.5 Centre; 1.5 Front	Nylon twine	Non-Selective	Rainy Season	1 FM and 1 boat	Minimum use
Gill netting	Gill net	Puti jal	10-12	0.5-1.0	0.5-1.0	Nylon twine	Selective	Round the year	3 FM and 1 boat	Most widely used
		Maya jal	10-12	0.5-1.0	0.5-1.0	Nylon twine	Selective		1 FM and 1 boat	
		Fash jal	10-12	2-5	5-8	Mono-filament nylon	Selective		1 FM and 1 boat	

Table 10. Fishing Traps operating in Baors

Type of gear	Local name	Description			Mesh size (cm)	Materials used	Fishing period	Number of trap used/unit	Fisherman (FM) and boat needed
		Length (cm)	Height (cm)	Breadth (cm)					
Trap	Ramani	100-150	60-80	30-40	1.5-2.0	Split of bamboo and cane materials	Jun-Aug	5-10	FM 1 and Donga
	Arina	45	25	25	0.8	Steel wire	Jun-Aug	15-30	
	Charo	40	25	15	1.0-1.5	Steel wire	Jun-Aug	15-30	
	Ghuni	25-40	9-20	9-20	0.2-0.5	Steel wire	Jun-Aug	20-30	

Table 11. Hook and lines operating in Baors

Type of gear	Name of gear	Number of hook per line of lift	Bait used/Not	Fishing period	Fisherman (FM) and boat needed
Hook and line	Dhawn borshi	Several hundred	Bait used	June-Sep	FM 1 and Donga
	Nol/Dhap borshi	Several hundred	Bait used	June-Jan	FM 1 and Donga
	Sip borshi	1 hook	Bait used	All seasons except rainy day and winter	FM 1 and with or without Donga

Table 12. Wounding gears used in Baors

Type of gear	Name of gear	Number of spears	Fishing period	Fisherman (FM) and boat needed	Comments
Spear/Harpoon (Wounding gear)	Koach	1	Jul-Jan	FM 1-2 and 1 boat	Poacher's generally use it
	Juti	1	Jul-Jan	FM 1-2 and 1 boat	
	Jhupi	1	Jul-Jan	FM 1 and 1 boat	
	Fulkuchi	1	Jul-Jan	FM 1 and 1 boat	

Table 1: Physico-chemical parameters of water of Teesta and its adjacent rivers

Parameters (Unit)	Teesta (Mean \pm SE)	Buri Teesta (Mean \pm SE)	Ghaghat (Mean \pm SE)
Water temperature ($^{\circ}$ C)	27.84 \pm 3.67	25.02 \pm 2.31	23.58 \pm 3.65
DO (mgL^{-1})	8.62 \pm 0.23	8.84 \pm 0.40	6.32 \pm .34
DO saturation (%)	102.36 \pm 4.42	106.4 \pm 4.47	75.6 \pm 7.45
pH	7.93 \pm .12	7.64 \pm .09	7.18 \pm .08
mVpH	-52.1 \pm 9.27	-34.55 \pm 1.2	-12.65 \pm 3.4
Conductivity (μScm^{-1})	126.71 \pm 18.7	145.12 \pm .632	165.2 \pm 5.3
Absolute conductivity (μScm^{-1})	124 \pm 8.96	143 \pm 6.87	162 \pm 4.5
Oxidation reduction potential (mV ORP)	201.82 \pm 34.78	206.65 \pm 22.65	148.45 \pm 12.78
Resistivity ($\text{K}\Omega\text{cm}$)	0.0088 \pm 0.003	0.0068 \pm 0.002	0.0059 \pm 0.001
Alkalinity (mgL^{-1})	56.4 \pm 7.65	52.5 \pm 6.3	53.94 \pm 7.2
Salinity (mgL^{-1})	0.07 \pm 0.01	0.07 \pm 0.0	0.08 \pm 0.0
Total dissolved solids (mgL^{-1})	63.42 \pm 9.44	73.72 \pm 6.23	82.52 \pm 3.2
Hardness (mgL^{-1})	104.42 \pm 4.89	106.22 \pm 2.7	113.5 \pm 3.3



Figure (1a)



Figure (1b)



Figure (1c)



Figure (1d)



Figure (1e)



Figure (1f)

Figure 1. Sampling of different sampling sites (1a) Teesta rivers (1b) Ghaghat river (1c) Plankton collection (1d) Benthos collection (1e) water quality parameters (1f) Buri Teesta rivers.

Phytoplankton and zooplankton availability in Teesta and its adjacent river

Phytoplankton and Zooplankton were collected from sampling site by using plankton net, preserved in 7 to 10% buffered formalin solution and taken into FSS, Saidpur Laboratory. Up to this research period 18 species of phytoplankton and 7 species of were zooplankton were identified. Among the phytoplankton, there were 5 species of Bacillariophyta, 4 species of Charophyta, 5 species of Chlorophyta, 2 species of Cyanophyta and 2 species of Dinophyta. Among the zooplankton, there were 3 species of Copepoda, 2 species of Cladocera, 1 species of Rotifera and Crustaceans larvae. Qualitative and quantitative abundance of phytoplankton and zooplankton are presented in Table 2, 3 and 4, respectively.

Table 2. List of Phytoplankton identified up to research period of Teesta and its adjacent rivers.

Bacillariophyta	Cyanophyta	Charophyta	Chlorophyta	Dinophyta
Cyclotella	Spirunila	Spirogyra	Chlorella	Dinophysis
Fragilaria	Oscillatoria	Closterium	Ulothrix	Ceratium
Navicula		Cosmarium	Pediastrum	
Melosira		Micrasterias	Scenedesmus	
Asterionella			Volvox	

Among the eighteen species of phytoplankton Ulothrix, Spirogyra, Volvox found in mostly at Buri Teesta River. Bacillariophyta group remain dominant among others. Planktonic abundance was good in dry season instead of wet season due to surface runoff, turbidity and monsoon effect.



Figure 2a.



Figure 2b.

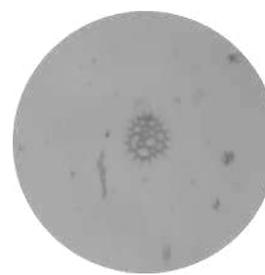


Figure 2c.

Figure 2. Phytoplanktons such as (2a) Ulothrix (2b) Navicula (2c) Pediastrum etc. of Teesta and adjacent rivers.

Table 3: List of zooplankton identified up to research period of Teesta and its adjacent rivers.

Copepoda	Rotifera	Cladocera	Crustacean larvae
Diaptomus	Brachionus	Dyaphanosoma	Nauplius
Bosmina		Moina	
Cyclops			



Figure 3a.



Figure 3b.



Figure 3c.

Figure 2. Zooplanktons such as (2a) Diaptomus (1b), (3b) Cyclops and (3c) Dhapnia etc. of Teesta and adjacent rivers.

Among the seven species of zooplankton, Copepoda found dominant, especially Cyclops sp. and Diaptomus sp and among the Rotifer group, Brachionus were found lowest.

Table 4. Counting of phytoplankton and zooplankton of Teesta and its adjacent rivers.

River Name	Phytoplankton (Cells/L)	Zooplankton (Cells/L)
Teesta	9.39×10^3	0.99×10^3
Buri Teesta	8.56×10^3	0.94×10^3
Ghaghat	7.13×10^3	1.09×10^3

Phytoplankton and zooplankton ratio were 10:1, 9:1 and 7:1 in Teesta, Buri Teesta and Ghaghat rivers, respectively. This ratio is suitable for an open waterbody (Aktar et al., 2020).

Available benthic invertebrate in the Teesta and its adjacent rivers

Benthic community was collected from sampling sites by using Ekman Dredge and taken into FSS, Saidpur Laboratory. Collected specimen are showed in the following Table.

Table 5: List of identified Benthos in FSS, Saidpur Laboratory.

Class	Family	Local Name	Scientific Name
Bivalvia	Unionidae	Unio	<i>Unio sp.</i>
	Sphaeriidae	Musculium	<i>Musculium sp.</i>
Gastropoda	Limnaeidae	Patla shamuk	<i>Limnaea sp.</i>
	Unionidae	Jhinuk	<i>Lamellidens marginalis</i>
Insecta	Viviparidae	Choto shamuk	<i>Viviparous bengalensis</i>
	Paludomidae	Choto gulshamuk	<i>Paludomus conica</i>
Branchiura	Argulidae	Fish lics	<i>Branchiura sp.</i>

Mostly macro benthos was found during this research period. Among which Limnaeidae family was dominant.

Domestication and Conservation of Some Important Threatened Stream Fishes in Northern Part of Bangladesh

Researchers

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Objectives

- To collect the fry/semi-adult/adult of the selected fishes from wild sources;
- To study the reproductive biology *viz*; sex ratio, gonadosomatic index (GSI), fecundity and egg diameter of the fish;
- To domesticate and brood development of the fish in captive condition;
- To determine the reproduction response of the selected fish to different doses of natural and synthetic hormones in captive condition; and
- To develop the larval and nursery rearing techniques of the selected fish in captive condition.

Achievements

Collection of Fingerling/Sub-Adult of the Stream Fishes from the Atrai, Kakra and Teesta River

A total of 700 sub-adults of *Chagunius chagunio*, 1200 sub-adults of *Salmostoma bacaila* and were collected from the Atrai, Kakra and Teesta rivers for the studies of reproductive biology and domestication in ponds at the Freshwater Sub-Station, Saidpur, Nilphamari.

Studies of Reproductive Parameters of *C. chagunio*

The sex ratio and gonadosomatic index (GSI) of *C. chagunio* was studied to know the spawning season of this fish. A total of 226 fishes were dissected during July 2022 to June 2023 and studied monthly. The results have been presented in Table 1.

Table 1. Sex ratio and GSI values of *C. chagunio* during July 2022 to June 2023.

Month	Individual	♂	♀	♂:♀	GSI% (♀)
July, 22	21	09	12	1.0:1.33	0.67±0.14
August, 22	24	08	18	1.0:2.25	2.22±0.26
September, 22	25	10	15	1.0:1.50	3.75±0.47
October, 22	22	10	12	1.0:1.20	3.89±0.28
November, 22	19	06	13	1.0:2.16	4.27±0.24
December, 22	20	10	10	1.0:1.0	5.29±0.20
January, 23	20	09	11	1.0:1.22	5.47±0.29
February, 23	24	10	14	1.0:1.40	6.23±0.18
March, 23	17	7	10	1.0:1.42	4.55±0.93
April, 23	10	7	3	1.0:0.43	0.72±0.10
May, 23	12	9	3	1.0:0.33	0.59±0.07
June, 23	12	7	5	1.0:0.71	1.11±0.11

Studies of Absolute And Relative Fecundity

The estimated fecundity was is presented in Table 2.

Table 2. Mean values of relative fecundity of *C. chagunio*.

Class interval (cm)	Parameters			Fecundity (Per 100g bwt)
	TL (cm)	BW (g)	GW (g)	
15.1–18.0	17.05±1.04	67.74±24.85	2.61±1.5	3463±2639
Range	15.2-18.0	35.98-120.6	1.25-4.95	1423-7730
18.1–21.0	19.79±0.75	101.95±25.11	4.35±2.67	5586±2727
Range	18.5-21.0	69.9-182.0	1.13-12.61	1038-10607
21.1–24.0	22.1±0.87	132.09±22.96	5.03±1.42	6628±2487
Range	21.1-24.0	110.3-177.28	2.34-7.26	2848-10512
24.1-above	29.4±2.66	352.67±106.53	14.88±7.42	19186±4226
Range	27.8-31.0	277.34-427.99	9.63-20.12	16198-22175
Mean±SD	20.55±2.85	118.13±64.55	4.76±3.34	6201±4068
Range	15.2-31.0	35.98-427.99	1.13-20.12	1038-22175

Domestication and Brood Development of *C. Chagunio* and *S. Bacaila* in Captive Condition

Pond preparation and experimental design

The experiments were conducted at the BFRI, FSS, Saidpur for a period of 12 months, from late October 2022 to late September 2023 to observe the growth, gonadal maturation and also yield performance of *C. chagunio* and *S. bacaila* in captive condition. For this experiment, the ponds were selected 10 decimals in size. The water depth was maintained at 1.5 meter. The ponds were prepared by drying, liming (CaCO_3 , 1 Kg dec^{-1}) and fertilization (Urea 1.5 ppm and TSP 2 ppm and MP 0.5 ppm). The fish were stocked at late October 2022 as per to experimental design. The experimental design is presented in Table 3. The effects of stocking densities on growth performances of *C. chagunio* and *S. bacaila* and Physico-chemical parameters of the experimental ponds were studied for 8 (eight) months. The results have been furnished in Tables 3, 4, 5 and 6, respectively.

Table 3. Brood rearing of *C. chagunio* and *S. bacaila* in captive condition.

Treatment	Stock. dens. (indi. ha ⁻¹)	
	<i>C. chagunio</i>	<i>S. bacaila</i>
T ₁	3,000	7,500
T ₂	4,000	10,000
T ₃	5,000	12,500

Table 4. Growth performance of *C. chagunio* under different stocking densities

Parameters	Treatments		
	T ₁	T ₂	T ₃
Culture period (days)	240	240	240
Initial length (cm)	16.1±1.0	15.7±1.3	14.9±1.2
Initial weight (g)	21.3±1.0	22.2±1.3	20.8±1.2
16 th sampling length (cm)	34.74±2.86	32.55±2.90	31.97±3.37
16 th sampling weight (g)	168.35±2.80	156.62±4.15	148.26±4.22
Weight gain (g)	147.04±2.10	134.42±4.65	127.46±3.26
SGR (% day ⁻¹)	0.86±0.03	0.82±0.02	0.81±0.03
ADG (g day ⁻¹)	0.61±0.03	0.56±0.02	0.53±0.02
HC (g cm ⁻¹)	4.84	4.81	4.63

Table 5. Growth performance of *S. bacaila* under different stocking densities.

Parameters	Treatments		
	T ₁	T ₂	T ₃
Culture period (days)	240	240	240
Initial length (cm)	2.5±.3	2.4±.4	2.2±.2
Initial weight (g)	1.1±.10	1.1±.10	1.1±.10
16 th sampling length (cm)	13.9±2.10	12.6±1.6	12.2±1.7
16 th sampling weight (g)	16.8±1.10	15.7±0.95	14.9±1.03
Weight gain (g)	15.7±1.5	14.6±1.7	13.8±1.2
SGR (% day ⁻¹)	1.13±.03	1.11±0.02	1.0±0.02
ADG (g day ⁻¹)	0.07±0.01	0.06±0.01	0.05±0.01
HC (g cm ⁻¹)	1.21	1.24	1.21

Table 6. Physio-chemical parameters in three treatments of brood development of *C. chagunio* and *S. bacaila* in captive condition.

Parameters	T1	T2	T3
Water Temperature (°C)	26.2±3.2	26.8±2.4	27.3±2.3
DO (mgL ⁻¹)	5.72±0.23	5.84±0.40	5.42±.34
pH	7.93±.12	7.46±.09	7.38±.08
Conductivity (µScm ⁻¹)	136.71±18.7	155.12±.6.32	125.2±5.3
Absolute Conductivity (µScm ⁻¹)	114±8.96	123±6.87	142±4.5
Oxidation Reduction Potential (mV ORP)	130.82±34.78	145.8±22.65	148.45±12.78
Alkalinity (mgL ⁻¹)	92.4±7.65	102.5±6.3	98.4±7.2
Salinity (mgL ⁻¹)	0.05±0.01	0.03±0.0	0.02±0.0
Total Dissolved Solids (mgL ⁻¹)	156.42±8.44	143.72±6.23	132.52±3.2
Hardness (mgL ⁻¹)	111.42±4.89	112.22±27	103±33

Induced Breeding of *C. Chagunio* and *S. Bacaila* Using Natural and Synthetic Hormone

Induced Breeding of *C. Chagunio* Using Natural and Synthetic Hormone

The experiment was conducted at the hatchery of BFRI, FSS, Saidpur to determine the reproductive response of *C. chagunio* using different types of hormones. The results are furnished in Tables 7 and 8, respectively.

Table 7. Spawning response of *C. chagunio* to PG under natural method.

Treatments	PG (mg kg ⁻¹)		Latency period (hrs)	Incubation temperature (°C)	% of egg release	% of fertilization	% of hatching	Remarks
	M	F						
T ₁	3	6.0	-	25.73±0.23	-	-	-	No fertilization, ovulation and spawning
T ₂	4	8.0	-	26.86±0.20	-	-	-	
T ₃	5	10	-	24.97±0.28	-	-	-	

Table 8. Spawning response of *C. chagunio* to synthetic hormone under stripping method.

Treatment	Ovuhom (ml kg ⁻¹)		Latency period (hrs)	Incub. temp. (°C)	% of egg release	% of fertilization	% of hatching	Remarks
	M	F						
T ₁	0.5	2.0	18-20	20.0-22.0	90	85	78	Good amount of hatching
T ₂	0.3	1.5	19-23	20.0-22.00	82	78	72	Average amount of hatching
T ₃	0.7	2.5	16-20	20.0-22.0	75	74	69	Hatching rate lower

Induced Breeding of *S. Bacaila* Using Synthetic Hormone

The experiment was conducted at the hatchery of BFRI, FSS, Saidpur to determine the reproductive response of *S. bacaila* using different types of hormones. The results are presented in Table 9.

Table 9. Spawning response of induced breeding of *S. bacaila* in hatchery condition.

Treatment	Ovuhom (ml kg ⁻¹)		Latency period (hrs)	Incub. temp. (°C)	% of egg release	% of fertilization	% of hatching	Remarks
	M	F						
T ₁	0.4	0.8	-	26.5-28.5	77	71	69	fertilization, ovulation and spawning but rate is lower
T ₂	0.5	1.0	9.0	26.4-27.2	92	84	87	Good amount of fertilization, ovulation and spawning. IP: 8-12 hours; Survival rate at 3 days after first feeding: 86%

Development of Nursery Rearing Technique of *Labeo Dero*

This experiment was carried out to develop the nursery rearing technique of hatchery produced *L. dero* in captivity. Six mini ponds (1 decimal each) were selected for each fish species. Ponds were prepared by weeding, liming (CaCO_3 , 1 kg dec^{-1}) and fertilizing (TSP: 2 ppm and Urea: 1.5 ppm). During culture period the fish were fed with 35% protein containing commercial feed at 25-10% of body weight. The spawn of both fish were stocked on late July 2022, at the age of 7 days after hatching and cultured up to late September 2022. The experimental design is presented in the Table 10. The growth performance of fish and water quality parameters of the nursery pond are presented in the Table 11 and 12, respectively.

Table 10. Experimental design for the nursery rearing of *L. dero*.

Treatment	Stock. of spawn (g dec^{-1})	Culture period (days)
	<i>L. dero</i>	
T ₁	8	60
T ₂	10	
T ₃	12	

Table 11. Growth performance of *L. dero* under different stocking densities.

Parameters	Treatments		
	T ₁	T ₂	T ₃
Culture period (days)	60	60	60
Initial length (cm)	0.91±0.02	0.93±0.02	0.90±0.03
Initial weight (g)	0.0054±0.0003	0.0055±0.0002	0.0053±0.0003
Final length (cm)	5.46±0.07	5.12±0.06	5.17±0.07
Final weight (g)	2.03±0.03	1.97±0.03	1.98±0.03
Weight gain (g)	2.02±0.03	1.96±0.03	1.97±0.03
SGR (% day^{-1})	9.88±0.13	9.80±0.11	9.87±0.12

Table 12: Physiochemical parameters in three treatment ponds of nursery rearing of *L. dero*.

Water quality parameters	T ₁	T ₂	T ₃
Water temperature (°C)	26±1.0	25.67±.50	27.2±1.2
Water pH	7.50±.02	7.8±0.6	7.9±0.25
DO (mg L^{-1})	6.2±0.10	5.9±0.2	5.3±0.24
NH ₃ (mg L^{-1})	0.05±.03	0.07±.02	0.09±.03
TDS (mg L^{-1})	146.42±8.44	133.72±6.23	152.52±3.2
Hardness (mg L^{-1})	121.42±21	112.22±27	133±33

Last year, growth, gonadal maturation, breeding and nursery development of *C. chagunio*, *S. bacaila* and *L. dero* were done. Three treatments were done for growth and yield performance of *C. chagunio* and *S. bacaila* in FSS, Saidpur pond complex where T₁, T₂, and T₃ contained 3000, 4000 and 5000 indi. ha^{-1} and 7500, 10,000 and 12,500 indi. ha^{-1} , respectively. From Table 4, it has been showed that growth performance of *C. chagunio* had a better result in T₁ compare to T₂, and T₃ after 240 days of culture

period although health condition (1.24) was found better in T₂ presented in Table-5. The physio-chemical parameters in three treatments of brood development pond of *C. chagunio* and *S. bacaila* were found in suitable range for aquaculture. The water quality parameters viz., water temperature (°C), water pH, DO (mg L⁻¹), ammonia (mg L⁻¹), TDS (mg L⁻¹), Hardness (mg L⁻¹) and Alkalinity (mg L⁻¹) of experimental ponds under 3 different treatments were studied and presented in Table 6. The water temperature varied between 26.2 and 28.3 °C during the experiment. The values of water temperature are similar that reported by (Kohinoor, 2004). The pH was 7.9, 7.4 and 7.3 in T₁, T₂ and T₃, respectively. The DO concentration ranged from 5.4 to 5.8 mg L⁻¹ during the experiment and no significant difference were observed among the treatments. Analytical results showed the pH and DO values were inversely related with the stocking density. Alkalinity was also in suitable range 90-100 (mg L⁻¹) in experimental pond. According to Alikunhi (1957) total alkalinity should be within 80-200 mgL⁻¹ in high productive water bodies. The result of the present study comply with this finding. After several years of trial *C. chagunio* (♀) species was consider as winter breeder from the result of its GSI and fecundity value **6.23±0.18** and 19186±4226 in the month of February, respectively. Induced breeding success was achieved with synthetic hormone ovuhom at the doses of 0.5, 2.0 ml Kg⁻¹ for male and female fishes maintaining 1:1 ratio. Pawer *et al.* (2020) stated that winter breeder fish needs long range of incubation period. For *C. chagunio* Incubation period ranged within 84-106 hours. The highest rates of fertilization (88%) and hatching (82%) of eggs were recorded in *C. chagunio* injecting with 2.0 ml/Kg and 0.5 ml/Kg of hormone for female and male, respectively at 26°C in the month of January (Table 8). After stripping the eggs and milts were mixing and kept in a rectangular tray with continuous shower for fertilization (Figure 1). Embryonic developmental stages of fish have been observed under digital microscope. The nursery rearing technique of hatchery produced *L. dero* in captivity was also achieved in this year. Three treatments with different stocking 8, 10, and 12 (g dec⁻¹) spawn was kept in nine mini ponds. Physico-chemical parameters in three treatments of nursery rearing ponds of *L. dero* were in suitable range (Table 11). After 60 days of nursery rearing, T₁ had highest weight gain 2.02±0.03 compared to T₂ and T₃. No significant differences were found in terms of SGR (% day⁻¹) in all treatments.

Culture Suitability of *Barilius barila*, *Labeo angra* and *Labeo dero* under Polyculture in Farmers Pond of Northern Region of Bangladesh

Researchers

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Objectives

- To evaluate the production potentials of *Barilius barila*, *Labeo angra* and *Labeo dero* under polyculture system in seasonal water bodies of farmer's field
- To assess the water quality parameters of cultured water bodies
- To assess the BCR of culture technologies and
- To disseminate suitable culture techniques of *Barilius barila*, *Labeo angra* and *Labeo dero* in different aqua-ecological zones in the northern part of Bangladesh.

Achievements

Development of Polyculture Technique of *Labeo Angra* with Indian Major Carps in Farmer's Ponds

The experiment has been conducted at the farmer's ponds of greater Rangpur district for a period of 05 (five) months from mid-April 2023 to mid-September 2023. Three treatments were maintained and each had three replications also. Seasonal ponds were selected with the concerning of relevant Upazilla Fishery Officer (UFO/SUFO). The following methodology was followed. The experimental design is presented in Table 1.

Table 1. Polyculture of *Labeo angra* (Pattern-II) in the farmer's ponds.

Treatments	Species combination	Stock. den. (indi.dec ⁻¹)	Fingerlings size
T ₁	Angrot+Catla+Silver carp+Sarpunti+ GIFT	150+10+5+10+5	Over wintered
T ₂	Angrot +Catla+Silver carp+Sarpunti + GIFT	200+10+5+10+5	
T ₃	Angrot +Catla+Silver carp+Sarpunti+ GIFT	250+10+5+10+5	

Pond Preparation

The selected ponds were prepared by dewatering, liming and fertilizing. At first pond were dried in the month of December. Bottom sludge was removed and kept for 5-7 days. Then 3 types of netting/fencing were done such as slope netting, side netting and surface netting for protection from predator or any type of harmful animals. After that liming was done for buffering the soil pH maintaining (3:1) ratio CaO:CaCO₃ at the doses of 1Kg/decimal. Then watering of the pond was done. After 2/3 days, fertilizer were applied at the doses of Urea 1 ppm, TSP 1.2 ppm and MP 0.5 ppm was used for production of plankton. Molasses also used 5ppm rate for natural productivity.

Culture Period

Five months (May- September).

Stocking of Fingerlings

Average 2-4 cm size fingerlings were stocked as per experimental design (Table 1). Usually stocking of fry were done in the morning.

Feeding Regime

Fish is being fed containing 30-35% protein @ 10-5% of body weight twice daily.

Sampling

Length-weight data and water quality parameters such as water temperature ($^{\circ}\text{C}$), water pH, and dissolved oxygen DO (mgL^{-1}), NH_3 (mgL^{-1}), Conductivity (μScm^{-1}), alkalinity (mgL^{-1}), total dissolved solids (mgL^{-1}) and hardness (mgL^{-1}) of the experimental ponds were collected fortnightly.

Growth Performance of *Labeo Angra* and Water Quality Parameters under Polyculture in the Farmer's Ponds

After 60 days of culture, the growth performances of Angush and physico-chemical parameters of the experimental ponds are presented in Tables 2 and 3, respectively.

Table 2. Growth performances of *Labeo angra* under polyculture in the farmer's ponds.

Parameters	Treatments		
	T ₁	T ₂	T ₃
Stock. Dens. (indi.dec^{-1})	150	200	250
Culture Period	150	150	150
Initial Length (cm)	2.5 \pm 0.4	2.5 \pm 0.1	2.5 \pm 0.1
Initial weight (g)	0.62 \pm 0.1	0.64 \pm 0.1	0.61 \pm 0.1
4 th Sampling weight (g)	8.7 \pm 1.20	10.4 \pm 1.0	9.3 \pm 1.10
Weight gain (g)	8.08 \pm 1.5	9.76 \pm 1.2	8.69 \pm 1.3
SGR w (g day^{-1})	4.40 \pm 0.23	4.64 \pm 0.3	4.54 \pm 0.2
ADGw (g day^{-1})	0.13 \pm 1.1	0.16 \pm 1.1	0.14 \pm 1.1

After fourth sampling *Labeo angra* species under polyculture showed satisfactory growth. The highest weight observed at T₂ which was stocked 200 (indi.dec^{-1}) followed by T₃ and T₁. The specific growth rate (weight basis) also indicates good growth performance, which was 4.4, 4.64 and 4.54 (g day^{-1}) in T₁, T₂, and T₃ respectively. Others short cycle species showed better growth as they utilize others part of pond stratum for their feeding purposes.

The water temperature of the experimental ponds varied between 26.8 and 28.3 $^{\circ}\text{C}$ during research period and there was no significant difference among the treatments. The pH was 7.73, 7.46 and 7.38 in T₁, T₂ and T₃, respectively. The dissolved oxygen concentration ranged from 5.32 to 6.82 mgL^{-1} during the experiment and no significant difference was observed among the treatments. Alkalinity (mgL^{-1}), total dissolved solids (mgL^{-1}) and hardness (mgL^{-1}) range were also found within optimum level for fish culture. After 150 days of culture period fish will be harvested. Then total production of Angush, and others short cycle species will be estimated. With the relevant market value economic analyses will be done. Total cost and total gross margin will be measured for actual Benefits Cost Ratio (BCR) of this project after completion of project.

Table 3. Physico-chemical parameters of the experimental ponds.

Parameters	T1	T2	T3
Water temperature (°C)	27.0±3.2	26.8±2.4	28.3±2.3
DO (mgL ⁻¹)	5.62±0.23	6.82±0.40	5.32±0.34
DO saturation (%)	107.36±4.42	106.4±4.47	75.6±7.45
pH	7.73±0.12	7.46±0.09	7.38±0.08
mVpH	-72.1±9.27	-56.2±1.2	-62.65±3.4
Conductivity (µScm ⁻¹)	136.71±18.7	155.12±6.32	125.2±5.3
Absolute conductivity (µScm ⁻¹)	114±8.96	123±6.87	142±4.5
Oxidation reduction potential (mV ORP)	130.82±34.78	145.8±22.65	148.45±12.78
Alkalinity (mgL ⁻¹)	92.4±7.65	102.5±6.3	98.4±7.2
Salinity (mgL ⁻¹)	0.05±0.01	0.03±0.0	0.02±0.0
Total dissolved solids (mgL ⁻¹)	53.42±8.44	63.72±6.23	72.52±3.2
Hardness (mgL ⁻¹)	111.42±4.89	112.22±27.0	103±33.0

Climate Change and Anthropogenic Actors Affecting Fisheries Resources and Livelihoods in Riverine Ecosystem of Bangladesh

Researchers

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Objectives

- To determine the effects of climate change on biophysico-chemical parameters of water and water quality index
- To determine the effects of climate change on riverine fish species diversity
- To determine the effects of climate change on livelihood of riverine fisher's along the Meghna river Basin in Bangladesh
- To know the present status of the impact of climate change on riverine ecology, fish diversity and livelihood of the fisher's with probable future impacts

Achievements

Location of the study areas

The study was conducted to assess the impact of climate change on the river ecology, diversity of fish fauna and the livelihoods of fisher's folk in three fishing communities viz. Upper (S_1), Lower part of Meghna river (S_2) and Andharmanik river basin (S_3) are shown in figure 1. Most of the fishermen of the selected communities were professional and they were engaged in fishing round the year.

Data collection

To address the project objectives, data were collected through direct field observations and from the secondary sources. The secondary data mainly comprised of meteorological data and it was collected from the Meteorological Department and different published literatures. To study the impact of climate change, almost 30 fishers were randomly selected for interviews. The questionnaire mainly focused on fishers' livelihood characteristics, level of dependency on fisheries, and exposure to climatic hazards.

Physico-chemical parameters of water in the study areas

Water quality parameters of three stations exhibited considerable fluctuations. The average maximum air temperature ($^{\circ}\text{C}$) was found 27.3 ± 0.7 and water temperature ($^{\circ}\text{C}$) was 24.2 ± 1.1 at Station 3 (S_3). The average maximum and minimum value of water transparency (cm) were found 78 ± 5 and 65 ± 12 at S_2 and S_3 , respectively. The average highest dissolved oxygen (mg/l) content was found 7.3 ± 0.7 and 6.8 ± 0.8 respectively at station S_2 and S_3 . On the contrary, the average CO_2 (mg/l) were beyond 15 in all stations. The maximum alkalinity (mg/l) was also found 112 ± 6 and hardness (mg/l) was 346 ± 31 at S_3 (Figure 2). The average pH was found just slightly above the neutral limit in the studied areas. The results of the studied physico-chemical parameters revealed that water quality parameters were found within the acceptable limits for the growth of fish in all sampling sites.

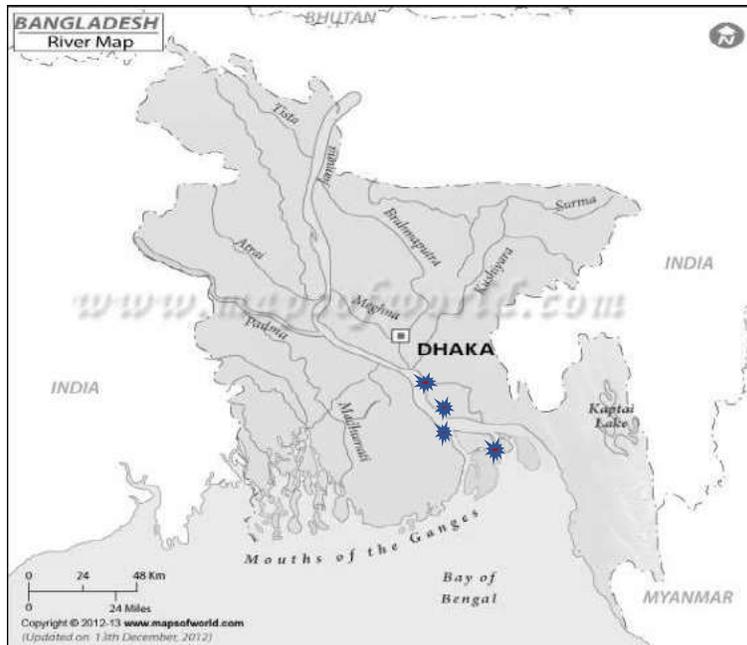


Figure 1. Sampling locations of the study areas

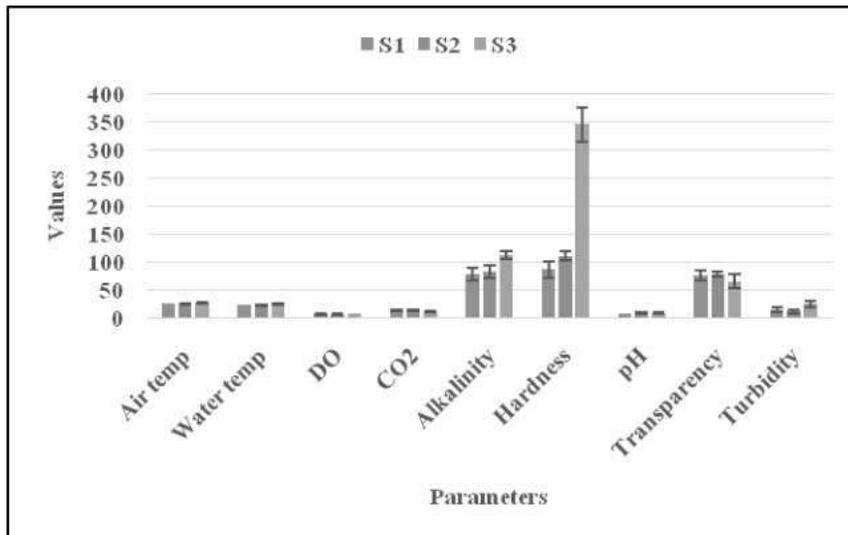


Figure 2. Water quality parameter of study areas

Species Diversity

A biodiversity index is used to describe the diversity of a sample or community by a single number. The concept of the “species diversity” involves two components: the number of species or richness and the distribution of individuals among species. The value of a diversity index increases both when the number of species and evenness increases. For a given number of species, the value of a diversity index is maximized when all species are equally abundant. Shannon-Wiener diversity index considers both the number of species and proportion of each species while evenness and dominance indices represent the number of species present in an ecosystem as well as the relative abundance of each species.

The results of diversity index revealed that Simpson's index was found highest in station S₂ (0.65) and Shannon-Wiener index were found highest in S₃ (1.1). The higher value of Shannon-wiener diversity index was reflected by higher number of species. Furthermore, the highest Evenness index was recorded in stations S₂ (0.18) and the lowest in S₃ (0.17), respectively. Margalef richness value is used as an indicator to compare the species numbers in different sites. Margalef richness value was found highest in S₂ (2.42) and minimum at S₁ (1.879). The results of others diversity indices have been furnished in Table 1.

Table 1. Diversity indices of species in the study areas

Diversity indices	S ₁	S ₂	S ₃
Simpson_1-	0.3338	0.6554	0.485
Shannon_H	0.6817	0.12506	1.099
Evenness_e^H/S	0.172	0.1809	0.171
Brillouin	0.6808	0.7406	1.091
Menhinick	0.3381	0.341	0.2404
Margalef	1.879	2.427	2.139
Equitability_J	0.2393	0.2465	0.3878
Fisher_alpha	2.569	2.93	2.199
Berger-Parker	0.7999	0.7853	0.6974

The study recorded 39 fish species and 2 decapods in the Meghna river basin that belonged to 10 orders. Hilsa (*Tenualosa ilisha*) was the main commercial species of the Meghna and Tetulia rivers (S₂). Among the observed fish species, a total of 38.0% of fish belonged to Siluriformes, followed by Cypriniformes, (16.3%), Perciformes (19.0%), Osteoglossiformes (6.0%), Tetraodontiformes (3.3%), Channiformes (3.3%), Synbranchiformes (3.0%), Pleuronectiformes (3.0%) and Decapoda (6.0%) (Figure 3 and Table 2).

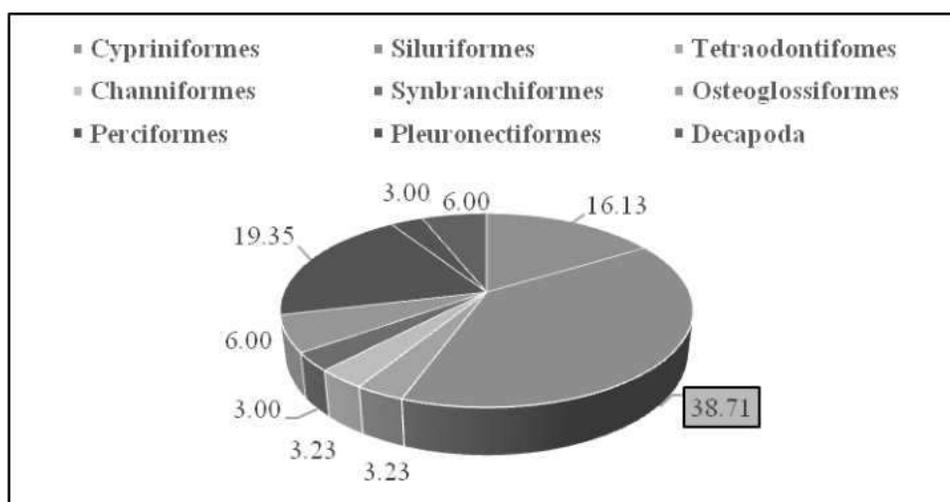


Figure 3. Orders wise fishes in the study areas

Table 2. Availability of hilsa and other commercially important fishes in the study areas

Orders	Scientific name	Local name
Cypriniformes	<i>Esomus danrica</i>	Darkina
	<i>Puntius chola</i>	Chela puti
	<i>Puntius ticto</i>	Tit puti
	<i>Labeo rohita</i>	Rui
	<i>Amblypharyngodon mola</i>	Mola
Siluriformes	<i>Eutropiichthys vacha</i>	Bacha
	<i>Ompok pabda</i>	Pabda
	<i>Wallago attu</i>	Boal
	<i>Silonia silondia</i>	Shilong
	<i>Pangasius pangasius</i>	Pangas
	<i>Ailia coila</i>	Kajuli
	<i>Rita rita</i>	Rita
	<i>Sperata aor</i>	Air
	<i>Mystus vitatus</i>	Tengra
	<i>Mystus tengara</i>	Gang Tengra
	<i>Clupisoma garua</i>	Gaura
	<i>Pseudeutropius atherinoides</i>	Batashi
	Tetraodontiformes	<i>Tetraodon cutcutia</i>
Channiformes	<i>Channa punctatus</i>	Taki
Clupiformes	<i>Tenualosa ilisha</i>	Ilish
	<i>Corica soborna</i>	Kachki
Synbranchiformes	<i>Monopterus cuchia</i>	Cuchia
Osteoglossiformes	<i>Notopterus notopterus</i>	Foli
	<i>Chitala chitala</i>	Chital
Perciformes	<i>Colisa fasciatus</i>	Kholisa
	<i>Anabas testudineus</i>	Koi
	<i>Chanda beculis</i>	Chanda
	<i>Glossogobius giuris</i>	Bele
	<i>Nandus nandus</i>	Bheda
	<i>Otolithoides pama</i>	Poa
Pleuronectiformes	<i>Cynoglossus arel</i>	Kukurjib
Decapoda	-	Shrimp
	<i>Scylla serrata</i>	Kakra

Fishing gears

Fishers were found used different types of fishing gears to catch fishes in the studied areas. The use of fishing gears also varied from season to season, depending on the availability of fish. A total of 11 types of fishing gears belongs to 3 categories like Chandijal (drift gill net), Gultijal (drift gill net), Current jal (drift gill net), Trawling net, (drift gill net), Berjal (drift gill net), Vasajal (seine net), Moiajal (seine net), Poajal (seine net), Moshurijal (seine net), Chai (fishing trap), hook and lines (fishing trap) were found in these areas. Among the gears only Chandijal, Gultijal, hook and lines were legal and others were illegal (Table 3).

Table 3. Fishing gear and types in the study areas

Name of Gear	Types	Required man power	Specification	Status	Haul time	Available fish
Chandijal	Drift gill net	6-8	Mesh size (4-5 cm)	Illegal	3hr/2/day	Ilish, Poa, Shilong
Gultijal	Drift gill net	4-5	Mesh size (4-5 cm)	legal	2.5hr/3d	Ilish, Poa, Shilong, Taposhi,
Current jal	Drift gill net	4-5	Mesh size (2-3 cm)	Illegal	2hr/5d	Ilish, Poa, Shilong, Taposhi, Pangas, Rita.
Trawling net	Drift gill net	10-15	Mesh size (5 cm)	legal	1hr/4-5/d	Shrimp, Kajuli, Shilong, Taposhi, Poa, Air, Pangas, Bele, Bacha, Gawra, Chewa etc.
Berjal	Drift gill net	8-12	Mesh size (.5 cm)	Illegal	3hr/2d	Shrimp, Kajuli, Shilong, Taposhi, Poa, Air, Pangas, Bele, Bacha, Garwa, Chewa, Boal etc.
Vasajal	seine net	5-6	Mesh size (1 cm)	Illegal	1hr/5d	Shrimp, Chewa, Bele, Air, Poa etc.
Chwajal	seine net	4	Mesh size (1 cm)	Illegal	1hr/4d	Gora kata, Tengra, Air, Shrimp etc
Poajal	seine net	8-10	Mesh size (2 cm)	Illegal	1hr/4-5d	Tengra, Air, Shilong, Shrimp etc
Moiajal	seine net	1-3	Mesh size (1 cm)	Illegal	1hr/4-5d	Shrimp, kajuli, Shilong, taposhi, Poa, Air, Pangas, Bele, Bacha, Garwa, Chewa, Kukurjib, Golda, Crab, Gora kata, Gonichapila, Chela puti etc.
Moshurijal	seine net	2-3	Mesh size (.5 cm)	Illegal	1hr/3d	Bele, Bacha, Garwa, Chewa, Kukurjib, Golda, Crab, Gora kata, Gonichapila, Pangas, Tit puti etc.
Chai	trap	2-3	3-4 ft. length	Illegal	5hr/2d	Pangas
Hook and lines	trap	1-2	2-3 ft. length	legal	3hr/4d	Bele, Boal, Taki, Shol, Air etc

Social profiles of the fishermen

The demographic status of the fishing communities was quite a different from the other professional communities. In fisher's village the average number of individuals per household is 5. Among the 30 fishers interviewed, 25 were exclusively involved in fishing, 5 were involved both in fishing and other agricultural farming and small business for the maintenance of their daily life. Among all the fishermen 85% were married, 11% unmarried and 4% were divorced (Figure 4).

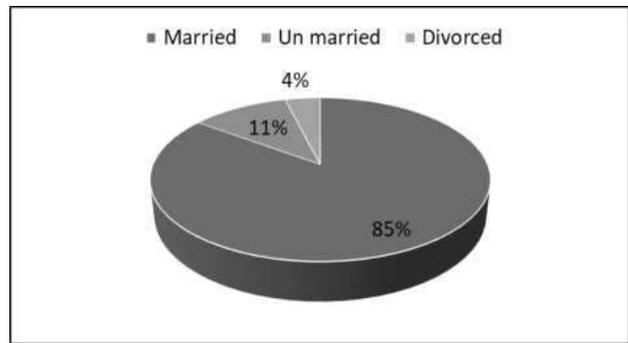


Figure 4. Marital status of the fisher’s folk

Family size and types

Family size is a significant socioeconomic indicator since it has an impact on household income, food consumption, and socioeconomic well-being. According to the survey results, 71% of fisher's have 6-8 family members, 24% have less than 5 family members, 3% have more than 8 family members and 2% have more than 10 family members, respectively. Family structure ranged from joint (consists of grandfather and mother, husband, wife, children, uncles, aunties, nephews etc.) to single nuclear types (consists of husband, wife and children) family (Figure 5).

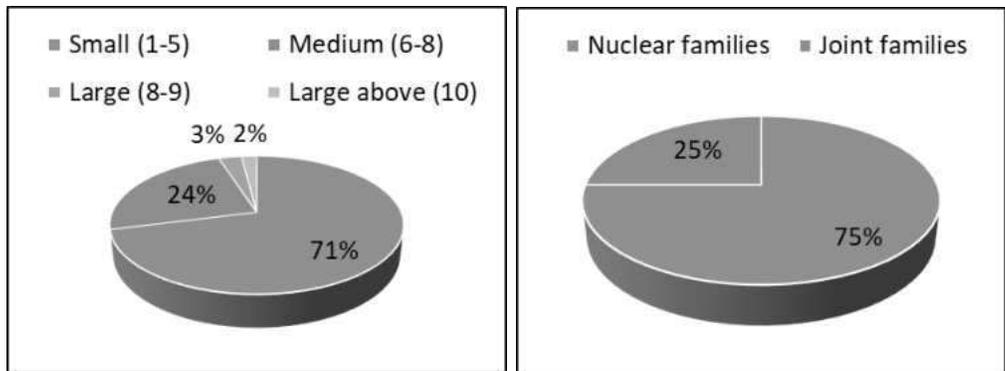


Figure 5. Family size and types of the fisher’s folk

Age structure

The interviewed fishermen's ages ranged from far under 20 to well over 60. Only around 3% of the fishermen were younger than 20. Two-fifths were between the ages of 21 and 40, another 40% were between the ages of 41 and 50, 10% were between the ages of 51 and 60, and the remaining 7% of fisherman were older than 60. The results revealed that people in the age range of 40 to 50 actively participate in fishing more than those in any other age group (Figure 6).

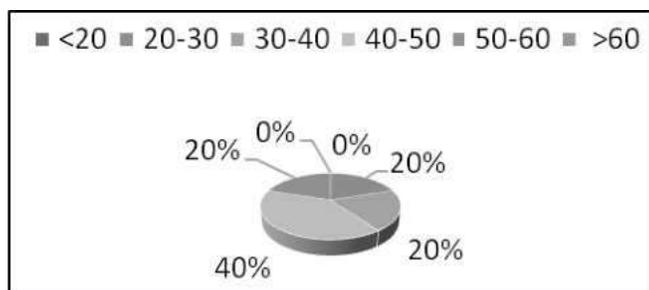


Figure 6. Age structure of the fisher’s folk

Sex composition and religion

The male members of the fisherman’s family were preponderant. There were 62% males and 38% females in the fishermen community. Religiously, around 96% were Muslims and 4% were Hindus within the fishing community (Figure 7). The small-scale fishing and trade community was heavily influenced by religious and social stratification.

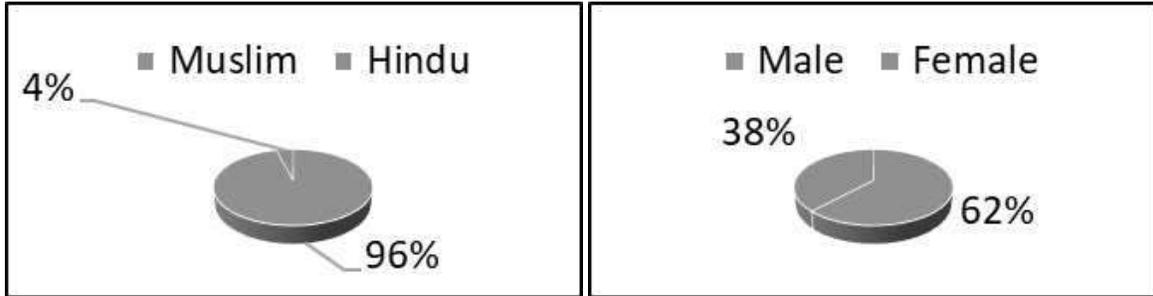


Figure 7. Sex composition and religion of the fisher’s folk

Educational and literacy status

The study revealed that fishermen did not have enough education. Sixty-two percent of small-scale fishermen were either illiterate or only had a primary school education. There were four distinct categories of fishermen depending on their average degree of education. The illiteracy rate was just 15% overall, but 85% among fishermen's kids. About 31% of fisher's kids were in elementary school, 5% in primary school, 2% in high school, and 0.01% in college. It seems the fisherman, despite their lack of access to formal education, were coming to terms with the need of formal education (Figure 8).

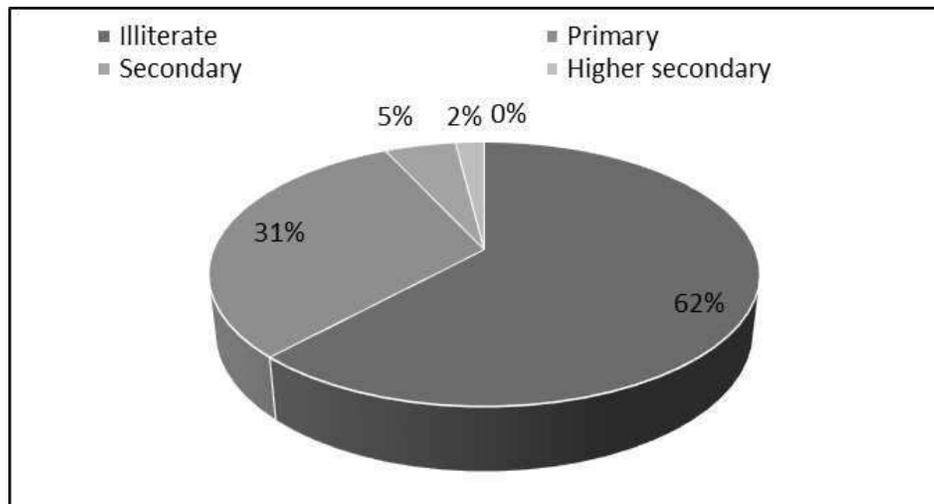


Figure 8. Literacy status of the fisher’s folk

Health facilities

The fishing communities' access to healthcare is inadequate. According to the present investigation, 30% of fisher households experienced major issues and migrate to the upazila health complex, 35% rely on kabiraj, and 35% (Figure 9) of fisher households depend on untrained/ unlicensed village doctors in drug houses whose owners lack knowledge of current medical science.

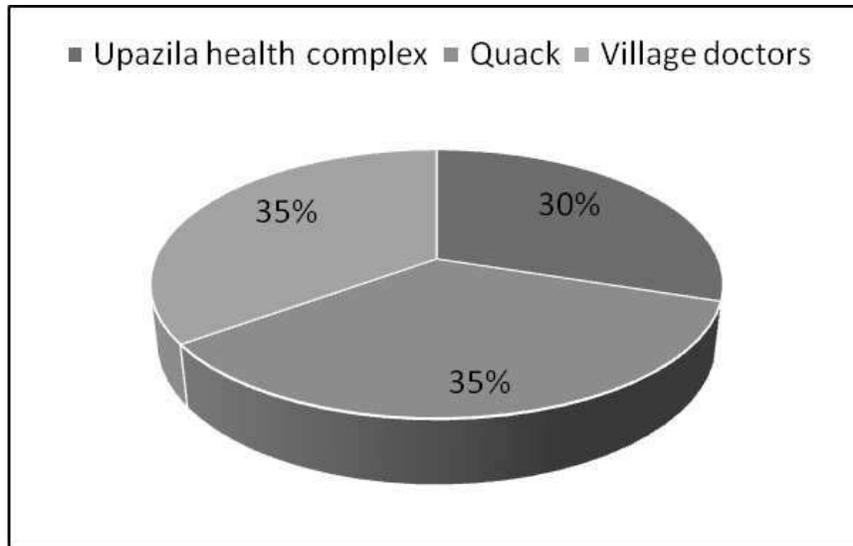


Figure 9. Health facilities of the fisher's folk

Drinking water facilities

Access to safe to drinking water is yet ensured in the studies areas. Some fisher's community still use pond water, river water, well water for drinking, cooking and bathing. It was observed that about 91% people use tube well, 7% people use well, 1% people use river and 1% people use pond water as a source of drinking water (Figure 10).

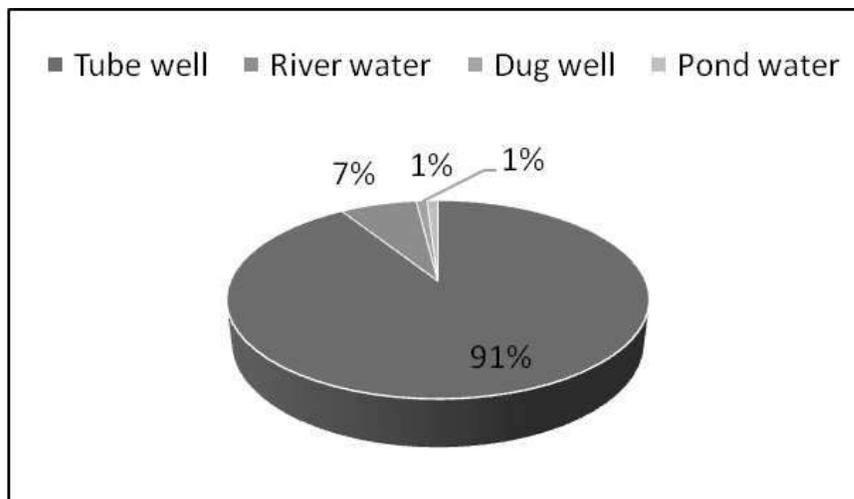


Figure 10. Drinking water facility of the fisher's folk

Housing and infrastructure

In the studied areas, the community houses were of three main types viz. kacha, semi pacca and pacca houses. Kacha-houses were made of bamboo spill and tin with mud flooring and semi pacca- was made of wood and tin with cement floor whereas pacca houses were made of bricks and tin with cement floor. Under the present study, it was found that among the fisher's community, 88% of housing structures were kacha, 10% were semi pacca and only 2% were pacca houses (Figure 11). Road and transportation system were found under developed.

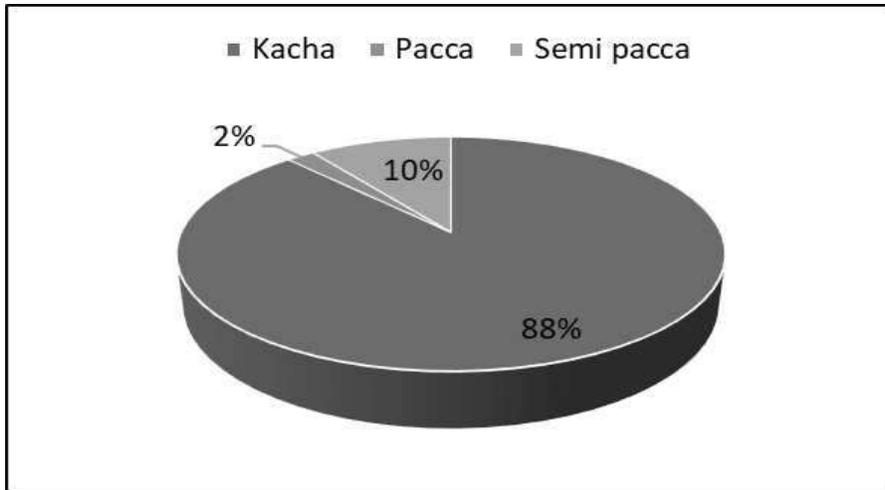


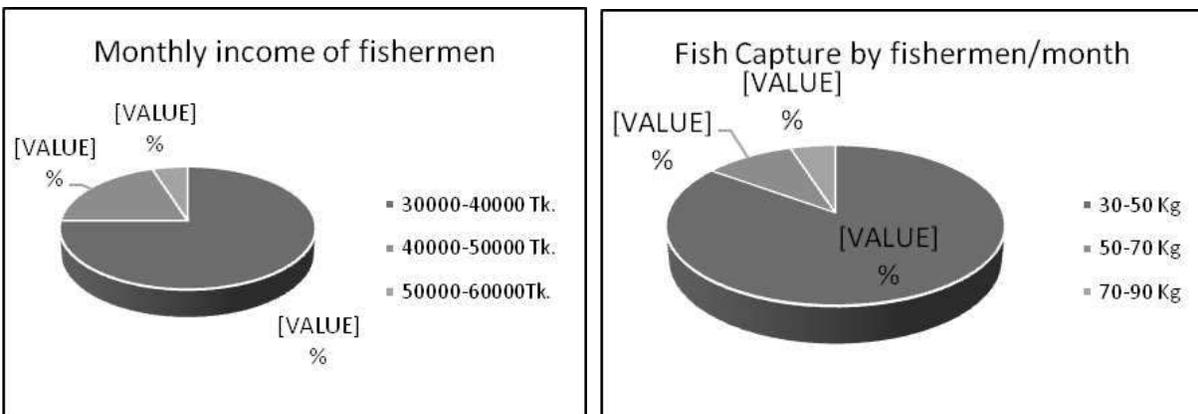
Figure 11. Housing and Infrastructure facilities of the fisher’s folk

Fishing activities, income and living standard

A family's economic standing in a community was largely defined by its disposable money. The fishermen had a miserable standard of living. The majority of fishermen lived in abject poverty due to their meager earnings. About 75% of fishermen made between 3000-5000 Tk. (BDT) per month; 25% made between 3500-5000 Tk. (BDT); and 5% made between 5000-6000 Tk. (BDT). Additionally, 85% of fishermen caught between 30-45 Kg of fish per month; 10% caught between 4-60 Kg of fish per month; and 5% caught between 50-75 Kg fish per month. It was found that during the study period, 85% of fishermen spent between 20,000- 25,000 Tk. (BDT) per year as their operation cost for catching fish, 10% spent between 30,000-40,000 Tk. (BDT) per year, and 5% spent between 40,000-50,000 Tk. (BDT) per year (Figure 12). In addition, many individuals were switching careers because of the rising continuous fishing pressure and climate change.

Fishing assets

Respondents to the study informed that the annual cost of maintaining and repairing their boats were between 20,000 and 50,000 Tk. (BDT). About 82% of the fishermen had their own boat and equipment. The remaining 18% contribute to the Mohajons' boat in some way, either as manual laborers or by sharing in the catch.



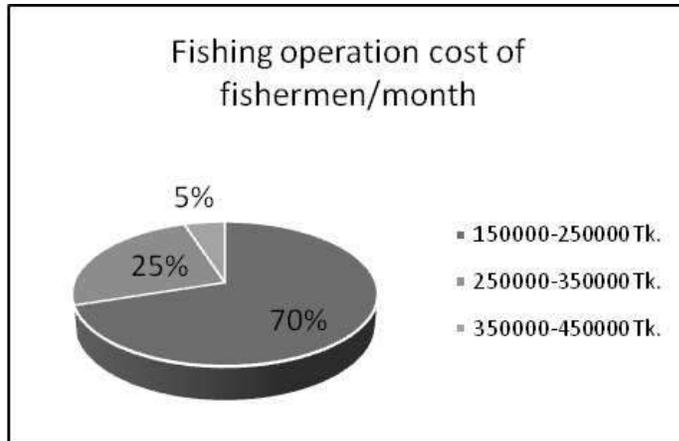


Figure 12. Fishing activities, income and living standard of the fisher's folk

Domestication and Conservation of Commercially Important Threatened Riverine Finfish

Researchers

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Objectives

- To collect the selected riverine fishes from wild sources
- To study the food, feeding habits, and reproductive parameters of the collected fishes
- To develop the brood management techniques of the fishes in captive conditions
- To develop the induced breeding techniques of the selected fishes in captive conditions
- To develop the nursery rearing techniques of the selected fishes in captive conditions
- To assess the growth and yield performance of selected fishes in captive conditions

Achievements

Collection of fry/fingerling/sub-adult/adult fishes

Labeo boggut (Bagat bata), *Silonia silondia* (Shilong) and *Gagata gagata* (Ghora kata) were collected for this year. A total of 2000 fingerlings of *Labeo boggut*, 600 sub-adults of *Silonia silondia*, and 400 adults & sub adults of *Gagata gagata* were collected from the wild sources to domesticate in ponds at the BFRI, RS, Chandpur.

Studies of the food, feeding habit and reproductive parameters of the selected fishes

Food and Feeding Habits

This study was conducted to estimate the food items in the stomach contents of the selected fishes. The collected specimens were dissected for food analysis. The total length, body weight, gut length, and gut weight were measured. The stomach contents of the specimens were noted, and the stomachs were classified as 100% full, 75% full, 50% full, 25% full and empty categories.

Gonadosomatic index (GSI)

This study was conducted to estimate the gonad value. About 100 individuals of each species were collected from the wild sources and studied. The total length and body weight of fish were measured. Gonads of fishes were dissected and then excess moisture was removed from the gonad before taking the weight of gonads. GSI of the male and female was calculated by using the formula.

Sex ratio

A total of 200 individuals of each selected species were collected from the rivers and studied. The male and female fish was differentiated, and data was recorded after dissecting the gonads of the individual fish.

Fecundity estimation

100 gravid females of each selected fish were studied for fecundity estimation. Fecundity was estimated by the gravimetric method. Fecundity was calculated by using the formula (Blay, 1981)

$$F = \frac{N * Gonad Weight}{Sample Weight}$$

, Where F is the fecundity and N is the number of eggs in the sample

Measurement of ova diameter

The diameter of the ova was taken under the microscope fitted with an ocular micrometer and determine the maturity according to Le Cren (1965). A diameter of about 10 ova were measured at random from the anterior, central, and posterior regions of each lobe of the ovaries.

Sex ratio

The study was conducted for twelve months. About 100 individuals of each selected species were collected from the rivers and studied monthly. The male and female fish were differentiated, and data was recorded after dissecting the gonads of the individual fish (Narejo et al., 2002).

A total of 150 *S. silondia* were examined and all fish guts were contained food. Among them, no empty gut was observed in all the dissected fishes. Out of 150 *S. silondia*'s stomachs 21 stomachs (14%) were quarter filled (<25% filled), 78 stomachs (52%) were half filled (25-50% filled), and 39 stomachs (26%) were three quarter filled (50-75% filled) whereas, 12 stomachs (8%) were full filled (75-100% filled). The *S. silondia* fish consumes a wide range of food and fourteen prey items were observed in the gut contents *i.e.* fish, crab body particles, crab chelate leg, shrimp, shrimp chelate leg, rotifers, debris, and worms were found frequently in the examined gut.

A total of 300 *G. gagata* were examined and all fish guts were contained food. Among them, no empty gut was observed in all the dissected fishes. Out of 300 *G. gagata*'s stomachs 36 stomachs (12%) were quarter filled (<25% filled), 120 stomachs (40%) were half filled (25-50% filled), and 81 stomachs (27%) were three quarter filled (50-75% filled) whereas, 63 stomachs (21%) were full filled (75-100% filled). A total of eight major groups of prey items which includes mollusk, worm, insect, plant, copepod, teleost, detritus, and debris were made up of the stomach contents.

Reproductive biology

To know the reproductive biology of *S. silondia* , data were collected on Gonadosomatic index (GSI), sex ratio and fecundity which are presented in Table 1.

Table 1. Reproductive parameter of *S. silondia*

Total length (cm)	Weight (g)	Sex Ratio	Gonad Weight (g)	GSI	Fecundity
32.66±3.54	270.66±81.74	M:F=1:1.5	30.07±14.94	10.65±2.32	148685 ± 73711

To know the reproductive biology of *G. gagata*, data were collected on Gonadosomatic index (GSI), sex ratio, fecundity and ova diameter which are presented in Table 2.

Table 2. Reproductive parameter of *G. gagata*

Total length (cm)	Weight (g)	Sex Ratio	Gonad Weight (g)	GSI	Fecundity	Ova diameter (mm)
13.92±1.24	25.35±8.35	M:F=1:1.15	1.13±0.41	4.61±1.71	3235±1044	0.446±0.13

Brood management techniques of the selected fishes in captive condition

This experiment is being conducted in earthen ponds under natural conditions at BFRI, RS, Chandpur for 12 months, from November 2022 to October 2023. The experiment was concerned with observing the growth, gonadal maturation and yield performance of *L. boggut*, *S. silondia* and *G. gagata* fishes under a polyculture system in the captive condition. Three ponds were selected for each candidate species. Three ponds will be divided into six parts. Each pond is considered as one treatment, e.g., Treatment-1 (T₁), Treatment-2 (T₂), Treatment-3 (T₃) and each part is considered as one replication. The ponds are 20 decimal in size. The water depth is maintained at 1-1.5 meters. The ponds were prepared by dewatering, liming (1kg dec⁻¹) and fertilization (Urea 100 g and TSP 50-100g dec⁻¹). The experimental design is presented in Table 3.

Table 3. Brood rearing of *L. boggut*/ *S. silondia*/ *G. gagata* with carps in captive condition

Treatment	Stock. dens. (indi. ha ⁻¹)	Stock. dens. (3,000 ha ⁻¹)			
	<i>L. boggut</i> / <i>S. silondia</i> / <i>G. gagata</i>	<i>C. catla</i>	<i>C. mrigala</i>	<i>L. rohita</i>	<i>P. sarana</i>
T ₁	2,000	40%	20%	30%	10%
T ₂	2,500				
T ₃	3,000				

Sources of fingerlings: Wild sources fingerlings of selected fishes and hatchery-produced fingerlings of carps were stocked.

Stocking size: The average 5-10g weight of fingerlings of *L. boggut*, *S. silondia*, *G. gagata* with same size fingerlings (15-20g) of carps were stocked in 15th November, 2022.

Supplementary feeding: Commercial fish feed (containing 28-30% protein) is being fed at 8-5% of their total biomass daily. Feed supply is being adjusted by estimating the standing crop by random stock sampling.

Sampling and data collection: Fishes are sampled once every fortnightly for a periodic check on growth. The growth study is recorded as total length in cm and weight in g.

Water quality data on water depth (cm), water temperature (°C), transparency (cm), dissolved oxygen (mg l⁻¹), water pH, free CO₂ (mg l⁻¹) and ammonia (mg l⁻¹) is recorded fortnightly.

Water quality parameters were congenial for brood rearing. Water quality parameters of different treatments are mentioned in Table 4.

Table 4. Water quality parameters in three treatments of the study

Parameters	T ₁	T ₂	T ₃
Air Temperature (°C)	26±1.41	26±1.41	26.25±1.06
Water Temperature (°C)	22±0.71	21.75±1.06	21.5±0.71
DO (mg l ⁻¹)	6.25±0.35	5.8±0.28	6±0.14
CO ₂ (mg l ⁻¹)	12.1±1.56	11.75±1.77	12.9±2.40
pH	7.25±0.35	7.25±0.35	7.25±0.35
NH ₃ (mg l ⁻¹)	0	0	0
Transparency (cm)	30±1.51	35±1.80	28±1.43

Length and weight of the selected fishes during stocking are shown in table 5 and average body weight of the selected fishes in pond condition after 150 days of culture are shown in Table 6.

Table 5. Stocking length and weight of the selected fishes in pond condition.

Parameters	Treatments		
	<i>S. silondia</i>	<i>L. boggut</i>	<i>G. gagata</i>
Initial length (cm)	13.27±2.95	5.85±0.66	10.67±1.78
Initial weight (g)	19.85±13.53	1.88±0.53	11.23±4.73

Table 6. Average body weight of the fishes in pond condition after 150 days of culture

Treatment	ABW (g)						
	<i>S. silondia</i>	<i>L. boggut</i>	<i>G. gagata</i>	<i>C. catla</i>	<i>C.mrigala</i>	<i>L. rohita</i>	<i>P. sarana</i>
T ₁	38.87±0.93	27.55±0.88	16.67±1.48	200±12.44	144±7.52	162±4.92	168±3.36
T ₂	38.25±1.03	26.88±0.73	15.33±0.73	208±17.23	154±8.22	164±5.72	170±2.85
T ₃	37.65±0.88	26.2±0.66	16.26±1.22	196±11.78	138±8.63	158±6.63	165±3.22

Niche Characterization of Meghna River Basin: Eco-morphological and Hydrodynamic Modelling

Researchers

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Objectives

- To formulate GIS-based models to picturize causal influence of stochastic and deterministic factors
- To develop models of geo-morphological and hydrodynamic aspects using GIS
- To generate spatio-temporal models of niche viability in context of meteorological alterations, interaction between different attributes and niche degradation
- To produce GIS-based models for characterization of entire niche to assess suitability.

Achievements

Data acquisition

To obtain a raw description for characterization of the niche of the Meghna River basin, a grab sampling of water and soil quality parameter was performed at 20 sites (Table 1, Figure 1).

Table 1. List of sampling locations with satellite view

No of Stations	Location Name	District
S1	Singapore Jame Mosque	Brahmanbaria
S2	Ashuganj Ferry Terminal	
S3	Sahabnagor Bazar	
S4	Nazarpur Natural Park	Narsingdi
S5	Tidirchar	Comilla
S6	Gazaria	Munshiganj
S7	Ekhlashpur Launch Terminal	Chandpur
S8	Horina Ferry Terminal	
S9	Altaf Master Launch Ghat	Laksmipur
S10	Motirhaat Machh Bazar	Noakhali
S11	Alexander New Launch Terminal	
S12	Ruhulamin Market Masque	
S13	Sukh Char	
S14	Sonadia	
S15	Daulatkhan Launch Terminal	Bhola
S16	Tajumuddin Launch Terminal	
S17	Char Annadaprasad	
S18	Char Kukri Mukri	
S19	Monpura Launch Terminal	
S20	Monpura Bangla Bazar	

b) Spatio-temporal distribution and changeability of riverbed geo-physico-chemical attributes

Spatio-temporal distribution and changeability of riverbed geo-physico-chemical attributes viz. soil texture, type, permeability, pH, acidity/alkalinity, sloping of sampling sites were monitored and all the geo-physico-chemical attributes were found amiable in range.

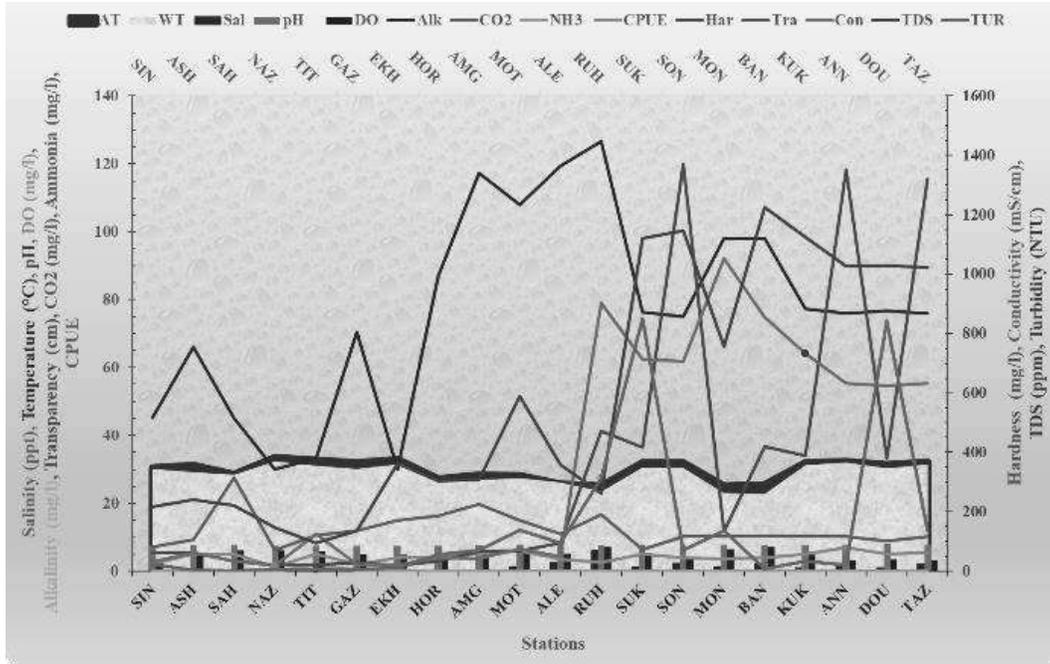


Figure 2. Spatial distribution and fluctuation of hydro-physico-chemical attributes along with bio resources

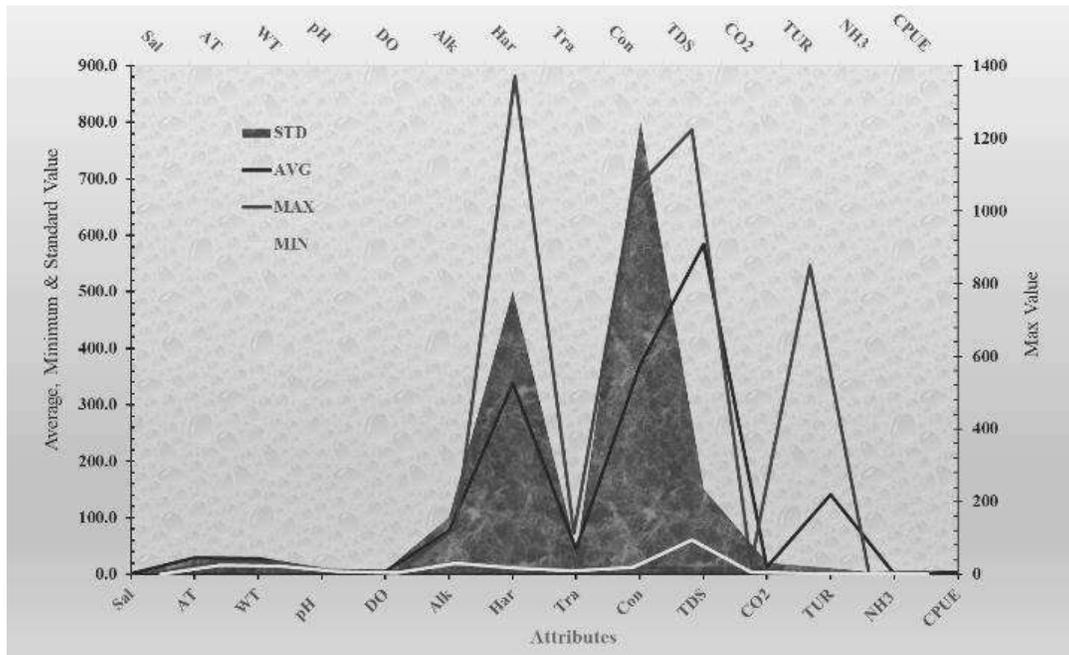


Figure 3. Contemporary distribution of hydro-physico-chemical attributes along with bio resources (in situ)

Table 2. Summary of observed hydro-physico-chemical attributes of all sampling sites

Parameters	AT (°C)	WT (°C)	pH	DO (mg/l)	CO ₂ (mg/l)	Alk (mg/l)	Har (mg/l)	Tra (cm)	Tur (NTU)	Con (µs/cm)	TDS (ppm)
AVG	29.87	28.76	7.67	5.08	12.16	76.58	338.17	104.00	141.60	3.69	584.67
SD	2.93	3.09	0.16	1.19	5.06	29.33	-	7.19	-	3.77	-
SEM	0.66	0.69	0.04	0.27	1.13	6.56	-	4.85	56.42	0.84	93.15
CV	0.10	0.11	0.02	0.23	2.29	0.38	1.37	-	1.78	1.02	0.71
MODE	32.00	30.20	7.50	7.00	30.56	30.00	62.00	32.00	7.00	6.00	300.00
MEDIAN	31.30	30.20	7.70	5.22	20.61	30.00	81.50	32.17	44.70	1.00	360.67
PE	0.44	0.47	0.02	0.18	0.76	4.42	69.88	96.48	38.06	0.57	62.83
MaxE	8.80	9.27	0.48	3.57	15.18	88.00	1389.94	0.11	756.97	11.31	1249.72
Precision	0.01	0.02	0.00	0.04	3.40	0.06	0.21	0.71	0.27	0.15	0.11

GIS Based Modelling of Response and Adaptive Ability of Niche Bio-resources Against Stochastic and Deterministic Factors

For GIS Based Modelling of Response and Adaptive Ability of Niche Bio-resources Against Stochastic and Deterministic Factors and for Niche Paradigm Modelling, different primary and secondary data (meteorological, hydrological, fish production, CPUE, fish landing centre, plankton, benthic macro-invertebrates etc.) were collected and analyzed.

a) Spatial distribution and variation of bio resources (Plankton)

A total of eight groups and 65 kinds of species of phytoplankton and 7 groups and 38 kinds of zooplankton were abundant in the Meghna River basin (Table 3 and 4). Abundance of plankton was highest in Nazarpur and lowest in Char Kukrimukri (Figure 4a). Relative abundance of zooplankton was about 4 times lower than phytoplankton (Figure 4 (b-c)). Among all phytoplankton groups, *chlorophyceae* was the most abundant and *dinophyceae* was the lowest abundant group (Figure 4d). Among all seven zooplankton groups (35 species), *cladocera* was the most abundant and *oligohymenophyceae* was the lowest abundant group.

b) Spatial distribution and variation of bio resources (Benthos)

Six groups of benthic macro-invertebrates were abundant in Meghna River basin, among those *annelida* was most abundant and *pleuroceridae* was lowest abundant group (Figure 4e). Singapore Mosque contained highest abundance and highest no. of groups and Ashuganj Ferry Terminal contained lowest abundance and lowest no. of groups of benthic macro-invertebrates.

Table 3. List of available phytoplankton

Group	Genus	No.
Cyanophyceae	<i>Spirulina, Scenedesmus, Microcystis, Polycystis, Anabaena, Nostoc, Oscillatoria, Coelosphaerium, Phormidium, Rivularia</i>	10
Chlorophyceae	<i>Pediastrum, Closterium, Ankistrodesmus, Eudorina, Crucigena, Chlamydomonas, Ceratium, Acanthocystis, Gonatozygon, Microspora, Genecularia, Pleodarina, Spirogyra, Volvox, Mougeotia, Zygnema, Synedra, Oedogonium, Tetraspora, Penium, Coelastrum, Docidium, Tetrapedia, Botryococcus, Scenedesmus</i>	26

Bacillariophyceae	<i>Naviculla, Melosira, Amphora, Tabellaria, Frustulia, Coscinodesmus, Cyclotella, Ditoma, Fragilaria, Nitzschia, Polycistis, Stphanodesmus, Synedra, Gomphonema, Anomoeoneis, Asterionella, Campylodiscus, Gyrosigma, Stephanodiscus</i>	19
Zygnematophyceae	<i>Euastrum, Staurastrum, Netrium, Spirotenia, Cosmarium</i>	5
Ulvophyceae	<i>Ulothrix</i>	1
Fragilariophyceae	<i>Synedra</i>	1
Trebouxiophyceae	<i>Botryococcus, Protococcus</i>	2
Dinophyceae	<i>Ceratium</i>	1

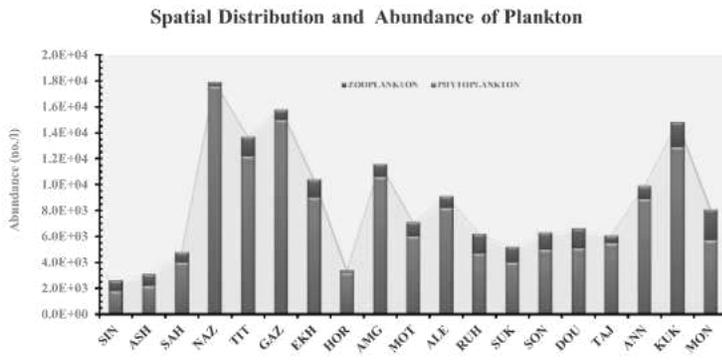
Table 4. List of available zooplankton

Group	Genus	No.
Protozoans	<i>Euglena, Phacus, Volvox, Diffflugia, Colpoda, Euglepha, Spirostomum</i>	7
Rotifers	<i>Brachionus Sp., Trichocera, Polyarthra, Asplancha, Keratella, Filinia, Trichocera, Rotaria, Lindia, Mytilina, Eubranchiopus, Trichocera, Trichotria</i>	14
Copepods	<i>Nauplius, Diaptomus, Cyclops, Mesocyclops, Limnocalanus</i>	5
Cladocerans	<i>Daphni, Diaphnosoma, Sida, Leptodora, Eubranchipus</i>	5
Diaphanosoma	<i>Chydorus, Bosmina, Moina, Sida, Ceriodaphnia</i>	5
Ostracods	<i>Cypridopsis</i>	1
Oligohymenophorea	<i>Paramecium</i>	1

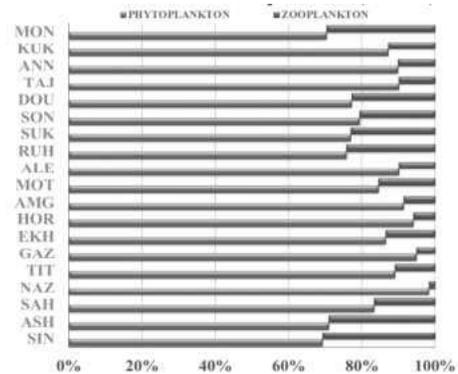
GIS-based Modelling of the Impact of Structural and Functional Traits Interaction on Niche suitability and Viability

a) Spatio-temporal distribution and variation of CPUE

Spatio-temporal variation of CPUE in Winter was lowest and highest 3.0 and 4.0 kg/100 m net/hr respectively at Tajumuddin and Char Annadaprasad, respectively, CPUE in Fall was 7 and 15 kg/100 m net/hr at Tajumuddin and Char Annadaprasad respectively, CPUE In Summer was 2.0 and 3.5 kg/100 m net/hr at Tajumuddin and Char Annadaprasad respectively (Figure 6 and 8). From the distribution plot, CPUE was symmetrically distributed in the winter and asymmetrically distributed in the fall (Figure 4.5 & 6).



a) Spatial distribution and abundance of Plankton



b) Relative abundance of Plankton

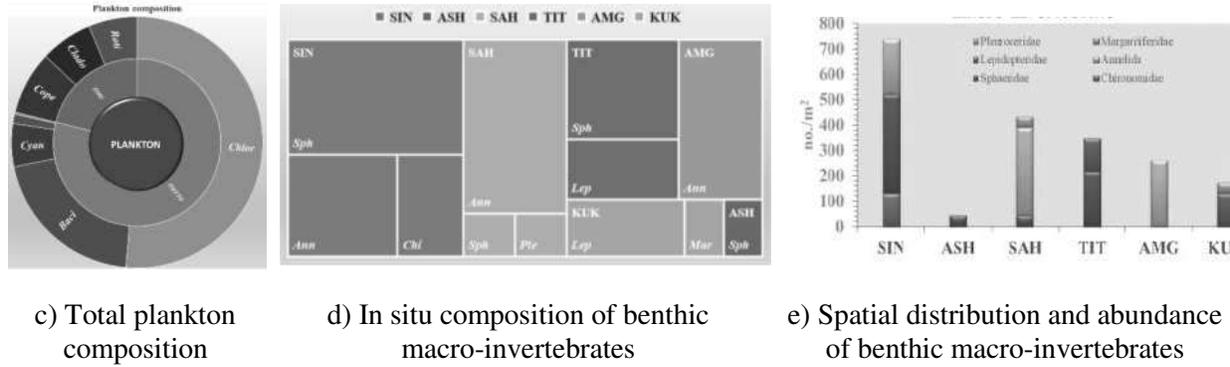


Figure 3. Availability and composition of plankton and benthic macro-invertebrates (a-e) CPUE was positively associated with CO₂, alkalinity and hardness and negatively associated with transparency and available plankton composition.

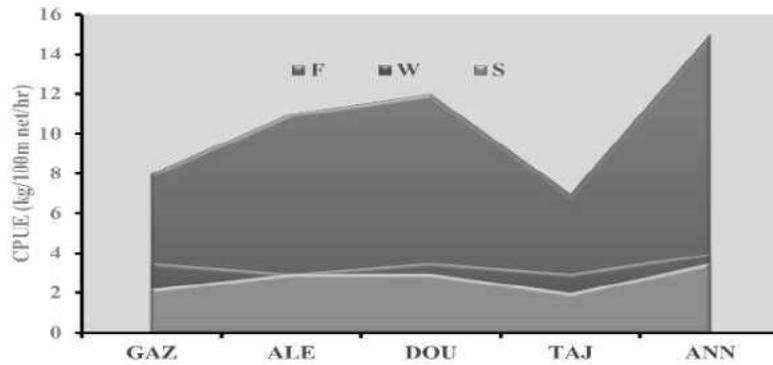


Figure 4. Temporal variation of CPUE

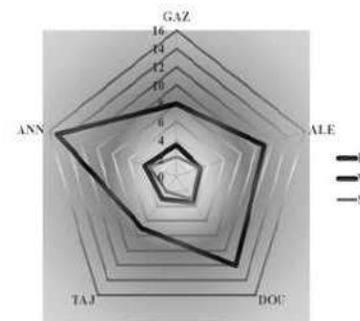


Figure 5. Temporal distribution of CPUE

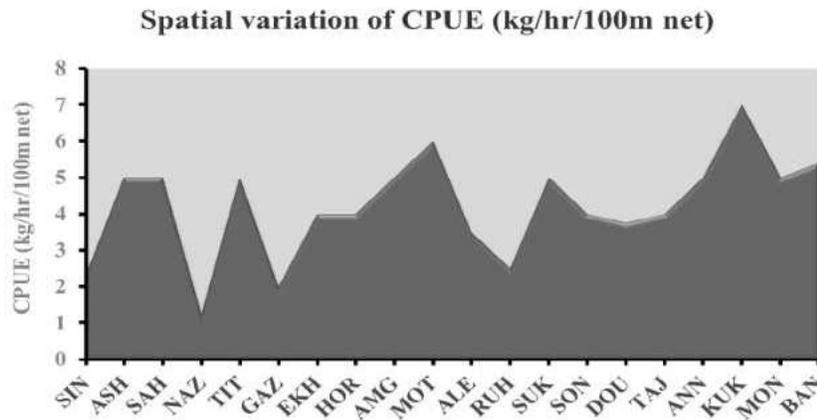


Figure 6. Spatial variation of CPUE

c) Impact of Structural and Functional Traits Interaction on Niche suitability and Viability

Most of the attributes of all the stations were differed statistically (Figure 7). Air temperature was positively associated with water temperature, DO, CO₂, NH₃ and plankton composition (Figure 8). Among the three clusters, S2-S4, S8-S16 and S20 formed the biggest cluster with maximum similarity

(Figure 9). Among 16 diver factors Plankton and CPUE were found as a major driver factor; TDS and conductivity were found as a second driver factors (Figure 10).

GIS-based Modelling of Effect of Stochastic Factors on Geo-Morphological and Hydrodynamic features in context of Meteorological Alteration

a) Spatio-temporal distribution and Changeability of Hydro-dynamic aspects of Meghna River basin

Spatio-temporal distribution and Changeability of Hydro-dynamic attributes of Meghna River basin viz. water level, maximum soil concentration, water discharge, sediment load were monitored and analyzed.

b) Spatio-temporal distribution and Changeability of Geo-Morphological and Hydro-physical attributes of Meghna River basin

Spatio-temporal distribution and changeability of geo-morphological and hydro-physical attributes of Meghna River basin viz. depth, width and CSA were monitored and analysed.

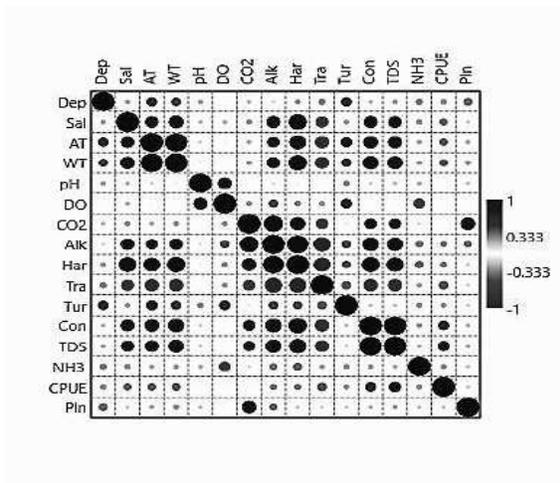


Figure 7. Degree of Association Plot

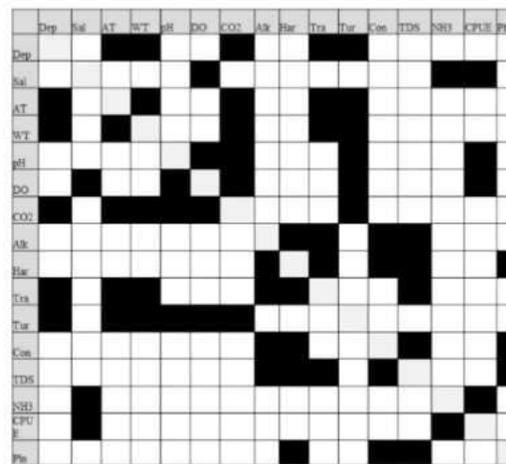


Figure 8. Post Hoc. Checkerboard

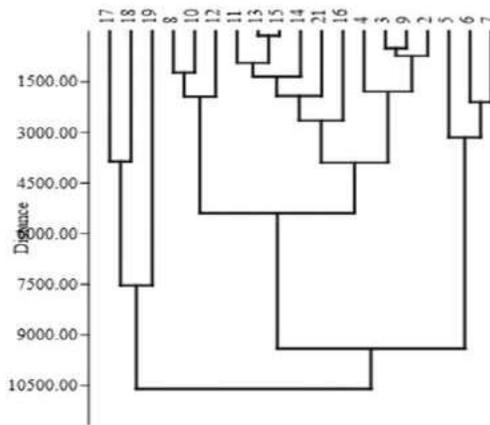


Figure 9. Spatial Clustering (In situ)

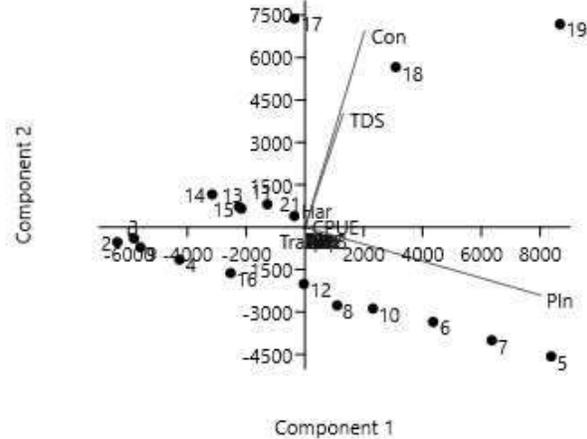


Figure 10. PCA (In situ)

Ecological assessment of inland open water fisheries population with bio-physicochemical properties to frame EBFM approach (Comp-D)

Researchers

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Objectives

- To estimate population ecology and diet composition of some commercially significant inland open water fishes (especially *haor* and *beel* resident fishes)
- To assess bio-physicochemical properties of some selected inland water bodies (*haors* and *beels*) including seasonal variation and impact assessment of agro-chemicals level
- To assess stock and biomass of some important ecological fish groups i.e. Planktivores/ Herbivores, Detrivores, Carnivores & Omnivores based on catch and CPUE data
- To formulate ecosystem based management approach of some major inland open water bodies (especially *haors* and *beels*) with emphasizing to increase productivity, stock enhancement and conservation of the fisheries resources

Achievement

Water quality of Dekar and Kawadeghi Haor

Water quality parameters were collected monthly from different sampling spot of Dekar and Kawadeghi Haor. Water quality parameter such as Transparency, Temperature, Dissolved Oxygen, pH, CO₂, Alkalinity, Hardness, Ammonia, Conductivity and TDS of sampling sites were monitored monthly. Almost all water quality parameters were acceptable ranges for fish growth. Some exceptions were observed in case of Alkalinity and Hardness among the sampling spots. Highest value of Alkalinity was 51mg^l⁻¹ and the highest value of Hardness was 48mg^l⁻¹. Lowest value of Alkalinity was 14mg^l⁻¹. Lower values of alkalinity and hardness indicating beel water to be fewer nutrients enriched. Some exceptions were also observed in case of Transparency among the sampling spots. This result may be due to the vice versa relationship among planktonic community and fish density of a water body. Ammonia was not found during the sampling period in Dekhar Haor But in casse of Kawadeghi Haor, very fewer amounts such as 0.1mg^l⁻¹ was present in Alkhadobi Gang.

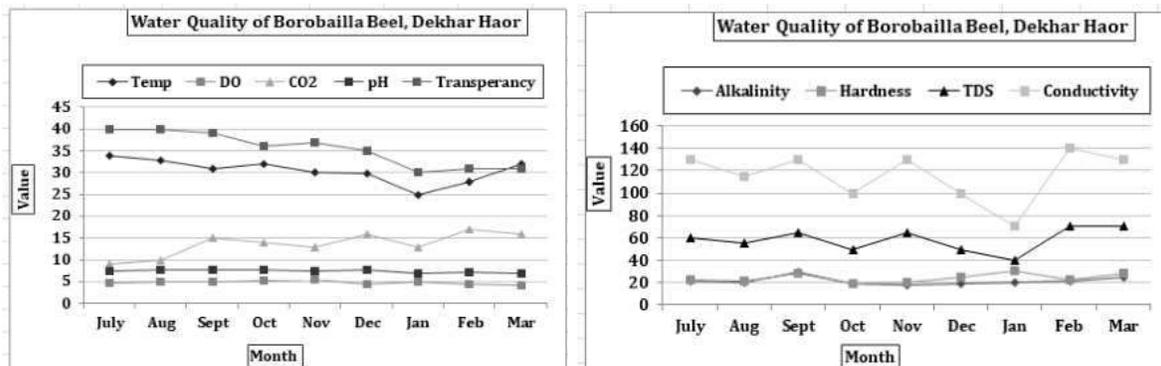


Figure 1. Water quality parameters of Borobailla Beel of Dekhar Haor Sunamgonj

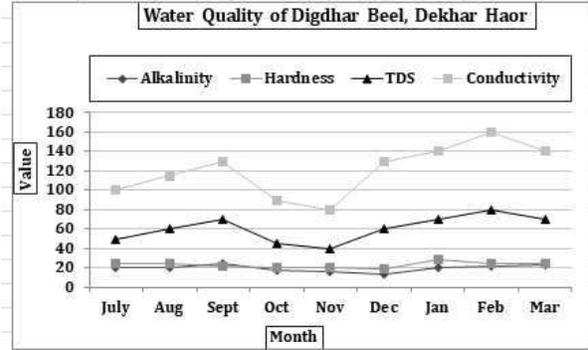
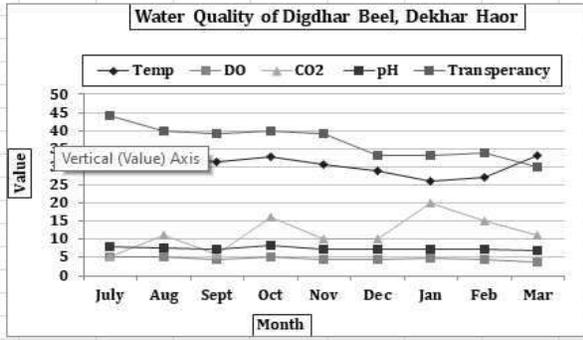


Figure 2. Water quality parameters of Dighdar Beel of Dekhar Haor, Sunamgonj

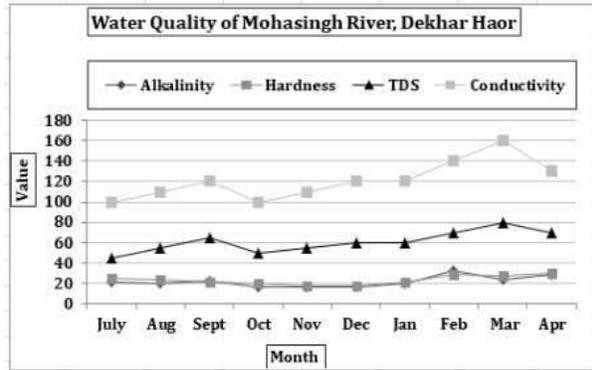
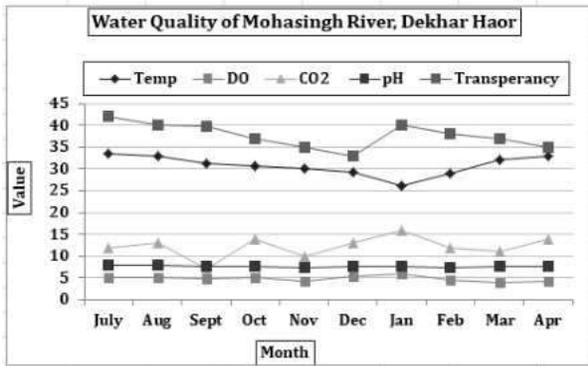


Figure 3. Water quality parameters of Mohasingh River of Dekhar Haor, Sunamgonj

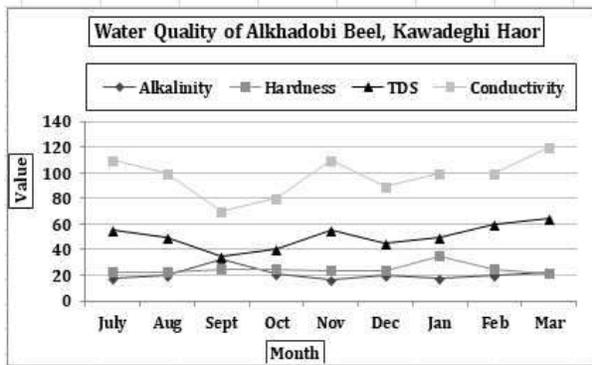
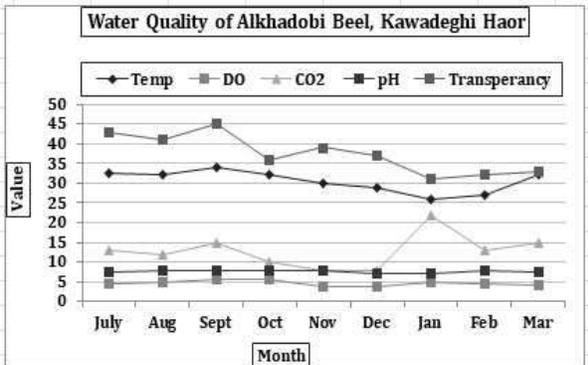


Figure 4. Water quality parameters of Alkhadobi Beel of Kawadeghi Haor, Moulvibazar

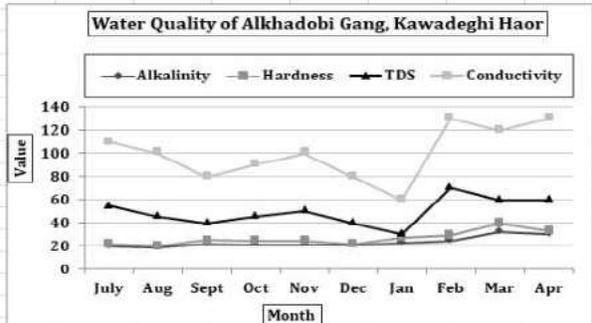
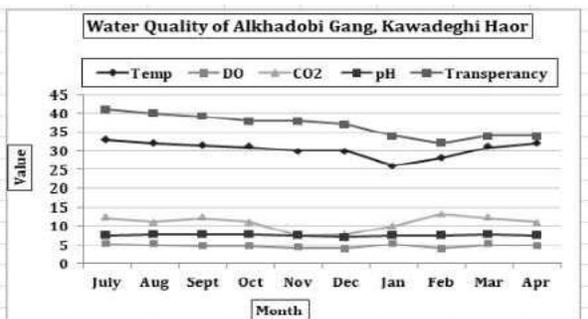


Figure 5. Water quality parameters of Alkhadobi Gang of Kawadeghi Haor, Moulvibazar

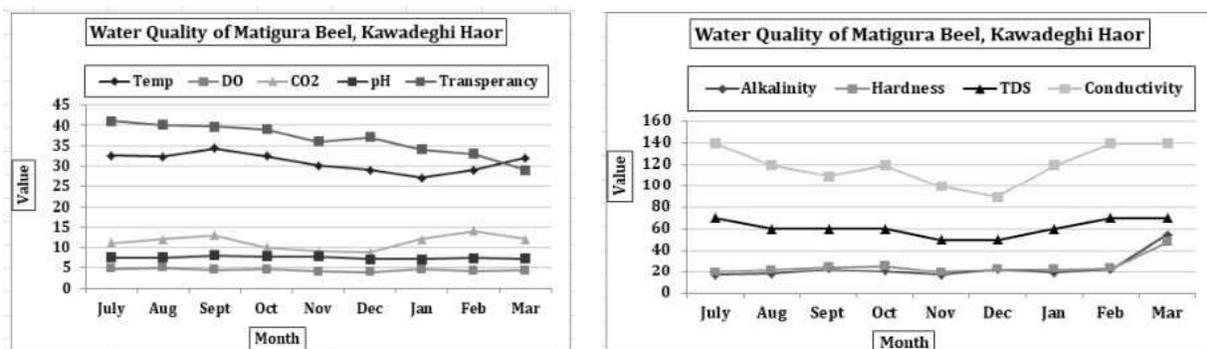


Figure 6. Water quality parameters of Matigura Beel of Kawadeghi Haor, Moulvibazar

Water Quality Standard

Almost all water quality parameters were acceptable range for fish according to Bangladesh standard. Which is suitable for the fish and other aquatic animals. (Table: 1)

Table 1: Water quality standard

Sl. No.	Parameter	BD Standard	Source
1	Air Temperature (°C)	30.5	DoE, 2001
2	Water Temperature (°C)	30	EQs, 1997
3	Dissolved Oxygen (mg/L)	6.5	DoE, 2001
4	Carbondioxide (mg/L)	23	EPAUS, 1976
5	pH	8.5	EQs, 1997
6	Transperancy (cm)	45	Hossain, 2011
7	Alkalinity (mg/L)	100-200	Boyd & Tucker, 1998
8	Hardness (mg/L)	500	DoE, 1997

Plankton identification

A total of 29 genera of phytoplankton and 10 genera of zooplankton were identified of which Chlorophyceae in phytoplankton population and Crustacea in zooplankton population were dominant.

Length weight

Length-weight of a total of 15 commercially important fish species individuals was recorded. There average mean length- weight and standard deviation were described in table-3.

Table 1. Plankton distribution and abundance of Dekhar Haor, Sunamgonj

Plankton Type	Plankton Groups	Genus
Phytoplankton	Bacillariophyceae	<i>Asterionella</i> , <i>Coscinodiscus</i> , <i>Fragilaria</i> , <i>Navicula</i> , <i>Nitzsehia</i> and <i>Synedra</i>
	Cyanophyceae	<i>Spirulina</i> , <i>Anabaena</i> , <i>Aphanocapsa</i> , <i>Coelosphaerium</i> , <i>Polycystis</i> , <i>Lyngbia</i> , <i>Microcystis</i> , <i>Oscillatoria</i> , <i>Spirulina</i> and <i>Nostoc</i>
	Euglenophyceae	<i>Euglena</i> , <i>Phacus</i> and <i>Trachelomonas</i>
	Chlorophyceae	<i>Pediastrum</i> , <i>Spirogyra</i> , <i>Pandorina</i> , <i>Closterium</i> , <i>Tetraedron</i> , <i>Scenedesmus</i> , <i>Volvox</i> , and <i>Ankistrodesmus</i>

Zooplankton	Copepoda	<i>Cyclops</i> , <i>Diaptomus</i> and <i>Nauplius</i>
	Rotifera	<i>Lecane</i> , <i>Brachionus</i> and <i>Keratella</i>
	Branchiopoda	<i>Bosmina</i> , <i>Daphnia</i> and <i>Moina</i>
	Protozoa	<i>Arcella</i>

Table 2. Plankton distribution and abundance of Kawadeghi Haor, Moulvibazar

Plankton Type	Plankton Groups	Genus
Phytoplankton	Bacillariophyceae	<i>Asterionella</i> , <i>Cyclotella</i> , <i>Navicula</i> , <i>Synedra</i> , <i>Coscinodiscus</i> and <i>Fragilaria</i>
	Cyanophyceae	<i>Spirulina</i> , <i>Microcystis</i> , <i>Nostoc</i> , <i>Anabaena</i> , <i>Aphanocapsa</i> and <i>Coelosphaerium</i>
	Coscinodiscophyceae	<i>Coscinodiscus</i>
	Euglenophyceae	<i>Euglena</i> and <i>Phacus</i>
	Chlorophyceae	<i>Spirogyra</i> , <i>Ankistrodesmus</i> , <i>Eudoria</i> , <i>Pandorina</i> , <i>Pediastrum</i> , <i>Scenedesmus</i> , <i>Tetradon</i> and <i>Closterium</i>
Zooplankton	Copepoda	<i>Cyclops</i> and <i>Nauplius</i>
	Rotifera	<i>Brachionus</i> and <i>Lecane</i>
	Branchiopoda	<i>Daphnia</i> , <i>Bosmina</i> and <i>Moina</i>

Field data collection for estimation of population ecology of commercially significant Haor and Beel resident fishes

Table 3. Mean values of 15 fishes length-weight (mean \pm SD) recorded from different study areas

Fishes	Study Areas			
	Dekhar Haor		Kawadeghi Haor	
	L(cm)	W(gm)	L(cm)	W(gm)
<i>Puntius sarana</i>	7.8 \pm 0.84	5.95 \pm 1.8	7.84 \pm 0.61	8 \pm 1.2
<i>Kholisha Fasciata</i>	9 \pm 1.07	11.68 \pm 3.52	9 \pm 1.07	11.68 \pm 3.52
<i>Anabus testedenus</i>	14.17 \pm 1.66	46.27 \pm 14.97	13.94 \pm 1.57	43.28 \pm 13.25
<i>Nandus nandus</i>	10.23 \pm 2.54	19.5 \pm 15.94	10.01 \pm 2.5	14.8 \pm 10.73
<i>Heteropeneusteus fossilis</i>	14.6 \pm 4.05	19.3 \pm 3.6	15.96 \pm 4.27	25.3 \pm 19.97
<i>Mystus vittatus</i>	8.37 \pm 1.44	5.78 \pm 2.59	8.4 \pm 1.39	5.57 \pm 2.42
<i>Wallago attu</i>	68.5 \pm 16.13	1770.67 \pm 1436.18	69.66 \pm 16.74	1802.5 \pm 1444
<i>Ompak pabda</i>	14.46 \pm 3.89	19.6 \pm 12.9	11.23 \pm 1.35	7.98 \pm 2.52
<i>Channa punctata</i>	16.67 \pm 4.24	57.14 \pm 37	16.51 \pm 4.17	56.3 \pm 37
<i>Channa straitus</i>	35.7 \pm 5.2	365 \pm 181	35.9 \pm 4.5	360 \pm 182
<i>Cirrhinus mrigala</i>	43.45 \pm 7.55	868 \pm 549	45.9 \pm 8.18	1050.46 \pm 663
<i>Labeo rui</i>	42.5 \pm 15.5	1098 \pm 1027	41.8 \pm 15.8	1087 \pm 1020
<i>Labeo kalbasu</i>	30 \pm 9.8	450 \pm 52.8	29.7 \pm 9.5	435 \pm 507
<i>Labeo gonia</i>	31.01 \pm 8.1	418 \pm 258	30.76 \pm 9.52	445.8 \pm 285
<i>Mystus ayr</i>	39.22 \pm 9.38	559 \pm 390	35.6 \pm 10.72	431 \pm 358

Gear study

Major gear used in those Beel: Various types of fishing gear/ trap is used in those study areas. Type of gear used depends upon fisherman desired output. Seine net, Cast net, Gill net and fish trap of different mesh size were operated daily.

Table 4. Location wise gear list

Sl. No.	Location		Net name and type
1	Dekhar Haor	Digdhar Beel	Ber jal (Seine net), Fash jal (Gill net), Current jal (Gill net), Jhaki jal (Cast net), Charu/Chai/Unta/Bosni/Paron (Fish trap), Veshal Jal, Thela Jal.
		Borobailla Beel	
		Mohasingh River	
2	Kawadeghi Haor	Alkhadobi Beel	Ber jal (Seine net), Pata jal (Gill net) Fash jal (Gill net), Current jal (Gill net), Jhaki jal (Cast net), Charu/Chai/Unta/Bosni/Paron (Fish trap), Veshal Jal, Thela Jal.
		Alkhadobi Gang	
		Matigura Beel	

Assessment of stock or biomass of commercially significant inland open water fishes as well as water bodies

Research achievement during monitoring period

Use of different fishing gears and traps can also serve as a rough indicator of the availability of different fish species. Some gear is species selective such as gill nets, traps, hook and lines and long line. We observed that gill net used widely during the sampling period in those study areas. CPUE of different type of fishing gear were presented in table 6 and 7.

Table 5. Monthly gearwise CPUE of Dekhar Haor, Sunamgong. [kg/Hour/100 m Net]

Gear types	Hour	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Seine net	2	14	16	20	15	18	12	20	17	13
Cast net	3	2	2	1.5	2	1	2	2	2	2
Push net	4	1.5	1.5	2	1.2	1	1	0.5	0.5	0.5
Ricksha net	4	2	2	2	2	2	2	4	4	
Fish trap	6	0.5	0.8	0.4	0.6	0.5	0.4	-	-	-
Veshal net	12	23	25	21	22	21		-	-	-
Gill/ Fash net	12	2	1.5	1.5	1.7	1	0.5	-	-	-

Table 6. Monthly gear-wise CPUE (kg/Hour/100m Net) of Kawadeghi Haor, Moulvibazar

Gear types	Hour	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Seine net	2	12	16	20	22	14	10	16	20	12
Cast net	3	2	2	1.5	2	1	2	2	1	2
Push net	4	1	2	2	1.6	1.3	1	0.5	0.5	0.5
Ricksha net	4	1.6	1.5	1	1.5	2	2	4	6	2
Fish trap	6	0.5	0.8	0.4	0.6	0.5	0.4	-	-	-
Veshal net	12	18	24	26	22	20		-	-	-
Gill/ Fash net	12	1	2	2.5	1.5	1	0.5	-	-	-

Impact of Lunar Periodicity, Saline Intrusion, Rainfall and Water Discharge on Hilsa Fisheries in a Changing Climate in Bangladesh

Researchers

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Objectives

- To determine the effects of lunar periodicity and tidal fluctuations on hilsa breeding and production
- To assess the extent and intensity of saline intrusion on hilsa navigation route in Bangladesh and its impact on hilsa abundance and distribution
- To determine the impacts of rainfall and water discharge on hilsa production
- To estimate the impact of physico-chemical parameters on hilsa production
- To update hilsa management interventions and policy guidelines

Achievements

In order to address the aforesaid objectives of the project, the data was collected from direct field observation, as well as some secondary data were accessed from some web sources that provide 24 hours real-time data on different meteorological factors. The data on tidal fluctuations (tidal co-efficient, tidal heights) was collected from “Tide Forecast.com” and Tides4Fishing” website. Lunar periodicity data were accessed from the “Phases of the Moon” app and classical “Time and Date.com”. The data on hilsa demographics (length, weight, percentage of male, female, spent and oozing hilsa) were collected from direct field investigations from the selected sampling locations (Figure 1).

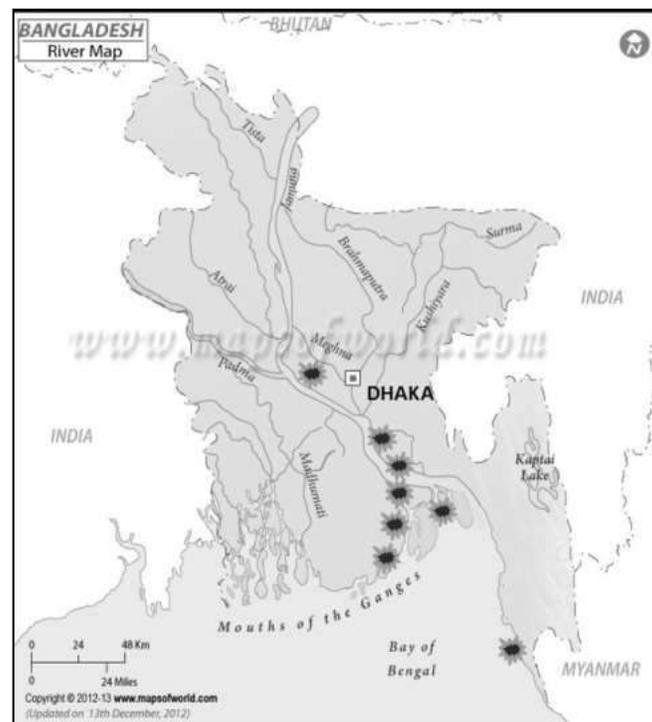


Figure 1. Sampling locations with asterisk mark on the map of Bangladesh

Average tidal co-efficient in different lunar phase

The tidal coefficients tell us the amplitude of the tide forecast (difference in height between the consecutive high tides and low tides in any given area). Average tidal co-efficient of Cox’s Bazar, Ramgoti, Barishal, Barguna (Pathatghata), Patuakhali (Mohipur) and Chandpur were calculated. The tidal co-efficient showed considerable variations in different lunar phases. The highest tidal co-efficient was observed during the new moon (NM) in Cox’s bazar, Barishal and Chandpur whereas the in Ramgoti the highest tidal co-efficient was found during the full moon (FM).

On the contrary, in Patuakhali and Barguna the highest tidal co-efficient was found during the third quarter (TQ) of the moon (Figure 2). The collected data on the tidal co-efficient is still inadequate, therefore; it’s difficult draw the firm line conclusion whether the tidal co-efficient is lunar phase dependent or place dependent. The relationship with average tidal co-efficient and lunar distance was also estimated based on the collected data and the results showed that the tidal co-efficient varies accordingly with the lunar distance.

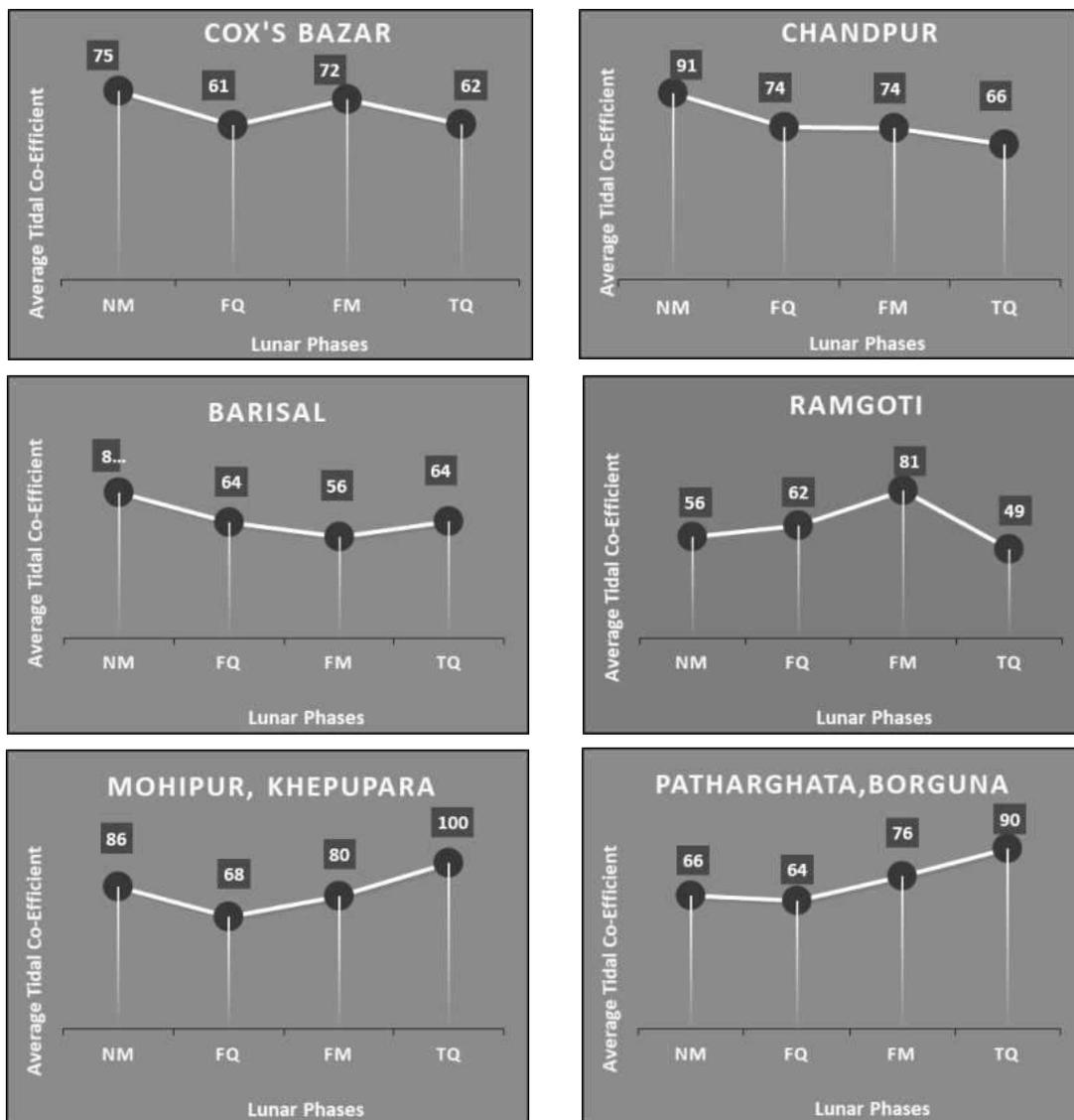


Figure 2. Average tidal co-efficient in different lunar phases

Total nos. of hilsa captured in different lunar phases also varied considerably. At Cox’s Bazar and Ramgoti, the highest total nos. of hilsa were captured during the FM and tidal co-efficient were also higher than other phases of moon. At Barishal and Chandpur, the highest nos. of hilsa were captured during the TQ of the moon whereas at Patharghata, Barguna and Mohipur, Patuakhali, the highest nos. of hilsa were captured during the FQ and NM, respectively. The results of the present study conducted till to date indicate that marine hilsa capture (Cox’s Bazar, Ramgoti and Patuakhali) is influenced by lunar distance viz. full and new moon (Figure 3). Albeit, tidal co-efficient is directly influenced by the lunar distance, still is difficult opine that it has specific and direct influence on the total nos. of hilsa captured, more data collection is required to reach in that conclusion.

Total nos. of hilsa in different lunar phases

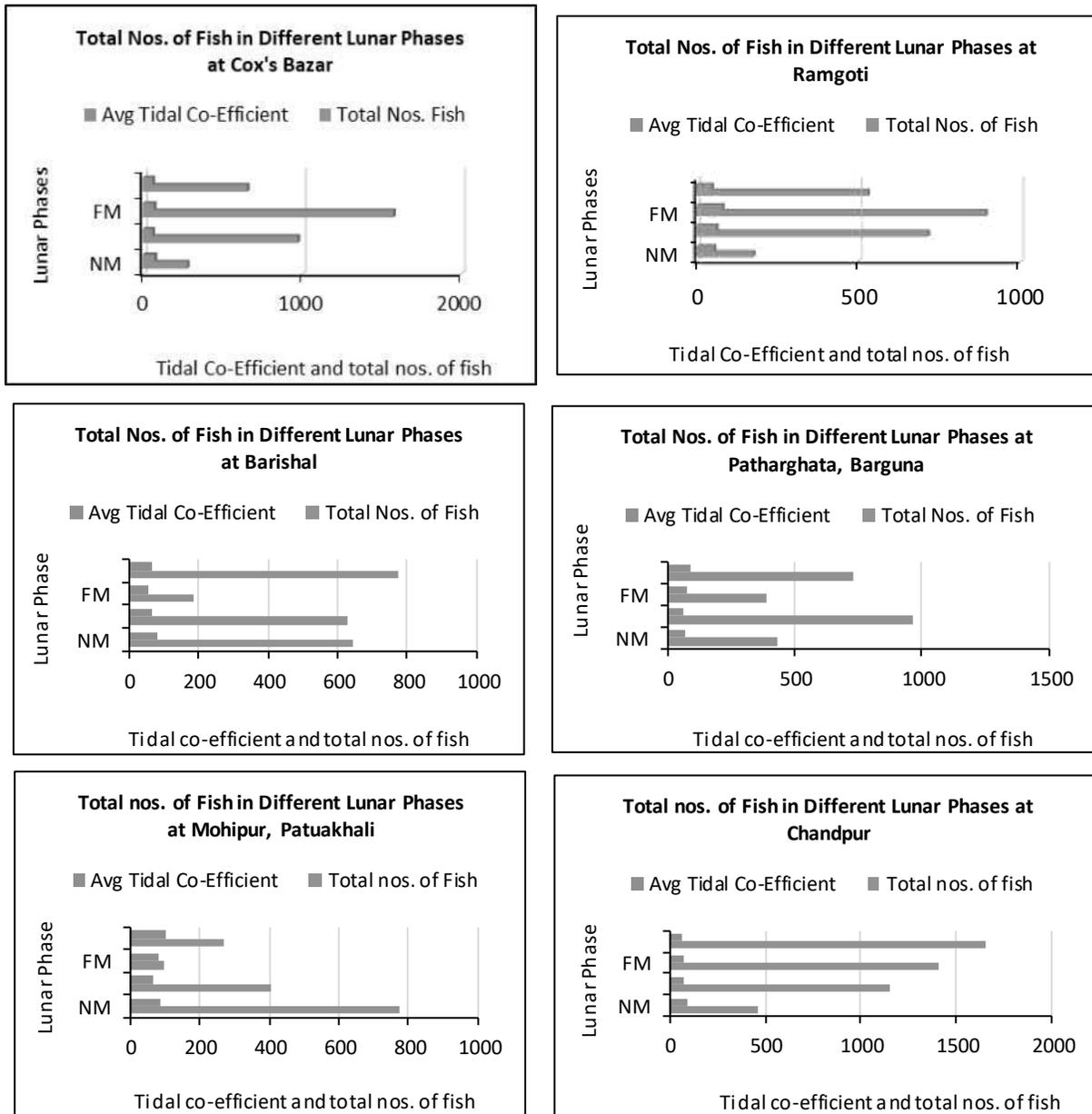


Figure 3. Total nos. of hilsa in different lunar quarters in relation to tidal co-efficient

Hilsa breeding performance in different lunar phases

The percentages of male, female, spent and oozing hilsa were calculated in the present study. The result demonstrated that highest percentages of male, female, spent and oozing hilsa were found during the NM followed by the other quarters.

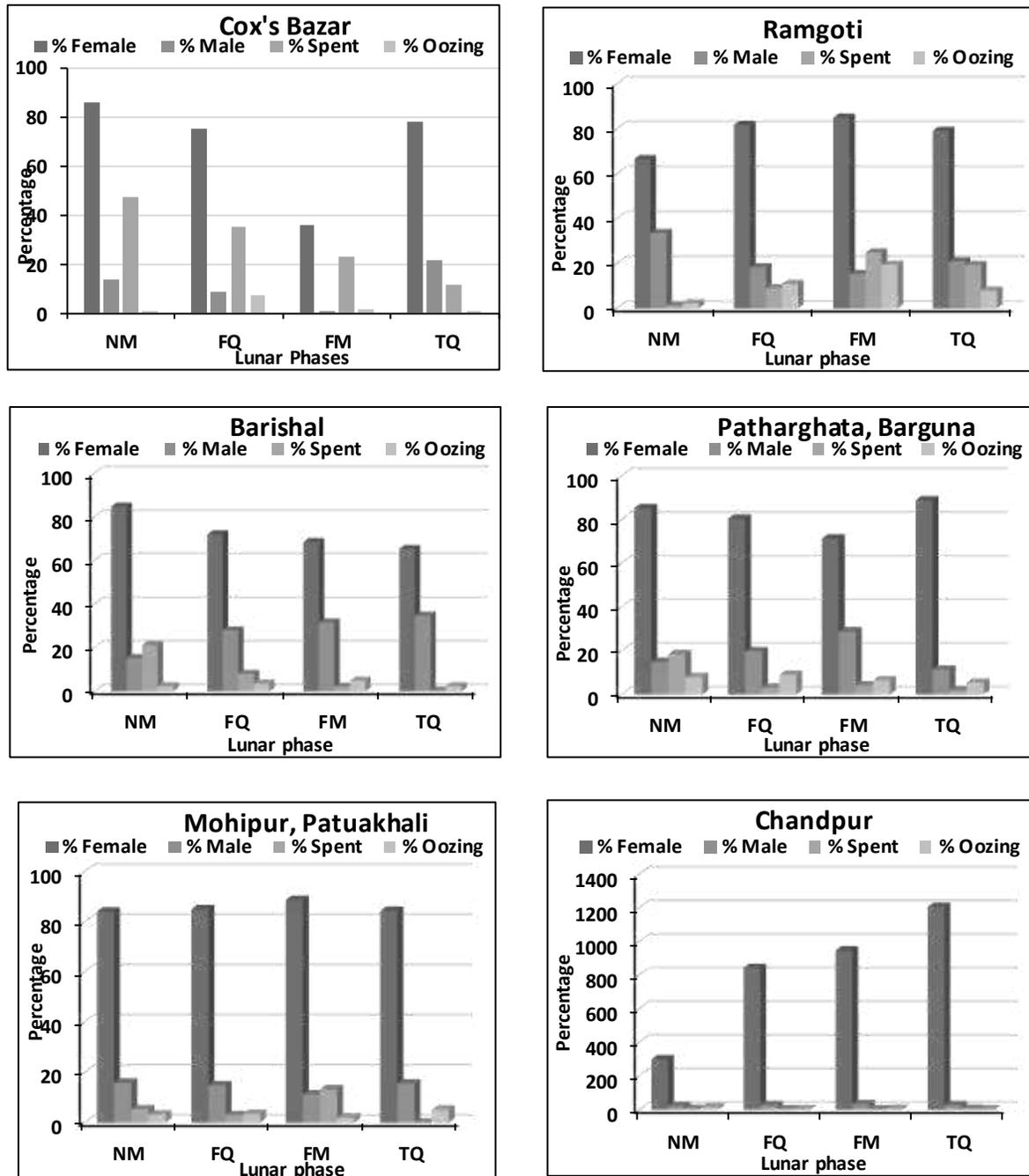


Figure 4. The percentages of male, female, spent and oozing hilsa during different lunar phases

The gonadosomatic index (GSI) of hilsa collected from all sampling locations in different lunar phases were also calculated and the mean value of GSI exhibited considerable fluctuations. The highest GSI value was found during the NM as well, indicating that hilsa prefers to breed during the NM rather than the other quarters (Figure 4 and 5).

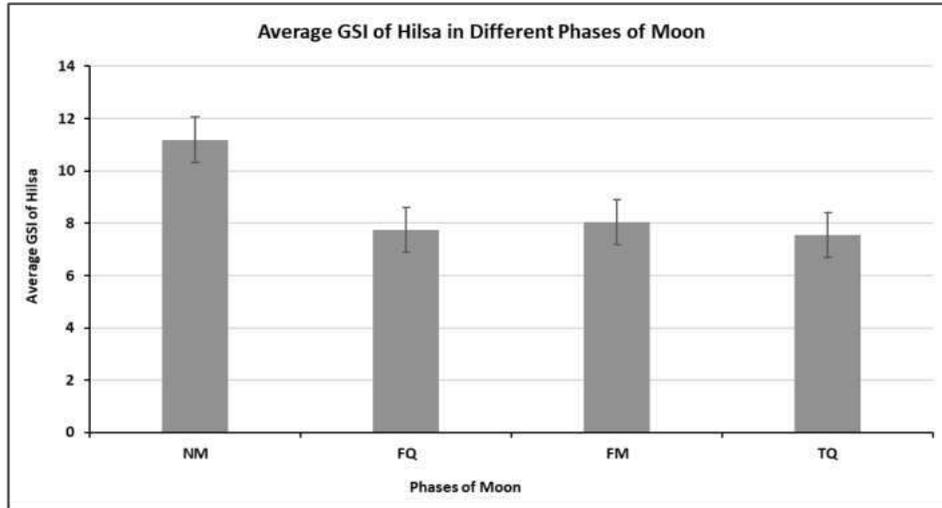


Figure 5. Gonadosomatic index of hilsa in different lunar phases

Oocyte Diameter

Annual increase in the oocyte diameter of *T.ilisha* was observed and compared with the GSI in Mohipur, Khepupara. Data of oocyte diameter showed significant correlation with GSI change, which suggest a synchronize development of gonads with the increasing size of eggs. Maximum oocyte diameter was in October ($0.591\pm 0.03\text{mm}$) whereas minimum oocyte diameter was found in April ($0.359\pm 0.029\text{mm}$) (Figure 6).

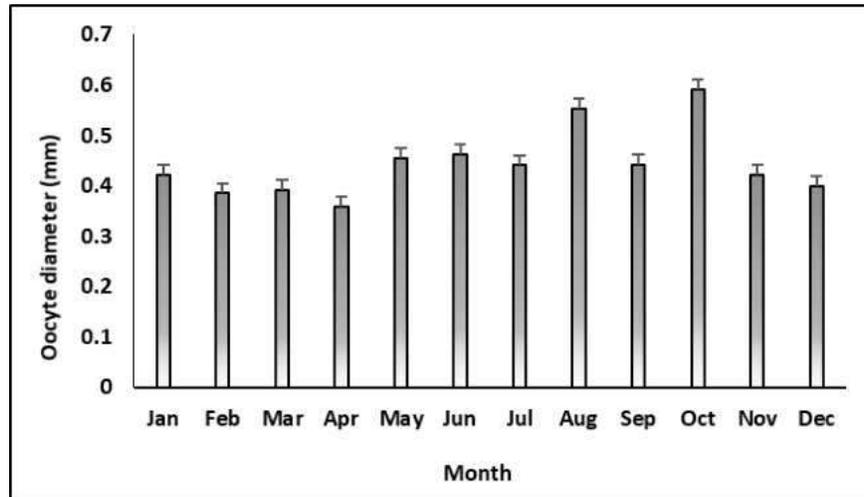


Figure 6. Oocyte diameter of *T.ilisha* collected from Mohipur, Khepupara in 2022

Annual Rainfall and Hilsa Production

Production and catchability of fish in many aquatic ecosystems varies considerably as a result of seasonal, annual, inter-annual and decadal variability in rainfall. The historical rainfall data (1991-2020) was

collected from the meteorological department and mean annual rainfall was calculated and correlated with year wise total hilsa production in Bangladesh (Figure 7). A regression model was constructed using mean annual rainfall and total hilsa production of the country (2010-2020) and the result showed weak linear association between these two variables (Figure 8). More data is required to reach in a conclusion in this regard.

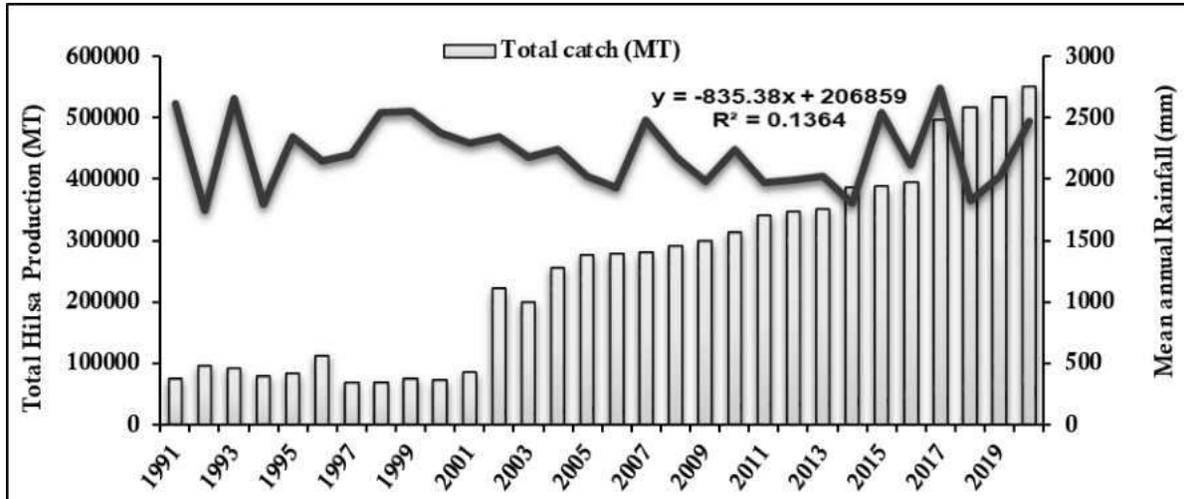


Figure 7. Mean annual rainfall and total hilsa production in Bangladesh (1991-2020)

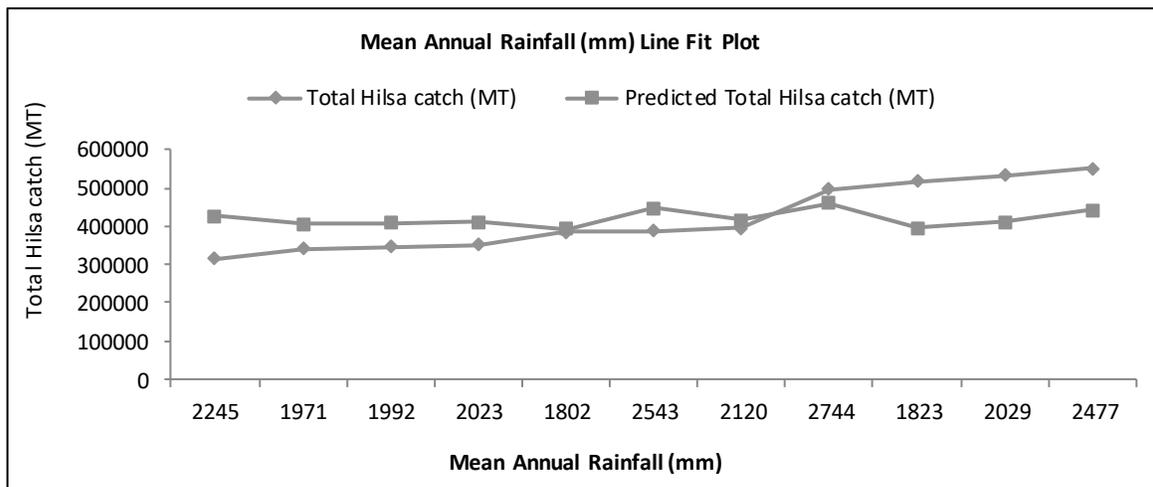


Figure 8. Linear regression model between mean annual rainfall and total hilsa production in Bangladesh (2010-2020)

Average Discharge and Hilsa Production

Discharge measurement has been conducted at Bhairab Bazar site of the Meghna by BWDB Surface Water Hydrological Circle (Figure: 9). Monthly maximum discharge of the Meghna at the Bhairab Bazar observatory came up to 14198.83 m³/s in July 2020 and 9560.00 m³/s in July 2021 respectively. While, there are no discharge during November to May in most of the years. This is due to combined results of scarce runoff and tidal effect. Annual Hilsa production of 2020 and 2021 in our sampling site were calculated and correlated with Average Discharge of the Meghna at Bhairab Bazar point of 2020 and 2021 (Figure: 10). The result showed considerable variations between these two variables. More data is required to reach in a conclusion.

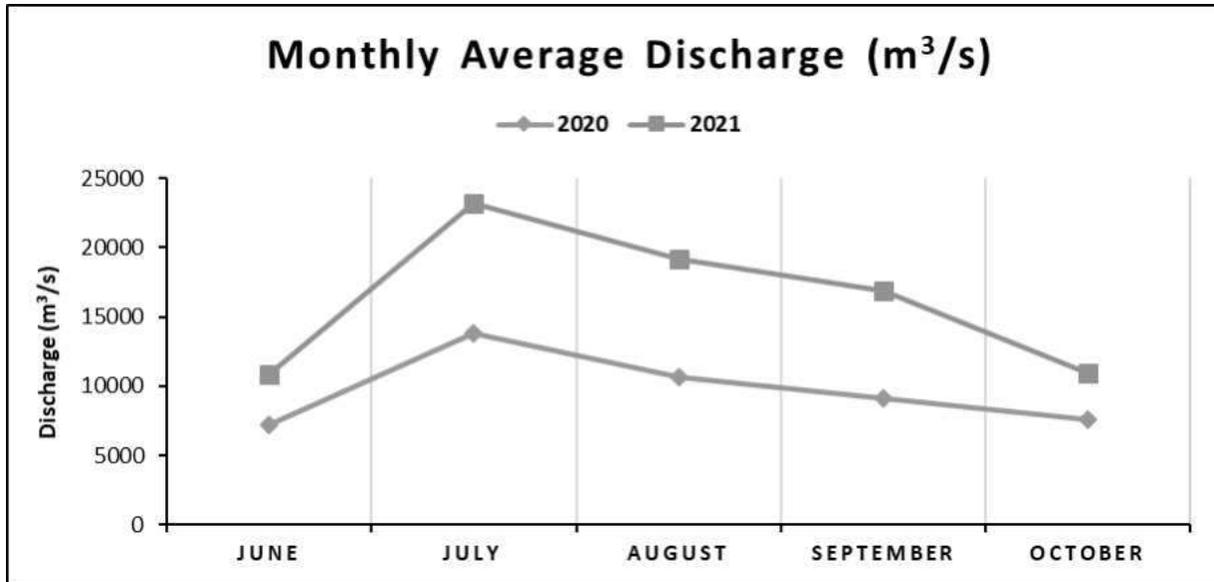


Figure 9. Monthly Average Discharge (m³/s) of the upper Meghna River.

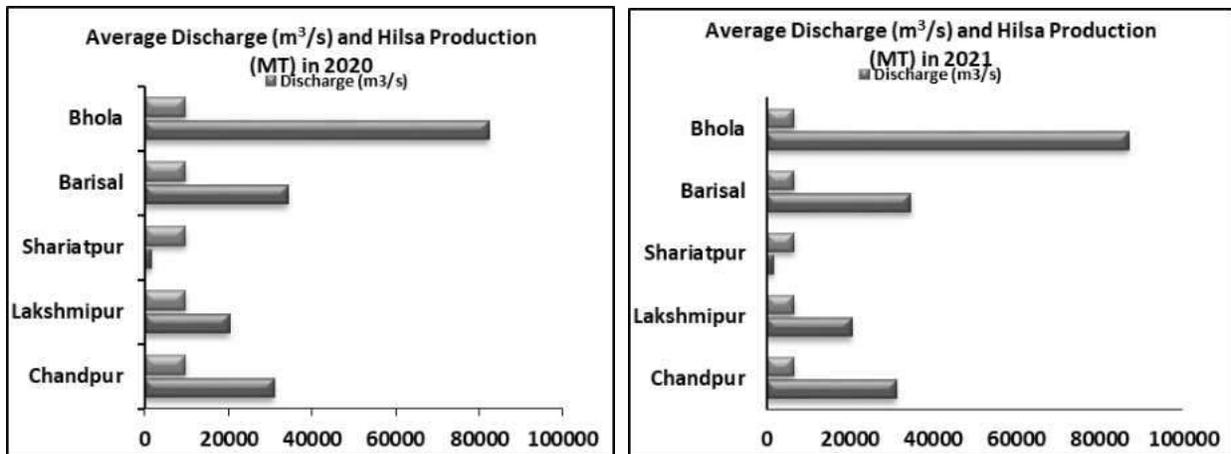


Figure 10. Hilsa production (MT) of different sampling site in relation to Monthly Average Discharge (m³/s) of the upper Meghna River in 2020 and 2021

Physico-chemical parameters of water in the sampling locations

Analyses of various physico-chemical factors of the water quality from different sampling points are presented in Figure 11. The ranges of all studied water quality parameters were found within the acceptable limits for the growth of fishes.

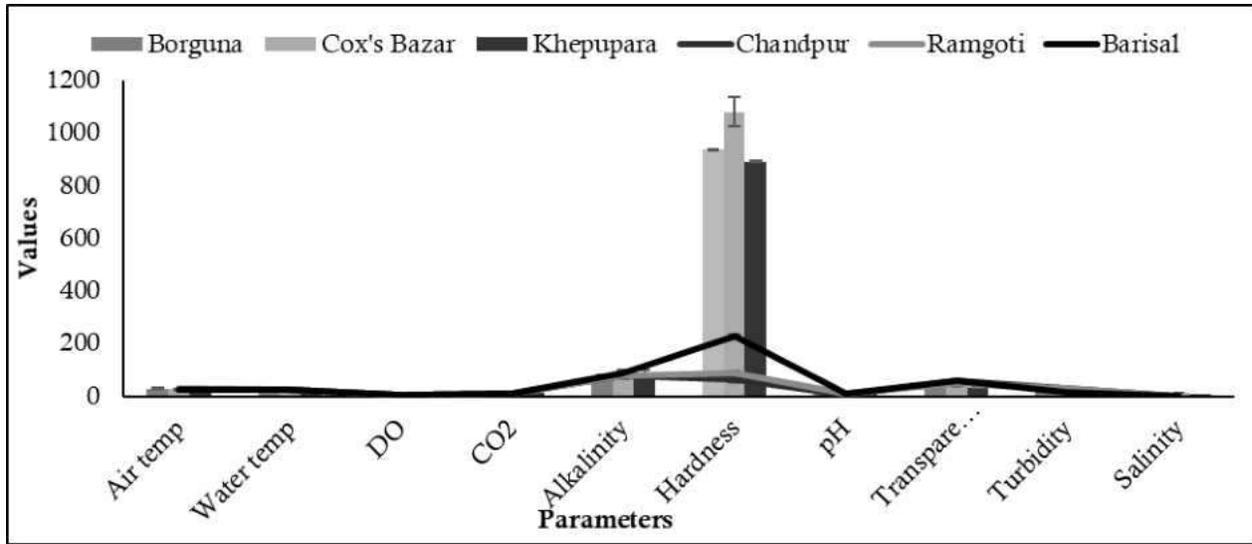


Figure 11. Physico-chemical parameters of the water quality from different sampling locations.

Parameters	Air temperature	Water temperature	DO	CO ₂	Alkalinity	Hardness	pH	Transparency
Standard Values	20-30 (EQS,1997)	20-30 (EQS,1997)	4-6 (EQS,1997)	6 ppm (EQS, 1997)	>100 (Rahman, 1992)	200-500 (DOE, 2003)	6.5-8.5(EQS, 1997)	40 or less (Rahman, 1992)

Estimation of nutrient flux and primary productivity in the major nursery grounds of hilsa

Researchers

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Objectives

- To assess the primary productivity of nursery grounds of hilsa
- To study the factors affecting primary productivity of nursery grounds of hilsa
- To assess the carrying capacity of nursery grounds of hilsa

Achievements

In order to address the aforesaid objectives of the project, monthly data from six sampling locations (Shatnol, Chandpur-Alexander, Laxmipur 100 km considered as station 1, Lower Meghna and Tarabunia, Shariotpur 20 km, Lower Padma considered as station 2, Hizla, Mehindigonj, Barishal (82 km) considered as station 3, Bheduria, Bhola, Char Rustom, Potuakhali (100 km, Tetulia River) considered as station 4, Char Ilisha-Char Pial, Bhola (90 km, Shahbazpur Channel considered as station 5, Kalapara Upazilla, Patuakhali (40km) considered as station 6) were collected and analyzed.

Primary productivity of nursery grounds of hilsa in the study areas

Using a water sampler, representative water samples were taken from the mid-euphotic level at the crack of dawn in order to ascertain the primary production. After that, duplicates of the light and dark bottles were hung in the water at the same depth and allowed to incubate for half of the day. Standard procedures were followed in the data analysis. The result showed that the average NPP was found higher at S1 (0.51 ± 0.01), S2, (0.43 ± 0.01) and S4, (0.35 ± 0.02) are shown in Figure 1, respectively compared to the other sampling sites. The average GPP was found higher at S1, (0.81 ± 0.28), S2, (0.65 ± 0.27) and S5, (0.61 ± 0.26) are shown in Figure 1, respectively compared to the other sampling sites. The average respiration was found higher at S1, (0.30 ± 0.10), S5, (0.21 ± 0.11) respectively compared to the other sampling sites (Figure 1). This result also establishes coherence between the higher abundance of jatka (CPUE) and average NPP and GPP at Confluence compared to other sampling sites (Figure 2).

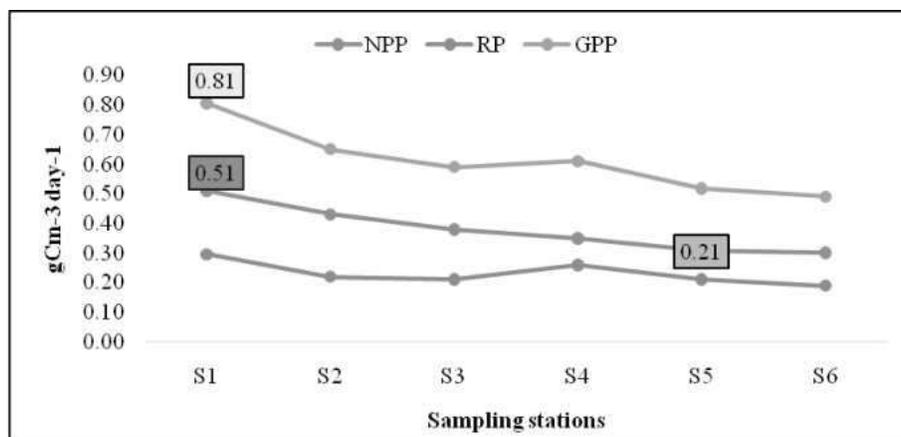


Figure 1. Net primary, Respiration and Gross primary productivity ($\text{gC/m}^3/\text{day}$) of sampling stations.

Fish larvae were sorted out from other zooplanktonic organisms using a dissecting microscope. Larvae of *T. ilisha* were differentiated from other zooplanktonic organisms collected based on common distinguishing characteristics of clupeiforms. For hilsa larvae collection, *Bongo net* was mainly used. *Bongo net* was set into the selected sampling locations for 30 minutes and all larvae were collected in plastic bottle and immediately preserved in ethanol (10%). Thereafter, the larvae of different fish species alongside with hilsa were identified with microscopic observation. The percentage of hilsa larvae was found higher at S5 (71 %) and S1 (70%) compared to other stations whereas the percentage of other larvae were higher in S6 (82 %) and S3 (65%) respectively (Figure 3).

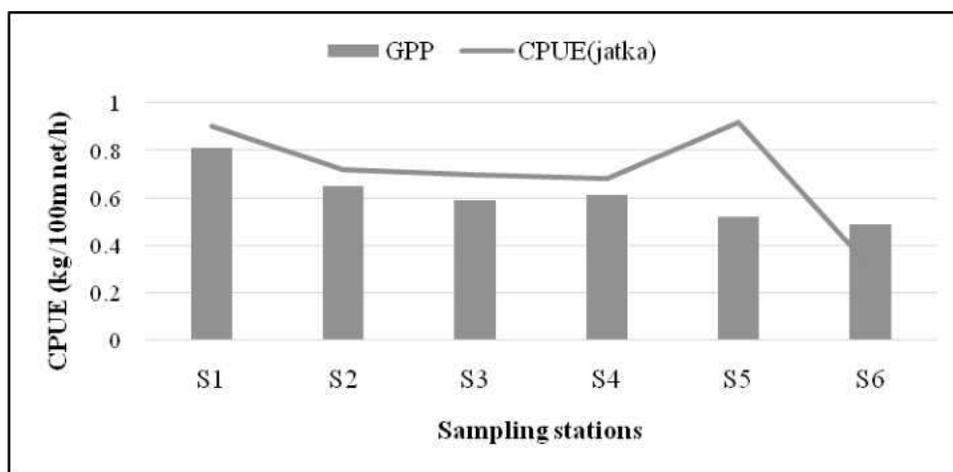


Figure 2. CPUE of jatka (kg/100 m net/h) at selected sampling stations.

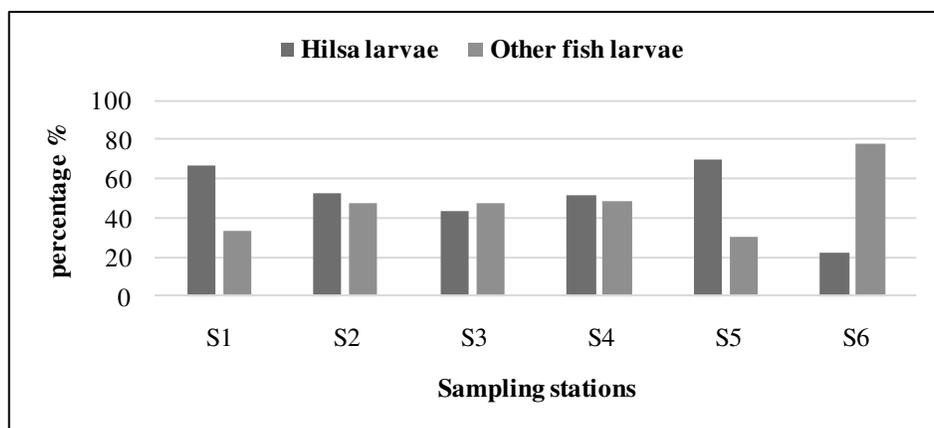


Figure 3. Abundance (%) of hilsa and other larvae at selected sampling Stations

Factors affecting the primary productivity

Physico-chemical parameters of water in the study areas

Water quality parameters of six stations exhibited considerable fluctuations. The maximum and minimum air temperature were found with mean value $29.4 \pm 1.3^\circ\text{C}$ and $26 \pm 0.7^\circ\text{C}$ at (St-3) and (St-4) respectively (Table 2) while the maximum and minimum water temperature were found mean value $26.8 \pm 0.5^\circ\text{C}$ and $24.9 \pm 0.8^\circ\text{C}$ at (St-3) and (St-4), respectively. The maximum and minimum values of water transparency were found 58.38 ± 8.2 cm and 32 ± 8.3 cm at St-1 and St-6, respectively. Average highest dissolved oxygen (mg/l) was found 7.2 ± 0.08 , 7.55 ± 0.47 , and 6.57 ± 0.42 respectively at (S2, S5 and S6). Average

CO₂ (mg/l) were in acceptable limits respectively. The maximum alkalinity was found 91±1.14 mg/l at S6 and hardness 220± 7.63 (mg/l) at S5 (Figure 4). The average pH was found just slightly above the neutral value in the studied sampling sites. In stations 1, 2 and 3 the ranges of all studied water quality parameters were found within the acceptable limits for the growth of fishes (Figure 4). In stations 4, 5 and 6 studied water quality parameters were slightly different but in acceptable limit (Figure 4).

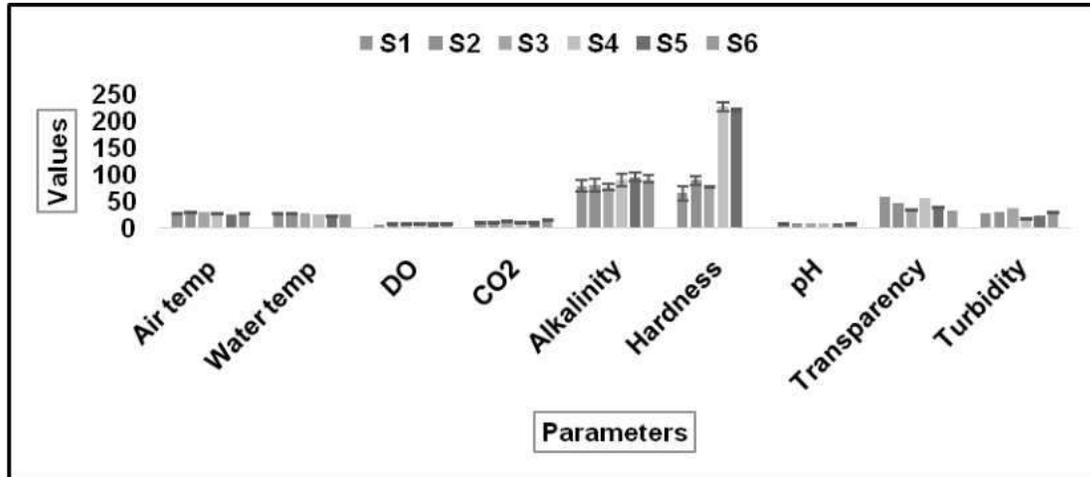


Figure 4. Water quality parameter of sampling stations

Water quality index (WQI) is a dimensionless number that combines multiple water quality parameters into a single number by normalizing values to subjective score (Miller et al., 1986). Conventionally it has been used for evaluating the quality of water for water resources such as rivers, streams, and lakes.

Parameter incorporated in WQI varies depending upon the designated water uses of the water body and local preferences. In the present study highest WQI values were found in S6 indicate moderately polluted water.

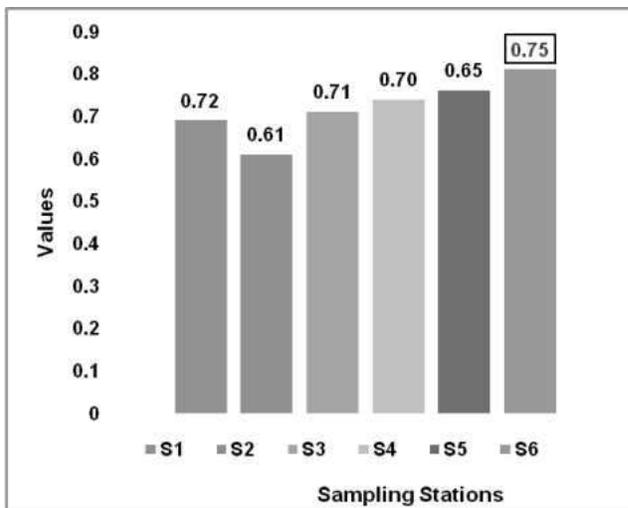


Figure 5. WQI at different stations

WQI Value	Category
<0.5	Excellent water
0.5-0.75	Good water
0.75-1	Moderately polluted water
>1	Highly polluted water

CA was carried out, using Bray Curtis Similarity, to show the similarity among the parameters. From the output of the cluster analysis, four clusters were found during different stations (Figure 6).

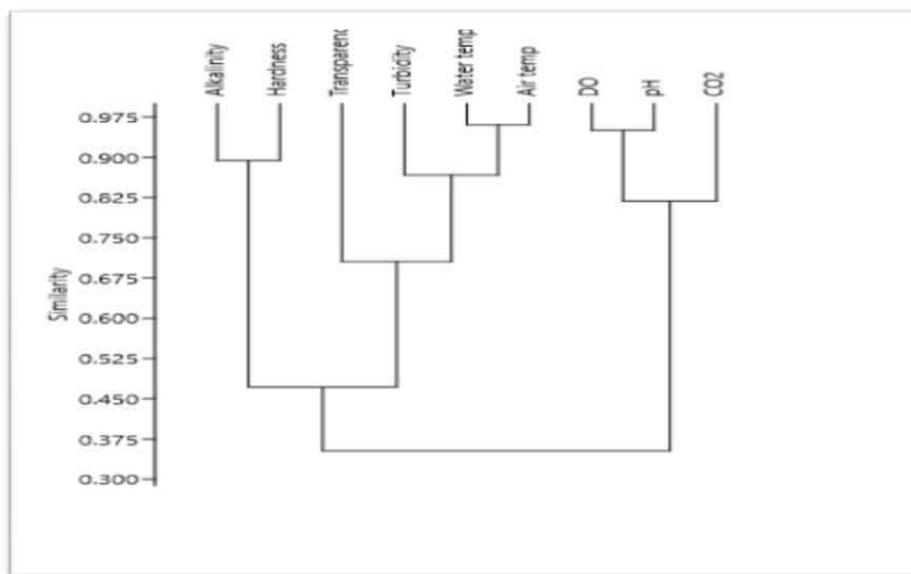


Figure 6. Dendrogram showing the percentage of similarity among water quality parameters

Nitrogen (N) and phosphorus (P) are primary nutrients and vital for life processes such as protein synthesis, cellular growth and reproduction. However, in inordinate quantities, the two elements are also a major source of stream and river impairment. Large inputs of these limiting nutrients can cause deleterious algal growth with a myriad of negative ecosystem responses including eutrophication.

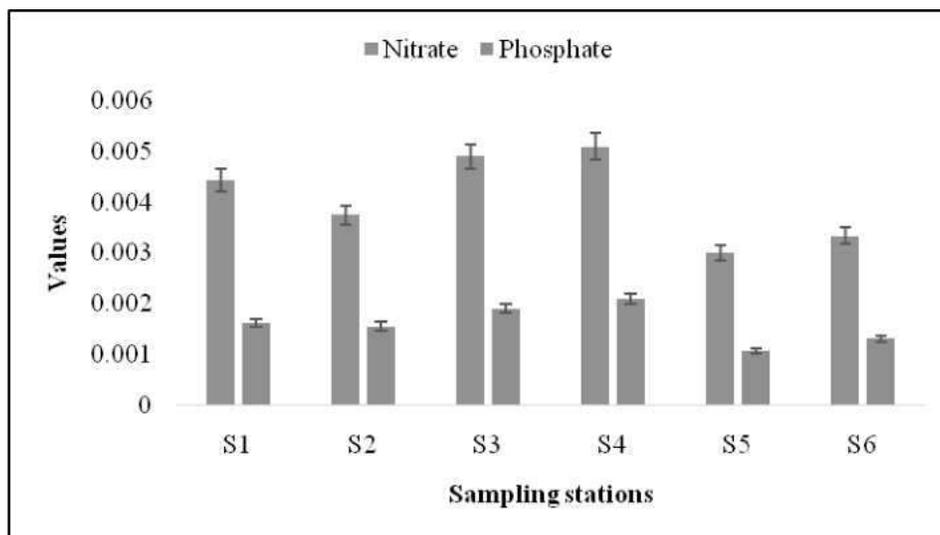


Figure 7. Concentrations of Nitrate (mg/l) and Phosphate (mg/l) in the selected sampling sites

Nitrate is important parameters of the water quality which trigger biological production in water bodies. Nitrate concentrations were found within the range 0.002 to 0.016 $\mu\text{g/L}$. The highest concentration ($0.0051 \pm 0.0037 \mu\text{g/L}$) was found at St-4 and the lowest ($0.0033 \pm 0.001 \mu\text{g/L}$) was found at St-6 (Figure 7).

Phosphate is a limiting factor in almost all water bodies because in water, it remains in a very small amount, in most cases less than 0.1 ppm. Almost all of the phosphorus present in water is in the form of phosphate (PO_4) and in surface water mainly present as bound to living or dead particulate matter and in

the soil is found as insoluble $\text{Ca}_3(\text{PO}_4)_2$. Phosphate concentration were found 0.001 to 0.008 $\mu\text{g/L}$ where the highest concentration ($0.0021 \pm 0.0025/\text{L}$) was found in St-4 and the lowest ($0.0015 \pm 0.0006\mu\text{g/L}$) in St-6 (Figure 7).

Concentration of nitrate 0.02-1.0 ppm is lethal to many fish species, > 1.0 ppm is lethal for many warm water fishes and < 0.02 ppm is acceptable (OATA, 2008). According to Stone and Thomforde (2004), the phosphate level of 0.06 mg/L -1 is desirable for fish culture. Bhatnagar *et al.* (2004), suggested 0.05-0.07 ppm is optimum and productive; 1.0 ppm is good for plankton and shrimp production. Thus, the nitrate and phosphate concentration in the present study was within the acceptable limit. The higher amount of contamination from fertilizers, municipal wastewaters, feedlots, septic systems in water increase the concentration of Nitrate, it refers that the higher (NO_2 and NO_3) the deviation the lower the quality of water for fish and other aquatic life and for common uses. The amount of nitrate could also be influenced by the growth of plankton.

The concentration of Chlorophyll a can act as an indicator of phytoplankton abundance in an aquatic ecosystem. One of the major objectives in analyzing photosynthetic pigments (Chlorophyll-a) in limnology is the estimation of phytoplankton biomass and its photosynthetic capacity. It is natural for levels of chlorophyll a to fluctuate over different seasons.

The concentration of Chlorophyll a can act as an indicator of phytoplankton abundance in an aquatic ecosystem. One of the major objectives in analyzing photosynthetic pigments (Chlorophyll a) in limnology is the estimation of phytoplankton biomass and its photosynthetic capacity. It is also reported in other research that chlorophyll a concentration remains high during low-water discharges (Devercelli and Peruchet, 2008). Chlorophyll-a concentrations ranged from 6.2 to 18 $\mu\text{g/L}$ where the highest concentration ($12.6 \pm 1.2 \mu\text{g/L}$) was found in St-6 and the lowest ($7.1 \pm 3.1 \mu\text{g/L}$) in St-1 (Figure 8). Chlorophyll-a value is an indicator of productivity in the water body, which shows an inverse relationship with water transparency.

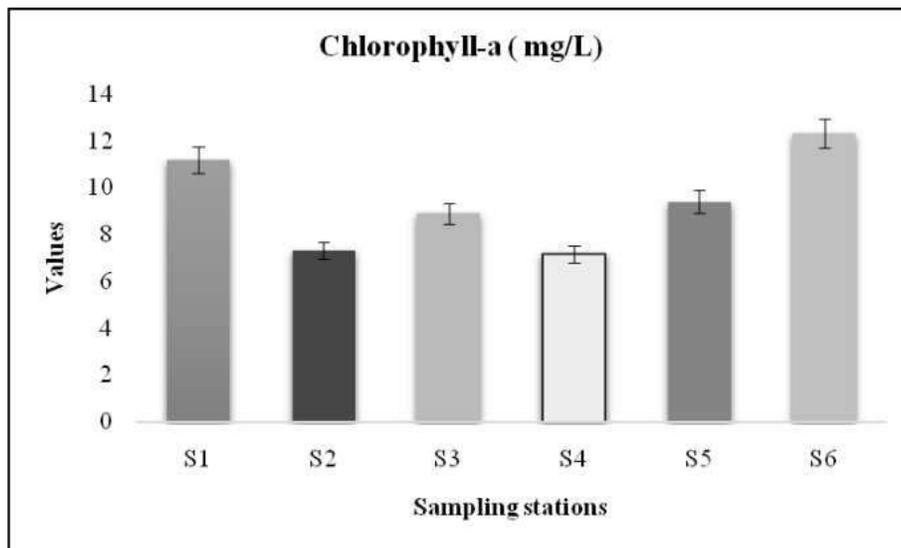


Figure 8. Concentrations of Chlorophyll-a (mg/L) in the selected sampling spots

Plankton abundance in the study areas

In station 1,20 taxa were identified in which 17 were phytoplankton and 3 were zooplankton. Phytoplankton belonged to the dominant groups *Zygnematophyceae* in all the sites in station 1 But in case of zooplankton the dominant groups was Nymphalidae (Figure 9)

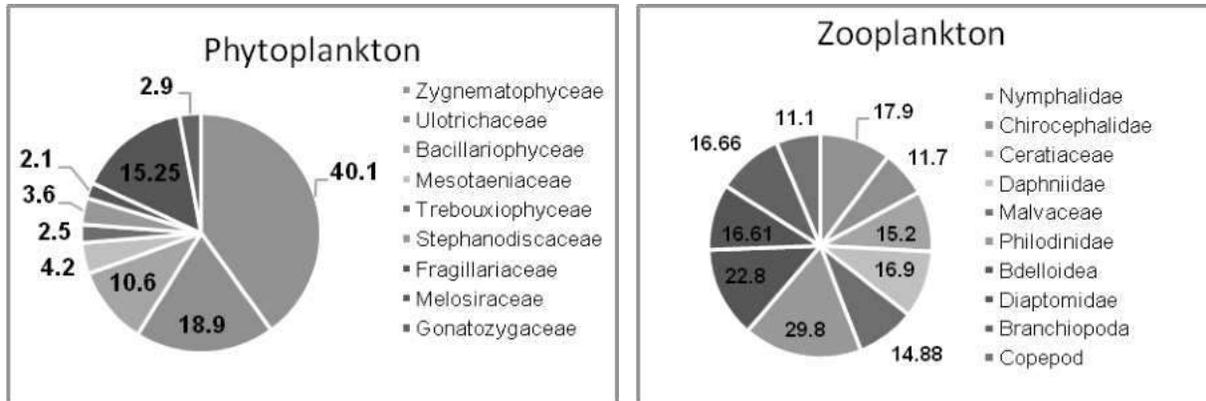


Figure 9. Phytoplankton and Zooplankton (%) of sampling station 1

In station 2, 14 taxa were identified among which 9 were phytoplankton and 5 were zooplankton. Phytoplankton belonged to the dominant groups *Zygnematophyceae* but in case of zooplankton the dominant groups was *Hexanauplia* (Figure 10).

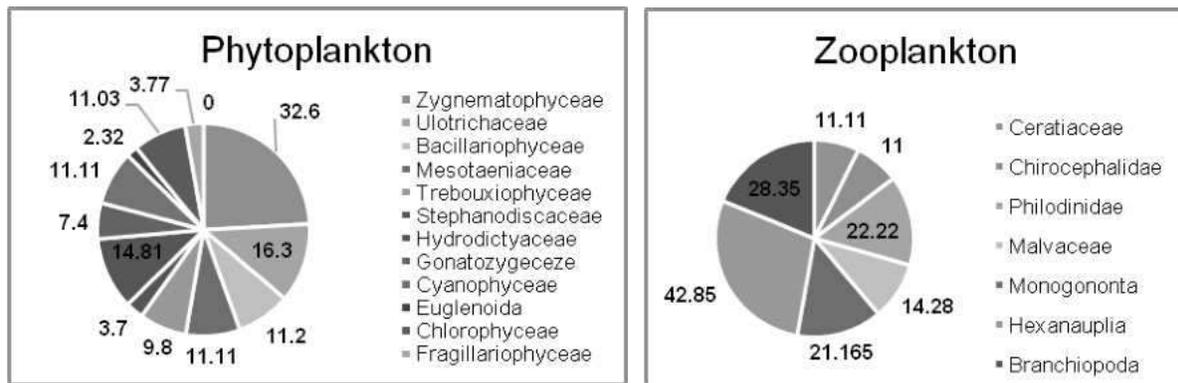


Figure 10. Phytoplankton and Zooplankton (%) of sampling station 2.

In station 3, 12 taxa were identified among which 7 were phytoplankton and 5 were zooplankton. Phytoplankton belonged to the dominant groups *Cholorophyceae* but in case of zooplankton the dominant groups was *Branchiopoda* (Figure 11).

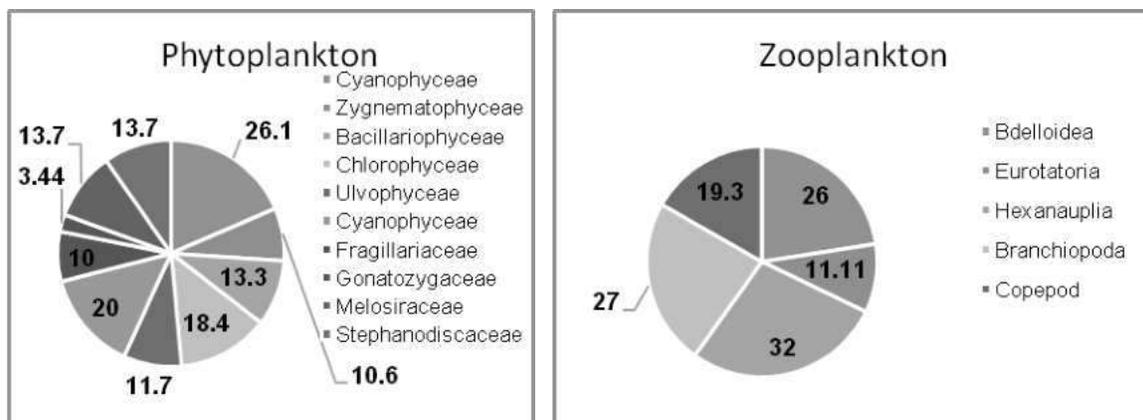


Figure 11. Phytoplankton and Zooplankton (%) of sampling station 3.

In station 4, 9 taxa were identified among which 6 were phytoplankton and 3 were zooplankton. Phytoplankton belonged to the dominant groups *Chlorophyceae* but in case of zooplankton the dominant groups was *Branchiopoda* (Figure 12)

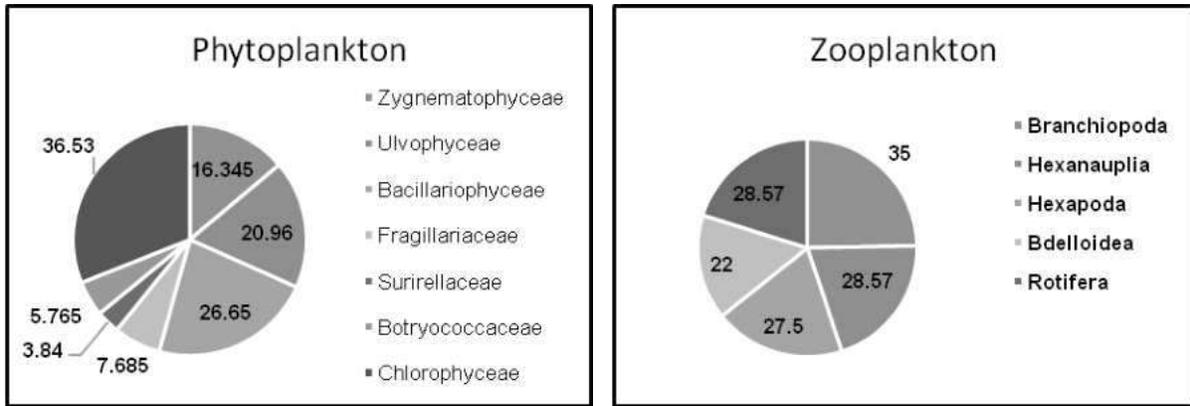


Figure 12. Phytoplankton and Zooplankton (%) of sampling station 4

In station5, 15 taxa were identified among which 9 were phytoplankton and 6 were zooplankton. Phytoplankton belonged to the dominant groups *Zygnematophyceae*, *Bacillariophyceae* and *Chlorophyceae* but in case of zooplankton the dominant groups were *Branchiopoda* and *Monogota* (Figure 13).

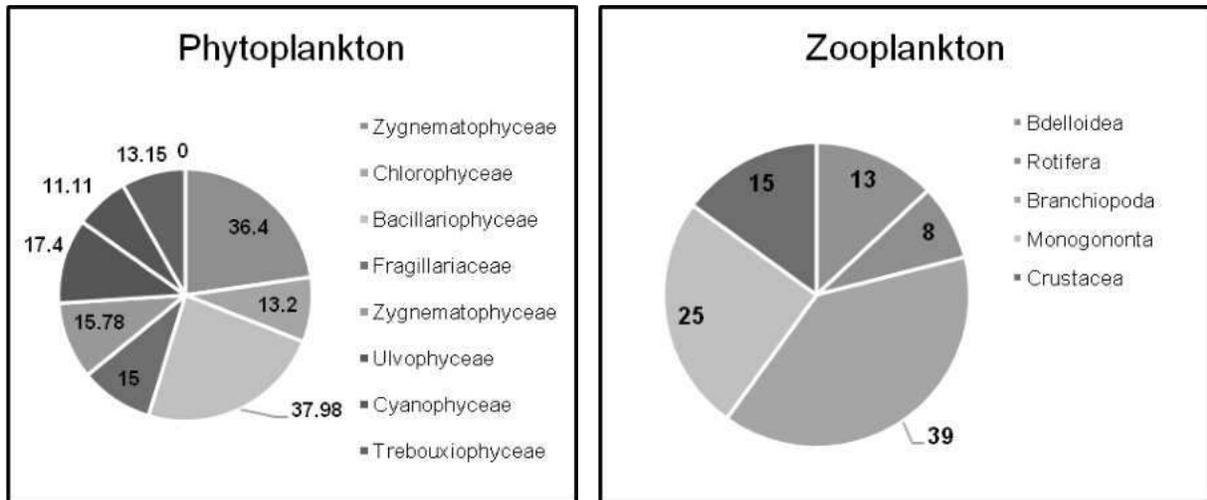


Figure 13. Phytoplankton and Zooplankton (%) of sampling Station 5

In station 6, 17 taxa were identified among which 10 were phytoplankton and 7 were zooplankton. Phytoplankton belonged to the dominant groups *Zygnematophyceae*, *Bacillariophyceae* and *Chlorophyceae* but in case of zooplankton the dominant groups were *Monogononta* and *Branchiopoda* (Figure 14).

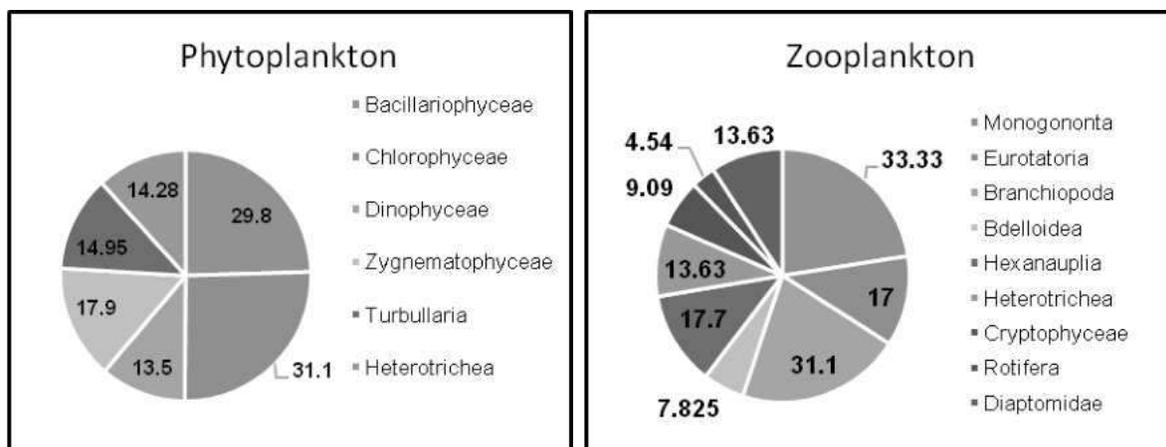


Figure 14. Phytoplankton and Zooplankton (%) of sampling Station 6

Table 1. Abundance of plankton at sampling stations

Sanctuary	Total Plankton	Phytoplankton	Zooplankton
Sanctuary 1	37×10 ²	34×10 ²	3×10 ²
Sanctuary 2	35×10 ²	33×10 ²	2×10 ²
Sanctuary 3	38×10 ²	32×10 ²	6×10 ²
Sanctuary 4	37×10 ²	33×10 ²	4×10 ²
Sanctuary 5	40×10 ²	37×10 ²	3×10 ²
Sanctuary 6	32×10 ²	23×10 ²	9×10 ²

Table 2. Class and Genus of Phytoplankton at sampling stations

Class	Genus
Chlorophyceae	<i>Pediastrum, Volvox, Scenedesmus, Acanthocystis</i>
Ulvophyceae	<i>Ulothrix</i>
Zygnematophyceae	<i>Spirogyra, Nitzschia, Netrium, Staurastrum, Gonatozygon</i>
Bacillariophyceae	<i>Navicula, Gomphonema, Asterionella, Diatoma, Frustulia, Stephanodiscus, Cyclotella</i>
Fragillariophyceae	<i>Tabellaria, Synedra</i>
Cyanophyceae	<i>Spirulina, Rivularia, Oscillatoria</i>
Trebouxiophyceae	<i>Protococcus, Botryococcus</i>
Dinophyceae	<i>Ceratium</i>
Euglenoida	<i>Euglena</i>

Table 3. Class and Genus of Zooplankton at sampling stations

Class	Genus
Branchiopoda	<i>Daphnia, Ceriodaphnia, Sida, Bosmina, Diaphanosoma, Leptodora, Eubranchipus</i>
Hexanauplia	<i>Cyclops</i>
Heterotrichea	<i>Spirostomum</i>
Diaptomidae	<i>Diaptomus</i>
Monogononta	<i>Filinia, Brachionus</i>
Bdelloida	<i>Nauplius, Rotaria</i>

Shannon-Wiener diversity index can be used as the pollution index in diatom communities. It is a commonly used diversity index that considers both abundance and evenness of species present in the community. Hendley (1977) put forward the following scale: of 0–1 for high pollution, of 1–3 for moderate pollution, and 3–4 for incipient pollution. In the present study, the highest Shannon-Wiener diversity index was found to be 3.143 at station 5 and a relatively low value (2.125) was observed at station 3 (Table 4 and fig.14). This means that station 5 has more abundance of plankton than the other stations. Balloch et al. found the Shannon Diversity Index to be a suitable indicator of water quality. Dash (1996) reported that the higher the Shannon-Wiener index (H') in Odisha lake, the greater the planktonic diversity. Simpson diversity index varied from 0.872 (station 2) to 1.012 (station 5) during the present study (Table 4 and fig. 15). This indicates that the values are approaching 1, signifying that sites have high relative diversity due to their supporting surrounding components.

Table 4. Plankton diversity index of six sampling stations

Station	S1	S2	S3	S4	S5	S6
Shannon (H)	2.94	2.81	2.84	2.92	3.14	2.12
Simpson (1/D)	0.89	0.87	0.92	0.95	1.01	0.93
Margalef	2.42	2.39	2.31	2.27	2.51	1.78
Evenness	0.44	0.42	0.45	0.46	0.76	0.40

According to Ali et al. (2003), the values of Margalef's index ranging between 1 and 3 indicate moderately polluted water with values less than 1 indicating the heavily polluted environment, while values greater than 3 windows clean water. The Margalef diversity index values varied from 1.786 to 2.512, during the present study (Table 5 and fig. 14) which indicates that the system is threatened by pollution, which may be as a result of anthropogenic activities going on within the area. Pielou's evenness index refers to how close in number each species in an environment is. In the present study, the Pielou's evenness index was found to range from 0.401 to 0.765 (Table 4 and fig. 14); if the evenness index is high (approaching 1), there is no species dominance and vice versa. Pirzan et al. (2008) opined that if the evenness index approaches zero, the species evenness in the community was low, and inversely if the evenness index approaches 1 the species in the community is the same.

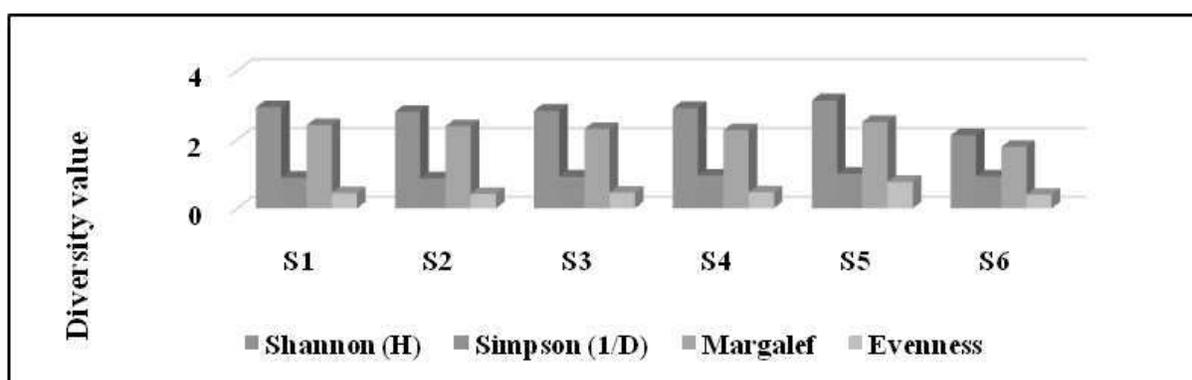


Figure 15. Diversity indices of plankton in the selected sampling stations

In the study period, this result also establishes coherence between the higher abundance of jatka and plankton density at S1 and S5 (Figure 16) compared to other sampling stations.

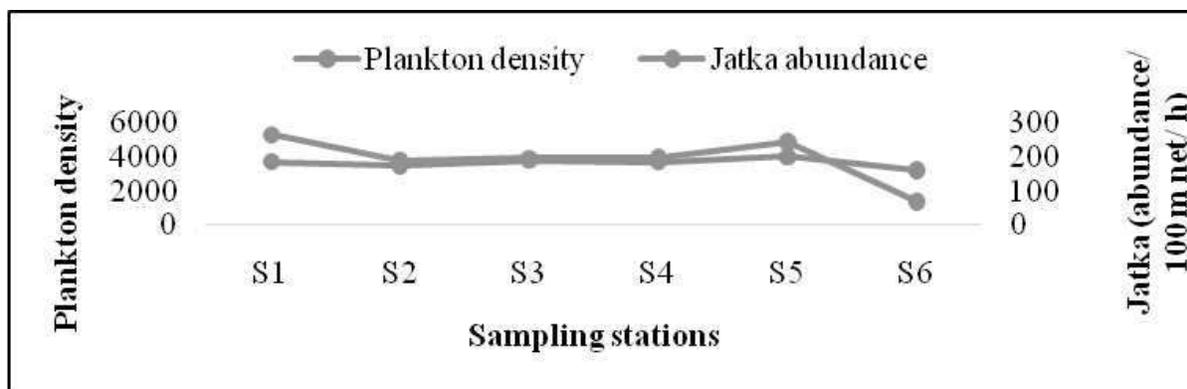


Figure 16. Relation between jatka abundance and plankton density at sampling stations

Table 5. Association between Primary productivity and Nutrient flux

	GPP vs. CPUE	GPP vs. Chlorophyll-a	GPP vs. Nitrate	GPP vs. Phosphate
95% confidence interval	0.059 to 0.981	0.451 to 0.991	0.178 to 0.985	0.101 to 0.982
R squared	0.690	0.854	0.747	0.7118
P (two-tailed)	0.040	0.008	0.026	0.034
P value summary	*	*	*	*
Significant? (alpha = 0.05)	Yes	Yes	Yes	Yes

In all four cases, the p-values are below the significance level (alpha = 0.05), indicating that there is a statistically significant relationship between GPP and the respective nutrient flux parameters (CPUE, Chlorophyll-a, Nitrate, and Phosphate). The R-squared values suggest that a substantial proportion of the variability in GPP can be explained by each of these nutrient flux parameters.

Assessment of Effectiveness of Existing Hilsa Sanctuaries for Sustainable Production in Bangladesh

Researchers

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Objectives

- To reassess the previously identified spawning and nursery grounds of Hilsa.
- To identify new spawning and nursery grounds of Hilsa.

Achievements

Study-1: Reassess the previously identified spawning and nursery grounds

The spawning and nursery ground of lower Meghna estuary (from Char Ilisha to Char Pial of Shahbazpur Channel, 90 km) was selected for this study.

Physico-chemical parameters

Mean values and ranges of Physico-chemical parameters over the study period from July 2022 to June 2023 are presented in Table 1. Physico-chemical parameters such as air and water temperature (°C), transparency (cm), DO (mg/l), CO₂ (mg/l), pH, total hardness (mg/l), and total alkalinity (mg/l) were determined. The air and water temperature of the study areas were found to vary from 22 to 31°C and 21 to 30°C, respectively. Dissolved oxygen and free CO₂ ranged between 5 and 7 mg/l and 7.2 and 13 mg/l, respectively. pH, transparency and salinity varied from 7.5 to 8, 8.1 to 29 cm and 1 to 10 ppt, respectively. Saline water intrusion was observed in Shahbazpur Channel from December to March 2022-2023 within the average ranges of 0.3-1.62 ppt. Alkalinity and hardness ranged from 54 to 99 mg/l and 62 to 270 mg/l during the study period. The results of the Physico-chemical parameters indicated that the water quality parameters were within suitable ranges for fishes in study areas.

Table 1. Physico-chemical parameters (average±sd) during July 2022 to June 2023 of Shahbazpur Channel, Meghna river

Parameters	Shahbazpur Channel	Standard value
Air temperature (°C)	28.06 ± 2.10 (22-31)	20-30 (EQS,1997)
Water temperature (°C)	26.41 ± 2.19 (21-30)	20-30 (EQS,1997)
DO (mg/l)	6.13 ± 0.52 (5-7)	4-6 (EQS,1997)
CO ₂ (mg/l)	10.225 ± 1.98 (7.2-13)	6 ppm or less (EQS,1997)
pH	7.63 ± 0.15 (7.5-8)	6.5-8.5 (EQS,1997)
Transparency (cm)	16.55 ± 7.93 (8.1-29)	40 or less(Rahman,1992)
Salinity (ppt)	3.75 ± 4.19 (1-10)	0-10 (Rahman,1992)
Total Alkalinity (mg/l)	71.33 ± 15.96 (54-99)	>100 (Rahman,1992)
Total Hardness (mg/l)	97.58 ± 53.90 (62-270)	40-400 ppm (Boyd,1998)

Plankton identification

Qualitative and quantitative analysis of planktons were done following the drop count method (APHA 1995). Plankton identification was made following Ward and Whipple (1959) and Prescott (1962). Ten plankton groups were identified in the qualitative study of plankton, among them seven were phytoplankton and three were zooplankton groups (Table -2). Among the seven phytoplankton groups, 22 genera were identified. Bacillariophyceae, Zygnematophyceae and Chlorophyceae were the most dominant groups. But in the case of three zooplankton groups, almost six different genera were observed having the same proportion.

Table 2. Identified Plankton groups during July 2022 to June 2023 available in Shahbazpur Channel, Meghna river

Group	Genus	Genus No.
Chlorophyceae	<i>Pediastrum, Volvox, Scenedesmus, Acanthocystis, Microspora</i>	05
Ulvophyceae	<i>Ulothrix</i>	01
Zygnematophyceae	<i>Spirogyra, Nitzschia, Netricum, Staurastrum, Gonatozygon</i>	05
Bacillariophyceae	<i>Navicula, Gomphonema, Asterionella, Diatoma, Frustulia, Stephanodiscus, Cyclotella</i>	07
Cyanophyceae	<i>Spirulina, Rivularia, Oscillatoria</i>	03
Dinophyceae	<i>Ceratium</i>	01
Euglenophyceae	<i>Euglena</i>	01
Copepoda	<i>Cyclops, Nauplius</i>	02
Rotifera	<i>Brachionus, Keratella</i>	02
Cladocera	<i>Daphnia, Bosmina</i>	02

The quantitative study of phytoplankton observed a higher amount on the lower side of the Meghna river than on the upper side (Table 3)

Table 3. Quantitative assessment of plankton (average) during July 2022 to June 2023 in Shahbazpur Channel, Meghna river

Sampling sites	Total Plankton (cells/L)	Total Phytoplankton (cells/L)	Total Zooplankton (cells/L)	Phytoplankton (%)	Zooplankton (%)
Char Ilisha	$32 \pm 5 \times 10^2$	$25 \pm 2.4 \times 10^2$	$7 \pm 2.6 \times 10^2$	78.12	21.88
Daulotkhan	$34 \pm 6 \times 10^2$	$27 \pm 3.5 \times 10^2$	$7 \pm 2.5 \times 10^2$	79.41	20.59
Tajumuddin	$35 \pm 5 \times 10^2$	$26 \pm 2.7 \times 10^2$	$9 \pm 2.3 \times 10^2$	74.28	25.72
Char Pial	$38 \pm 8 \times 10^2$	$30 \pm 5.1 \times 10^2$	$8 \pm 2.9 \times 10^2$	78.94	21.06

Spawning Success

In 2022, the spawning success was recorded during and after the 22 days banning period (07-28 October 2022). The average spawning success was 85.21 % across the Shahbazpur Channel.

Spent rate of Hilsa

In 2022, the spent rate of hilsa was recorded during and after the 22 days banning period (07-28 October 2022). The average spent rate of hilsa was 54.62 % across the Shahbazpur Channel.

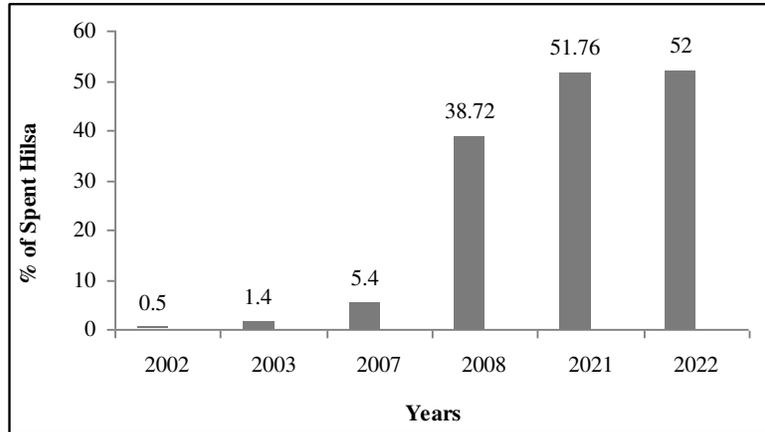


Figure 1. Spent rate (%) of Hilsa in Meghna river

CPUE of Hilsa at Shahbazpur Channel

Catch per unit effort (CPUE) of Hilsa was observed in higher amounts (4 -11 kg/100m net/hour/boat) in September and October, 2022 at Shahbazpur Channel in the lower Meghna river.

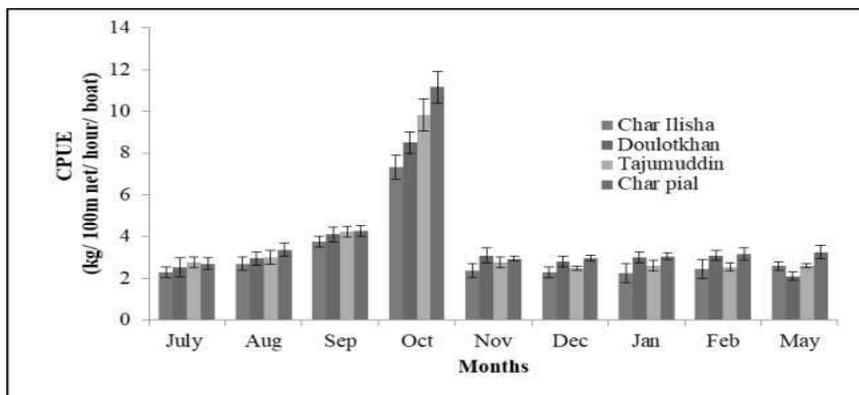


Figure 2. CPUE of Hilsa in Shahbazpur Channel in 2022

Abundance of Jatka in Meghna river

The average CPUE of Jatka in the Meghna river was observed in a higher amount in Doulatlkhan (20.5 kg/100 m net/hour/boat) and Char Pial (15 kg/100 m net/ hour/ boat) region.

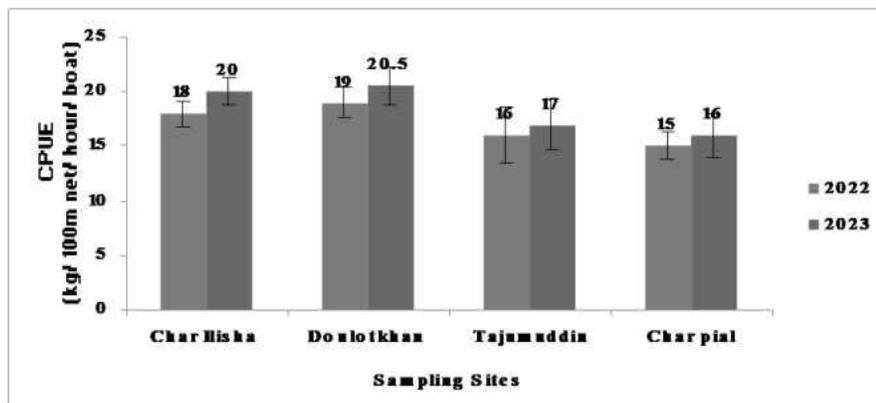


Figure 3. CPUE of Jatka in Meghna river

Study-2: Identification of New Spawning and Nursery grounds of Hilsa

Sampling was conducted from Noria (Sureswar) to Maowa Ghat (25 km) of the Padma river for the extension of 5th Hilsa sanctuary.

Physico-chemical parameters

Mean values and ranges of Physico-chemical parameters over the study period during July 2022 to June 2023 are presented in Table 4. Physico-chemical parameters such as air and water temperature (°C), transparency (cm.), DO (mg/l), CO₂ (mg/l), pH, total hardness (mg/l), and total alkalinity (mg/l) were determined. The air and water temperature (°C) of the study areas were found to vary from 24 to 32°C and 23 to 31°C, respectively. Dissolved oxygen and free CO₂ ranged between 4.5 and 8 mg/l and 7 and 11.8 mg/l, respectively. The study areas pH, transparency and salinity varied from 7.5 to 8.5, 16.5 to 33cm and 0 ppt, respectively. Salinity intrusion was not observed in the Padma River during the study period. Alkalinity and hardness ranged from 49 to 121 mg/l and 60 to 129 mg/l during the study period. The analytical results of the Physico-chemical parameters indicated that the parameters were within suitable ranges for fishes in the study areas.

Table 4. Physico-chemical parameters (Average±sd) of Padma river (Mawa Ghat and Sureswar)

Parameters	Padma river	Standard value
Air temperature (°C)	29 ± 2 (24-32)	20-30 (EQS,1997)
Water temperature (°C)	227.17 ± 1.94 (23-31)	20-30 (EQS,1997)
DO (mg/l)	5.73 ± 0.84 (4.5-8)	4-6 (EQS,1997)
CO ₂ (mg/l)	9.74 ± 1.45 (7-11.8)	6 ppm or less (EQS,1997)
pH	8.11 ± 0.31 (7.5-8.5)	6.5-8.5 (EQS,1997)
Transparency (cm)	27.94± 3.76 (16.5-33)	40 or less (Rahman,1992)
Alkalinity (mg/l)	65.67± 18.66 (49-121)	>100 (Rahman,1992)
Hardness (mg/l)	79.88 ±16.53 (60-129)	40-400 ppm (Boyd,1998)
Salinity (ppt)	0	0-10 (Rahman,1992)

Plankton identification

Following the drop count method, qualitative and quantitative planktons were analysed (APHA 1995). Plankton identification was made following Ward and Whipple (1959) and Prescott (1962). In the qualitative study among nine plankton groups six phytoplankton and three zooplankton groups (Table 5) were identified. Among the six phytoplankton groups, 21 genera were identified where Bacillariophyceae, Zygnematophyceae and Chlorophyceae were the most dominant groups. But in the case of zooplankton groups, five different genera were observed where Cladocera was the dominant group.

Table 5. Identified Plankton groups of Noria (Sureswar) and Mawa Ghat, Padma river

Group	Genus	Genus No.
Chlorophyceae	<i>Pediastrum, Volvox, Scenedesmus, Acanthocystis</i>	04
Ulvophyceae	<i>Ulothrix</i>	01
Zygnematophyceae	<i>Spirogyra, Nitzschia, Natrium, Staurostrum, Gonatozygon</i>	05
Bacillariophyceae	<i>Navicula, Gomphonema, Asterionella, Diatoma, Frustulia, Stephanodiscus, Cyclotella</i>	07
Cyanophyceae	<i>Spirulina, Rivularia, Oscillatoria</i>	03
Dinophyceae	<i>Ceratium</i>	01
Copepoda	<i>Nauplius</i>	01
Rotifera	<i>Keratella, Brachionus</i>	02
Cladocera	<i>Bosmina, Moina</i>	02

The quantitative study of plankton observed a higher amount in Noria (38×10^2 cells/ l) of Padma river than in Mawa ghat (32×10^2 cells/ l) (Table 6).

Table 6. Quantitative assessment of plankton (Average \pm sd) in the Padma river

Sampling sites	Total Plankton (cells/l)	Total Phytoplankton (cells/l)	Total Zooplankton (cells/l)	Phytoplankton (%)	Zooplankton (%)
Noria	$38 \pm 8 \times 10^2$	$30 \pm 5.1 \times 10^2$	$8 \pm 2.9 \times 10^2$	78.94	21.06
Lauhajang	$36 \pm 5 \times 10^2$	$27 \pm 2.6 \times 10^2$	$9 \pm 2.4 \times 10^2$	75	25
Mawa	$32 \pm 8 \times 10^2$	$25 \pm 4.1 \times 10^2$	$7 \pm 2.9 \times 10^2$	78.12	21.88

CPUE of Jatka in the Padma river

The average CPUE of Jatka in the Padma River was recorded at 4.75 Kg/ 100 m net/ hour/ boat, which is slightly more than the previous years.

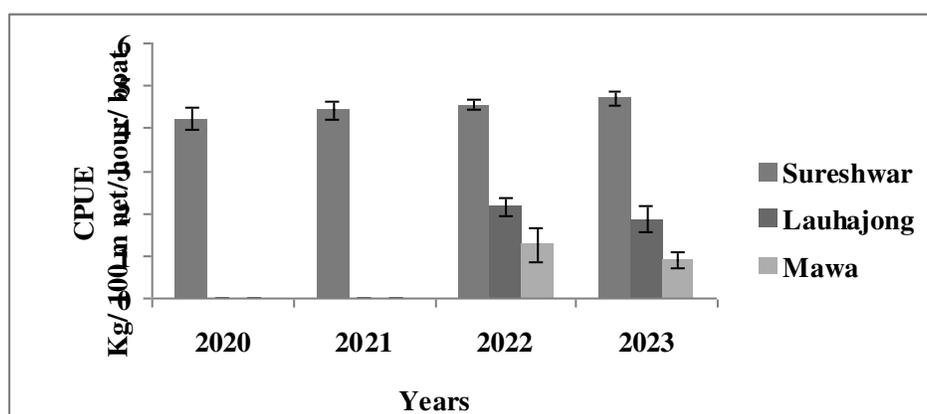


Figure 4: CPUE of Jatka in the Padma river

Sampling was done from lower Meghna river (Ramgoti to Tankirkhal) for the extension of 1st Hilsa sanctuary.

Physico-chemical parameters

Mean values and ranges of Physico-chemical parameters over the study period are presented in Table 7. Physico-chemical parameters such as air and water temperature ($^{\circ}\text{C}$), transparency (cm.), DO (mg/l), CO_2 (mg/l), pH, total hardness (mg/l), and total alkalinity (mg/l) were determined. The air and water temperature ($^{\circ}\text{C}$) of the study areas were found to vary from 25 to 31 $^{\circ}\text{C}$ and 23 to 29 $^{\circ}\text{C}$, respectively. Dissolved oxygen and free CO_2 ranged between 5 and 7 mg/l and 7.2 and 13 mg/l, respectively. The study areas pH, transparency and salinity varied from 7.5 to 7.82, 17 to 29cm and 2 to 3 ppt, respectively. Salinity intrusion was not observed in the Padma River during the study period. Alkalinity and hardness ranged from 54 to 120 mg/l and 62 to 235 mg/l during the study period. The analytical results of the Physico-chemical parameters indicated that the parameters were within suitable ranges for fishes in the study areas.

Plankton identification

Following the drop count method, qualitative and quantitative planktons were analysed (APHA 1995). Plankton identification was made following Ward and Whipple (1959) and Prescott (1962). In the

qualitative study among nine plankton groups six phytoplankton and four zooplankton groups (Table 8) were identified. Among the six phytoplankton groups, 18 genera were identified where Bacillariophyceae, Zygnematophyceae and Chlorophyceae were the most dominant groups. But in the case of zooplankton groups, seven different genera were observed where Cladocera was the dominant group.

Table 7. Physico-chemical parameters during July 2022 to June 2023 of lower Meghna river (Ramgoti to Tankirkhal)

Parameters	Average values (Ramgoti to Tankirkhal)	Standard value
Air temperature (°C)	27.83 ± 1.94 (25-31)	20-30 (EQS,1997)
Water temperature (°C)	26.21 ± 2.04 (23-29)	20-30 (EQS,1997)
DO (mg/l)	6.12± 0.60 (5-7)	4-6 (EQS,1997)
CO ₂ (mg/l)	10.38 ± 1.99 (7.2-13)	6 ppm or less (EQS,1997)
pH	7.62 ± 0.14 (7.5-7.82)	6.5-8.5 (EQS,1997)
Transparency (cm)	22.67 ± 4.47 (17-29)	40 or less (Rahman,1992)
Alkalinity (mg/l)	73.67± 20.62 (54-120)	>100 (Rahman,1992)
Hardness (mg/l)	97.91 ± 48.24 (62-235)	40-400 ppm (Boyd,1998)
Salinity (ppt)	2.5 ± 0.70 (2-3)	0-10 (Rahman,1992)

Table 8. Identified Plankton groups of lower Meghna river (Ramgoti to Tankirkhal)

Group	Genus	Genus No.
Chlorophyceae	<i>Pediastrum, Volvox, Scenedesmus, Microspora</i>	04
Ulvophyceae	<i>Ulothrix</i>	01
Zygnematophyceae	<i>Spirogyra, Nitzschia, Netricum, Gonatozygon</i>	04
Bacillariophyceae	<i>Navicula, Gomphonema, Asterionella, Diatoma, Frustulia, Cyclotella</i>	06
Cyanophyceae	<i>Spirulina, Rivularia,</i>	02
Dinophyceae	<i>Ceratium</i>	01
Euglenophyceae	<i>Euglena</i>	01
Copepoda	<i>Cyclops, Nauplius</i>	02
Rotifera	<i>Brachionus, Keratella</i>	02
Cladocera	<i>Daphnia, Bosmina</i>	02

The quantitative study of plankton observed a higher amount in Ramgoti (35×10^2 cells/ l) of lower Meghna river than in Tankirkhal (33×10^2 cells/ l) (Table 9) .

Table 9. Quantitative assessment of Plankton of 1st Hilsa sanctuary (Ramgoti to Tankirkhal)

Sampling sites	Total Plankton (cells/l)	Total Phytoplankton (cells/l)	Total Zooplankton (cells/l)	Phytoplankton (%)	Zooplankton (%)
Ramgoti	$35 \pm 7 \times 10^2$	$28 \pm 4.5 \times 10^2$	$7 \pm 2.5 \times 10^2$	80	20
Tankirkhal	$33 \pm 6.5 \times 10^2$	$26 \pm 4 \times 10^2$	$7 \pm 2.5 \times 10^2$	78.78	21.21

CPUE of Jatka of lower Meghna river (Ramgoti to Tankirkhal)

The average CPUE of Jatka of lower Meghna river (Ramgoti to Tankirkhal) was recorded at 8 Kg/ 100 m net/ hour/ boat, which is slightly more than the previous years.

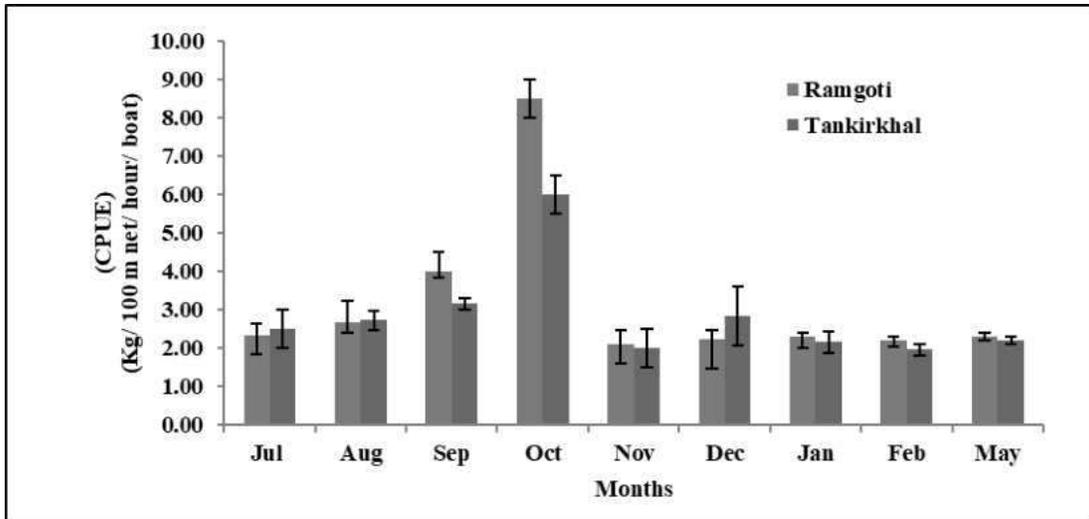


Figure 5. CPUE of Jatka in lower Meghna river (Ramgoti to Tankirkhal)

CPUE of Hilsa of lower Meghna river (Ramgoti to Tankirkhal)

Catch per unit effort of Hilsa at lower Meghna river (Ramgoti to Tankirkhal) was observed in higher amounts (4.5 -6.5 kg/100m net/hour/boat) in September and October, 2022 at Shahbazpur Channel in the lower Meghna river.

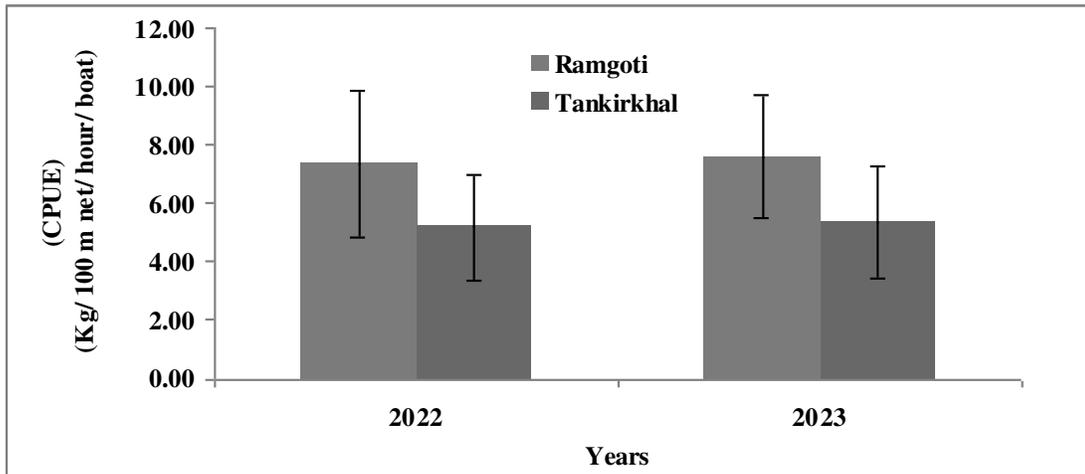


Figure 6. CPUE of Jatka in lower Meghna river (Ramgoti to Tankirkhal)

Diversity of adaptive gear and their impact on kaptai lake fisheries

Researchers

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Objectives

- To identify the gear used in the Kaptai Lake
- To determine the CPUE and catch composition
- Cataloging fish and gear of Kaptai lake
- To analyze cumulative length frequency
- To reassess existing breeding ground in Kaptai lake
- To Find new breeding ground in Kaptai lake

Achievements

Monthly catch composition of fishing gear, fish length, weight and other information of this project compiled for preparing data analysis and annual report. Regular Sampling was done according to project objectives for reassessing the existing breeding ground and finding a new breeding ground in Kaptai Lake.

Kechki net:

CPUE and catch composition of Kechki net which Length: 68.59 m; Width: 13.72m; Haul Time: 01 hr 30 min; CPUE: 6.8 kg and species found in the following table;

Table 1. Catch composition, Length and weight data of fishes collected from Kechki net

SN	Species Name	Total no	Total Weight (g)	Average Length (cm) ± SD	Average weight (g) ± SD
01	<i>Johnius coitor</i>	27	339	10.96±1.44	12.33±4.94
02	<i>Cirrhinus reba</i>	1	40	17.2±0.0	40±0.0
03	<i>Osteobrama cotio</i>	332	547	5.80±0.94	2.12±1.32
04	<i>Gudusia chapra</i>	14	15	4.63±1.40	1.04±0.93
05	<i>Glossogobius giuris</i>	19	32	5.65±1.75	2.038±2.615
06	<i>Eutropichthys vacha</i>	1	29	16±0.0	29±0.0
07	<i>Mastacembelus pancalus</i>	1	11.04	12.7±0.0	11.04±0.0
08	<i>Chanda baculis</i>	22	38	5.04±0.657	1.87±0.605
09	<i>Hyporhamphus limbatus</i>	3	1.27	5.42±2.15	0.38±0.17
10	<i>Gonialosa manmina</i>	4	18	7.68±1.12	4.36±1.80
11	<i>Corica soborna</i>	340	57	3.8±0.31	0.52±0.71
12	<i>Macrobrachium species</i>	274	210	4.58±0.72	0.23±0.30
13	<i>Mystus vittatus</i>	1	19.8	11.9±0.0	19.8±0.0
14	<i>Mastacembelus armatus</i>	1	1.31	8.7±0.0	1.31±0.0

SN	Species Name	Total no	Total Weight (g)	Average Length (cm) \pm SD	Average weight (g) \pm SD
15	<i>Salmostoma bacaila</i>	12	24	6.74 \pm 0.68	1.87 \pm 0.61
16	<i>Chela cachius</i>	19	35	5.99 \pm 0.45	1.82 \pm 0.51
17	<i>Esomus danricus</i>	11	12	4.45 \pm 0.817	1.12 \pm 0.780
18	<i>Puntius guganio</i>	28	18	5.8 \pm 0.31	0.64 \pm 0.6
19	<i>Puntius sophore</i>	10	63	7.4 \pm 1.00	6.16 \pm 3.55
20	<i>Lepidocephalichthys guntea</i>	2	3.72	5.65 \pm 0.35	1.86 \pm 0.296
21	<i>Chanda nama</i>	2	3.29	5.55 \pm 0.919	1.65 \pm 0.77

Fish Trap:

CPUE and catch composition of a Fish Trap by using small trees branches. Length: 2.286 m; Width: 1.067 m; Haul Time: 07 days; CPUE: 1330 gm and species found in the following table;

Table 2. Catch composition, Length and weight data of fishes collected from Fish Trap

SN	Species Name	Total no	Total Weight (g)	Average Length (cm) \pm SD	Average weight (g) \pm SD
01	<i>Mastacembelus armatus</i>	08	210	21.7 \pm 5.29	26.25 \pm 17.68
02	<i>Mystus bleekeri</i>	38	668	12.60 \pm 1.37	17.10 \pm 6.18
03	<i>Clarias batrachus</i>	01	127	24.8 \pm 0.0	127 \pm 0.0
04	<i>Notopterus notopterus</i>	02	51	15.6 \pm 0.99	25 \pm 5.66
05	<i>Heteropneustes fossilis</i>	02	13	10.6 \pm 0.70	6.0 \pm 1.41
06	<i>Labeo calbasu</i>	01	27	13.2 \pm 0.0	27 \pm 0.0
07	<i>Osteobrama cotio</i>	01	3.53	7.1 \pm 0.0	3.53 \pm 0.0
08	<i>Chanda baculis</i>	02	4.42	5.5 \pm 0.28	2.17 \pm 0.61
09	<i>Puntius chola</i>	07	24	6.41 \pm 0.49	3.40 \pm 0.77
10	<i>Glossogobius giuris</i>	19	75	7.88 \pm 1.19	3.89 \pm 1.75
11	<i>Channa Punctata</i>	02	41	\pm 12.45 \pm 1.63	21 \pm 7.07
12	<i>Macrobrachium lamerrei</i>	03	4.45	5.03 \pm 0.68	1.43 \pm 0.72
13	<i>Macrobrachium species</i>	02	2.0	5.1 \pm 0.42	4.96 \pm 5.64
14	<i>Mystus vittatus</i>	05	26	8.3 \pm 0.94	5.54 \pm 1.81
15	<i>Cirrhinus reba</i>	01	4.05	8.1 \pm 0.0	4.05 \pm 0.0

Brush Shelter:

CPUE and catch composition of a Brush shelter by using different tree branches; water hyacinth, fish bait or lure etc.

Table 3. Catch composition, Length and weight data of fishes collected from brush shelter

SN	Species Name	Total no	Total Weight (g)	Average Length (cm) \pm SD	Average weight (g) \pm SD
01	<i>Labeo calbasu</i>	65	9200	24.10 \pm 4.54	175.06 \pm 96.51
02	<i>Notopterus notopterus</i>	290	11590	16.98 \pm 4.63	43.11 \pm 37.65
03	<i>Heteropneustes fossilis</i>	10	135	18.16 \pm 5.29	41.29 \pm 35.44
04	<i>Mastacembelus pancalus</i>	5	39.8	12.5 \pm 0.0	7.44 \pm 0.0
05	<i>Cirrhinus reba</i>	15	375	13.93 \pm 3.31	24 \pm 14.93
06	<i>Channa Punctata</i>	15	88.2	8.0 \pm 0.2	5.84 \pm 0.87
07	<i>Chanda baculis</i>	270	730	5.46 \pm 0.91	2.56 \pm 1.17
08	<i>Pseudombasis lala</i>	10	9.90	5.6 \pm 0.66	2.49 \pm 1.04
09	<i>Mastacembelus armatus</i>	07	1069	40.84 \pm 8.79	152.71 \pm 80.66
10	<i>Clarias batrachus</i>	01	133	26.2 \pm 0.0	133 \pm 0.0
11	<i>Puntius shophore</i>	150	1110	7.87 \pm 0.70	6.97 \pm 2.09
12	<i>Channa marulius</i>	02	1022	38.5 \pm SD	511 \pm SD
13	<i>Channa stariata</i>	03	1821	43.8 \pm 2.26	740 \pm 176.77
14	<i>Colisa fasciata</i>	30	36.5	3.87 \pm 0.42	1.14 \pm 0.36
15	<i>Glossogobius giuris</i>	20	20.4	6.88 \pm 1.19	3.17 \pm 1.75
16	<i>Badis badis</i>	18	10.2	2.6 \pm 0.66	1.49 \pm 1.04
17	<i>Tricopsis vittata</i>	14	13.2	2.9 \pm 0.37	1.89 \pm 1.02
18	<i>Corica soborna</i>	20	7.4	3.8 \pm 0.31	0.52 \pm 0.71
19	<i>Esomus danricus</i>	02	1.73	4.45 \pm 0.81	1.12 \pm 0.78
20	<i>Aplochilus panchax</i>	01	0.31	3.6 \pm 0.26	1.2 \pm 0.74
21	<i>Colisa lala</i>	12	17.82	4.15 \pm 0.38	1.47 \pm 0.47
22	<i>Chanda nama</i>	01	0.82	4.6 \pm 0.0	0.82 \pm 0.0
23	<i>Macrobrachium species</i> (White chingri)	10	7.0	4.64 \pm 0.36	0.64 \pm 0.14
24	<i>Macrobrachium species</i> (Black chingri)	02	1.21	4.4 \pm 0.14	0.61 \pm 0.12
25	<i>Puntius ticto</i>	03	2.12	4.03 \pm 0.25	0.71 \pm 0.22

Current net:

CPUE and Length; Weight of a Current Net were Length: 228.66 m; Width: 3.66 m; mesh size; 3.5 cm
Haul Time: 03 hrs; CPUE: 922 gm

Table 4. Catch composition, Length and weight data of fishes collected from current net

SN	Species Name	Total no	Total Weight (g)	Average Length (cm) \pm SD	Average weight (g) \pm SD
01	<i>Cirrhinus reba</i>	09	922	21.8	102
02				19	68
03				20.4	89
04				21.3	95
05				21	93
06				21.3	92
07				24.6	158
08				23.9	145
09				19.2	79

Existing carp breeding grounds of Kaptai lake

1. Kasalong channel: Maynimukh and upwards; (N 22°58'42.73356" and E 92°11'18.51288")
2. Barkal channel: Jagannathchhari and upwards (N 22°73'38.89830" and E 92°39'66.68535")
3. Chengi channel: Naniarchhar and upwards (N 22°51'27.11664" and E 92°4'42.65112")
4. Raikhiyang channel: Bilaichhari and upwards (N 22°29'10.49964" and E 92°20'10.26384")

Table 5. Water Depth (m) of Existing carp breeding grounds in Kaptai lake

Location/ Month	Kassalong channel	Barkal channel	Chengi channel	Raikhiyang channel
January	1.54-1.72	2.64-6.60	2.33	1.14-2.87
February	Lowest water level	4.93	0.85	1.219
March	1.27 (increase water level after rain just before sampling)	Lowest water level	Lowest water level	Lowest water level
April	Lowest water level	Lowest water level	Lowest water level	Lowest water level
May	Lowest water level	Lowest water level	Lowest water level	Lowest water level
June	Slight increase water level	Lowest water level	Lowest water level	Lowest water level

***Lowest water level indicates below 1 m water Depth

Table 6. Physicochemical parameters of existing carp breeding grounds

SN	Location/parameter (January/23)	Kassalong channel (Mayni river)	Barkal channel	Chengi channel	Raikhiyang channel
01	Air Temp (°C)	32	25	22	24
02	Water Temp (°C)	24.03- 24.09	22.83- 24.7	22.4- 22.11	21.17-22.5
03	DO (mg/l)	4.74	4.94-5.36		3.68
04	DO Saturation (%)	-	-	1.98	-
05	Free CO ₂ (mg/l)	10	6-7	12	10
06	pH	7.84	7.83-8.04	7.28	7.67
07	mVpH	-55.6	-55.2; -64.8	-23.2	-44.8
08	Conductivity (μS/cm)	157	162-166	120	265
09	Absolute conductivity (μS/cm ^a)	155	155-162	113	244
10	Oxygen reduction potential (mVORP)	109.5	124.8-132.7	120.9	115.6
11	Resistivity (K/MΩcm)	6.4	6.0-6.2	8.3	3.8
12	Salinity (ppt, psu)	0.07	0.08	0.06	0.13
13	Atmospheric Pressure (atm)	0.9987	0.9979-1.0016	1.0008	1.004
14	Secchi disc (cm)	32	65-68	21.59	47
15	Alkalinity (mg/l)	344	328-338	214	174
16	TDS (ppm, mg/l)	79	81-83	60	132
17	Water Depth (m)	1.54-1.72	2.64-6.60	2.33	1.14-2.87

Table 7. Physicochemical parameters of existing carp breeding grounds

SN	Location/parameter (February/23)	Kassalong channel (Mayni river)	Barkal channel	Chengi channel	Raikhiyang channel
01	Air Temp (°C)	Water quality was not taken due to lowest depth and deterioration of water	23	23	24
02	Water Temp (°C)		25.48	28.94	27.8
03	DO (mg/l)		6.5	1.88	2.18
04	DO Saturation (%)		17.8		
05	Free CO ₂ (mg/l)		4	11	10
06	pH		7.60	7.60	7.78
07	mVpH		-56	-40.5	-53.2
08	Conductivity (µS/cm)		175	155	293
09	Absolute conductivity (µS/cm ^a)		178	167	308
10	Oxygen reduction potential (mVORP)		140.8	139.8	85.9
11	Resistivity (K/MΩcm)		5.7	6.5	3.4
12	Salinity (ppt, psu)		0.08	0.07	0.14
13	Atmospheric Pressure (atm)		1.0051	1.008	1.002
14	Secchi disc (cm)		47	27	21
15	Alkalinity (mg/l)		328-338	214	174
16	TDS (ppm, mg/l)		81-83	60	132
17	Water Depth (m)		2.64-6.60	2.33	1.14-2.87

Identified Plankton:

Mainly two types of plankton were identified in Kaptai lake; Phytoplankton and Zooplankton.

Table 8. Identified Phytoplankton in existing carp breeding grounds.

SN	Class	Genus		
01	Cyanophyceae	<i>Aphanocapsa</i>	<i>Aphanozomenon</i>	<i>Aphanothece</i>
		<i>Gloeocapsa</i>	<i>Nodularia</i>	<i>Oscillatoria</i>
		<i>Phormidium</i>		
02	Bacillariophyceae	<i>Tabellaria</i>	<i>Nitzschia</i>	<i>Navicula</i>
		<i>Pseudo-nitzschia</i>	<i>Synedra</i>	<i>Gyrosigma</i>
03	Zygnematophyceae	<i>Staurastrum</i>	<i>Cosmarium</i>	
04	Dinophyceae	<i>Gymnodinium</i>	<i>Cyclotella</i>	<i>Conscinodiscus</i>
05	Chlorophyceae	<i>Chlorella</i>	<i>Kirchnerilla</i>	
06	Euglenophyceae	<i>Euglena</i>	<i>Phacus</i>	<i>Monas</i>

Table 9. Identified zooplankton of existing carp breeding grounds in Kaptai lake

	CLASS	Genus		
01	Rotifera	<i>Gastropus</i>	<i>Dicranophorus</i>	<i>Polyarthra</i>
02	Copepoda	<i>Nauplius</i>	<i>Canthocamptus</i>	<i>Hexarthra</i>
03	Cladocera	<i>Bosmina</i>		

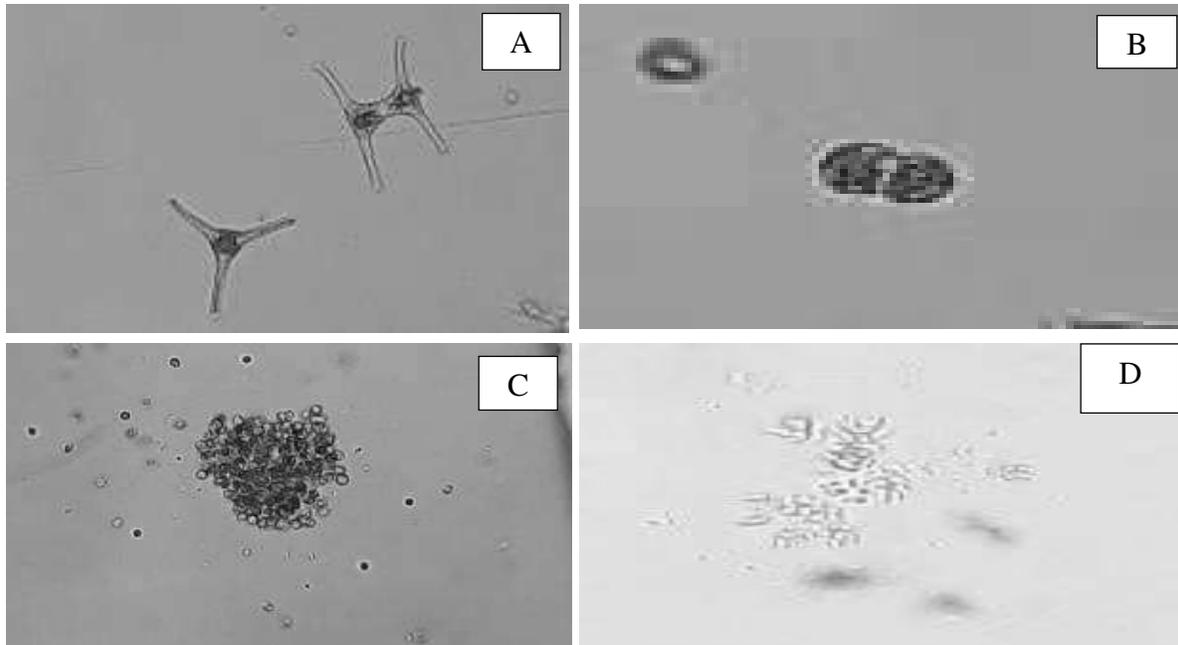


Figure 1. Phytoplankton: (A) *Staurastrum*; (B) *Cosmarium*; (C) *Gloeocapsa* and (D) *Kirchneriella*

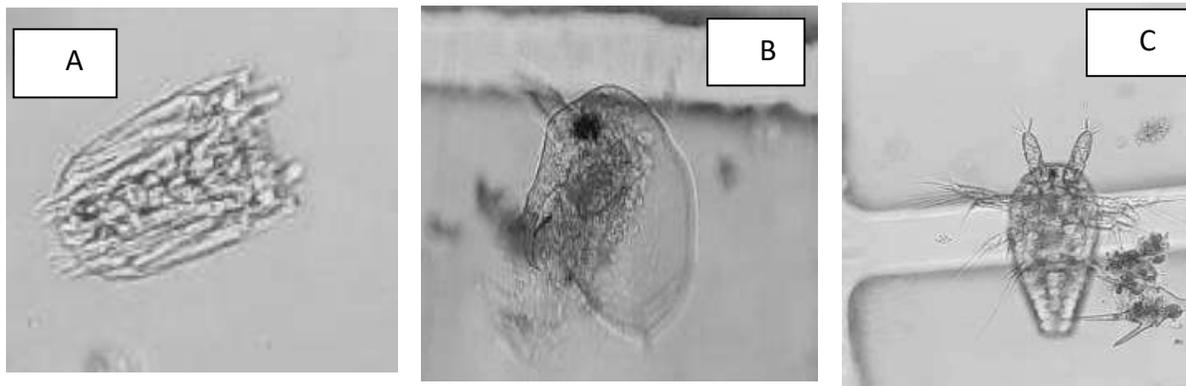


Figure 2. Zooplankton: (A) *Polyarthra*; (B) *Bosmina* and (C) *Nauplius*

Collection of Eggs/hatchlings/juvenile of Fishes

- This year water level was comparatively lower than previous year due to delay rainfall in the surrounding of Kaptai lake
- During peak breeding season sampling were done upto june 2023 in Kaptai lake.

New Breeding Ground

1. Barkal Mohona: Adjacent to the Karnaphuli river and Borkol Channel & it's upwards (Barkal Upazila)
2. Adjacent to Kassalong river and Mayni river & it's upwards (Longodu Upazila)
3. Sapmara mukh/Chor: Adjacent to few canal (Naniarchor Upazila)

Fishes found all of these places for breeding purpose in Kaptai lake. Now it's needed more investigation during peak breeding season as well as yearly data for confirmation.

Ecological assessment of inland open water fisheries population with bio-physicochemical properties to frame EBFM approach (Component-E)

Researchers

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Objectives

- To assess bio-physicochemical properties of the Kaptai Lake including seasonal variation.
- To assess stock of some important ecological fish groupwise: Herbivores, Detrivores, Carnivores & Omnivores based on catch and CPUE data
- To estimate population ecology and diet composition of some commercially significant Kaptai Lake fishes.
- To assist for framing ecosystem based management approach for Kaptai Lake with emphasizing to increase productivity and conservation of the fisheries resources.

Achievements

Experiment 1. Assessment of bio-physicochemical properties with seasonal variation in the Kaptai Lake

Seasonal variation of physicochemical properties

The study was conducted in four areas of the Kaptai Lake, they are i) Rangamati sadar ii) Langadu, iii) Kaptai and iv) Barkal *upazila*. The sampling of respective areas water body was monthly for recording seasonal variation. Seasonal variation of physicochemical properties are presented in Table 1.

Table 1. Seasonal and yearly variation of physico-chemical factors with range, mean values (x) and standard error (\pm SE).

Parameters (Unit)	Pre-monsoon	Monsoon	Post-monsoon	Mean \pm SE	Range
Air tem ($^{\circ}$ C)	31.17 \pm 0.96	29.45 \pm 0.25	25.18 \pm 0.95	28.52 \pm 0.92	25.18-31.17
Water tem ($^{\circ}$ C)	29.04 \pm 0.45	28.63 \pm 1.12	26.18 \pm 0.58	27.82 \pm 0.44	26.18-29.04
DO (mgL $^{-1}$)	6.69 \pm 0.59	7.63 \pm 0.29	5.95 \pm 0.19	6.74 \pm 0.22	5.95-7.63
pH	7.64 \pm 0.15	7.77 \pm 0.09	7.58 \pm 0.12	7.66 \pm 0.66	7.58-7.77
Conductivity (μ S/cm)	106.75 \pm 3.10	90.83 \pm 2.07	94.54 \pm 7.22	96.15 \pm 3.15	90.83-106.75
Alkalinity (mgL $^{-1}$)	123.38 \pm 2.89	67.00 \pm 2.29	85.31 \pm 10.66	87.88 \pm 5.69	67.00-123.38
Free CO $_2$ (mgL $^{-1}$)	6.13 \pm 1.09	10.58 \pm 1.16	6.88 \pm 0.67	8.05 \pm 0.64	6.13-10.58
Salinity (psu)	0.04 \pm 0.001	0.03 \pm 0.002	0.04 \pm 0.004	0.04 \pm 0.001	0.03-0.04
Transparency (m)	1.33 \pm 0.42	1.41 \pm 0.31	1.52 \pm 0.23	1.43 \pm 0.17	1.33-1.52
TDS (mgL $^{-1}$)	54.63 \pm 2.35	45.50 \pm 1.01	47.15 \pm 3.63	48.36 \pm 1.66	45.50-54.63
Hardness (mgL $^{-1}$)	79.88 \pm 0.59	51.58 \pm 2.77	53.85 \pm 0.71	59.33 \pm 3.00	51.58-79.88
Ammonia (mgL $^{-1}$)	0.09 \pm 0.03	0.03 \pm 0.01	0.02 \pm 0.00	0.03 \pm 0.01	0.02-0.09

*DO=Dissolved oxygen, TDS= Total dissolved solids.

The change in the air temperature and water temperature was in similar pattern with a significant temporal variation ($p < 0.01$) (Figure 1). Seasonal variation of air temperature ranged from 25.18-31.17°C ($\bar{x} \pm \text{SE}$: 28.52 \pm 0.92). The highest air temperature (31.17 \pm 0.96°C) was recorded in pre-monsoon season and lowest (25.18 \pm 0.95°C) was in post-monsoon season. The fluctuation of water temperature varied from 26.18-29.04°C ($\bar{x} \pm \text{SE}$: 27.82 \pm 0.44°C) (Table 1). The maximum water temperature (29.04 \pm 0.45°C) was recorded in monsoon and minimum (26.18 \pm 0.58°C) was recorded in the post-monsoon. Air temperature values showed strong positive correlation relation with the water temperature ($r = 0.90$, $p < 0.05$) during the pre-monsoon (Figure 2) and ($r = 0.50$, $p < 0.05$) during the post-monsoon season (Figure 4).

Dissolved oxygen is one of the most crucial parameters for aquatic organisms. The study recorded significant temporal variation ($p < 0.01$) (Figure 1) and ranged from 5.95-7.63 ($\bar{x} \pm \text{SE}$: 6.74 \pm 0.22). The highest value (7.63 \pm 0.29) was recorded in the monsoon and lowest (5.95 \pm 0.19) in the post-monsoon season (Table 1). Dissolved oxygen showed strong negative relation ($r = -0.77$, $p < 0.05$) with free CO₂ in the pre-monsoon season (Figure 2) and moderately positive relation with conductivity, salinity and TDS ($r = 0.58$, $r = 0.58$, $r = 0.59$; $p < 0.05$) in the monsoon season (Figure 3).

The pH of water always found to be slightly alkaline in nature; varied between 7.58-7.77 ($\bar{x} \pm \text{SE}$: 7.66 \pm 0.66) (Table 1) and did not fluctuate significantly ($p > 0.05$) (Figure 1). The water pH value was moderately negatively correlated with water temperature ($r = -0.76$, $p < 0.05$) and water depth ($r = -0.51$, $p < 0.05$) during the pre-monsoon season (Figure 2).

Conductivity value was found significantly varied ($p < 0.05$) (Figure 1.) and fluctuate from the range of 90.83-106.75 $\mu\text{S}/\text{cm}$ ($\bar{x} \pm \text{SE}$: 96.15 \pm 3.15) (Table 1). The highest value (106.75 \pm 3.10) was recorded in pre-monsoon and lowest (90.83 \pm 2.07 $\mu\text{S}/\text{cm}$) in monsoon season. Conductivity showed strong positive relation with total dissolved solids (TDS) ($r = 1.00$, $p < 0.01$) during the monsoon (Figure 3) and strong positive relation with alkalinity ($r = 0.80$, $p < 0.01$), free CO₂ ($r = 0.68$, $p < 0.01$) and TDS ($r = 1.00$, $p < 0.01$) during the post-monsoon (Figure 4).

The value of total alkalinity was significantly varied ($p < 0.01$) (Figure 1) with the range of 67.00-123.38 mg/l ($\bar{x} \pm \text{SE}$: 87.88 \pm 5.69). The highest value (123.38 \pm 2.89 mg/l) was recorded in pre-monsoon and lowest (67.00 \pm 2.29 mg/l) in the monsoon (Table 1). Total alkalinity was strongly positively correlated with TDS ($r = 0.81$, $p < 0.01$) in the post-monsoon (Figure 4).

Free CO₂ of water was recorded with significant ($p < 0.01$) (Figure 1) temporal variation. The value of free CO₂ ranged between 6.13-10.58 mg/l ($\bar{x} \pm \text{SE}$: 8.05 \pm 0.64) with the highest value (10.58 \pm 1.16 mg/l) was recorded in monsoon and lowest (6.13 \pm 1.09 mg/l) in the pre-monsoon (Table 1). The free CO₂ value was moderately positively correlated with TDS ($r = 0.69$, $p < 0.05$) during the post-monsoon (Figure 4).

Water salinity was almost same across the year ($p > 0.05$) (Figure 1) and range of 0.03-0.04 psu ($\bar{x} \pm \text{SE}$: 0.04 \pm 0.001). Transparency of the lake water was also same ($p > 0.05$) (Figure 1) around the year with values of 1.33-1.52 m ($\bar{x} \pm \text{SE}$: 1.43 \pm 0.17) (Table 1). The TDS value of water was significantly varied ($p < 0.05$) (Figure 1) with the value of 45.50-54.63 mg/l ($\bar{x} \pm \text{SE}$: 48.36 \pm 1.66) (Table 1). The highest TDS value (54.63 \pm 2.35 mg/l) was recorded in pre-monsoon and lowest (45.50 \pm 1.01 mg/l) in the monsoon. The total hardness was recorded with significant ($p < 0.01$) (Figure 1) temporal variation and the value was varied from 51.58-79.88 mg/l ($\bar{x} \pm \text{SE}$: 65.73 \pm 3.00). The highest value (79.88 \pm 0.59 mg/l) was recorded in pre-monsoon and the lowest was (51.58 \pm 2.77 mg/l) in monsoon season (Table 1). Ammonia level was almost similar ($p > 0.05$) (Figure 1) among the seasons.

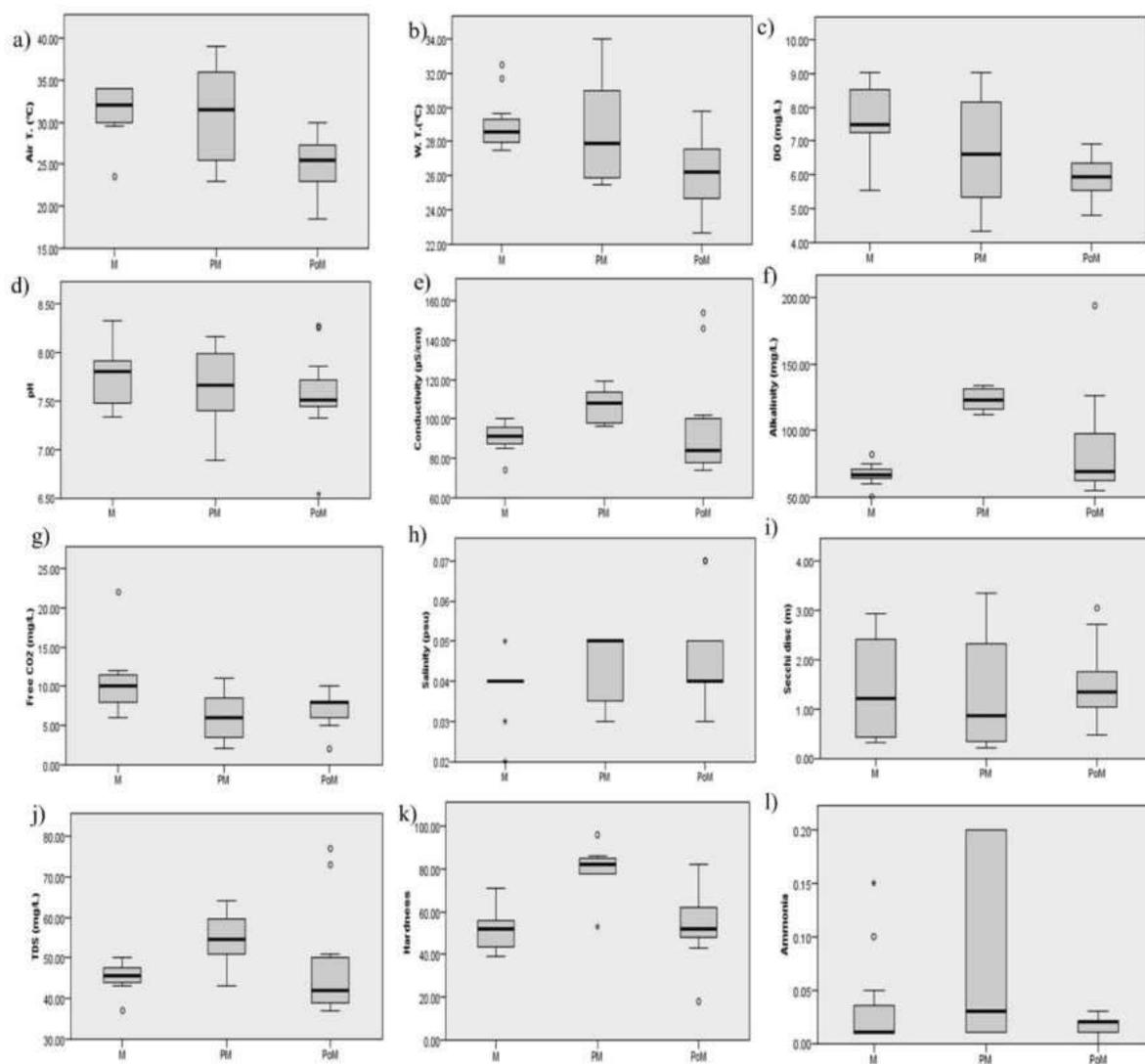


Figure 1. Seasonal variation of physicochemical parameters in Kaptai lake. [a) Air temperature; b) water temperature; c) DO; d) Free CO₂; e) Conductivity; f) Salinity; g) TDS; h) Ammonia a) Hardness; b) Alkalinity; c) pH; d) Secchi disc (transparency)]; The boxes represent the 25th and 75th percentile, the whiskers represent the 10th and 90th percentiles. The black bar represents the median and the points represents the 5th and 95th percentiles.

Seasonal variation of biological properties

The seasonal variations in gross primary productivity (GPP) were not significantly varied ($p > 0.05$) whereas net primary productivity (NPP) significantly varied ($p < 0.05$) and community respiration (CR) significantly varied ($p < 0.01$) (Figure 5). The GPP values fluctuated from 0.02-0.32 $\text{gCm}^{-2}\text{hr}^{-1}$, NPP values were ranged from 0.03-0.42 $\text{gCm}^{-2}\text{hr}^{-1}$ with a peak in post-monsoon and CR values were ranged from 0.01-0.25 $\text{gCm}^{-2}\text{hr}^{-1}$ with a peak in post-monsoon respectively. The GPP showed strong positive value with DO and water temperature ($p < 0.05$), negative relation was found with ammonia and free CO₂ (Figure 2 and 3) during the pre-monsoon and monsoon sea-son. The GPP, NPP and CR did not show any significant correlation with physico-chemical parameters (Figure 2, 3 and 4). Furthermore, the GPP always showed strong positive correlation with NPP ($p < 0.01$), and NPP showed strong positive correlation with CR ($p < 0.01$) (Figure 2, 3 and 4).

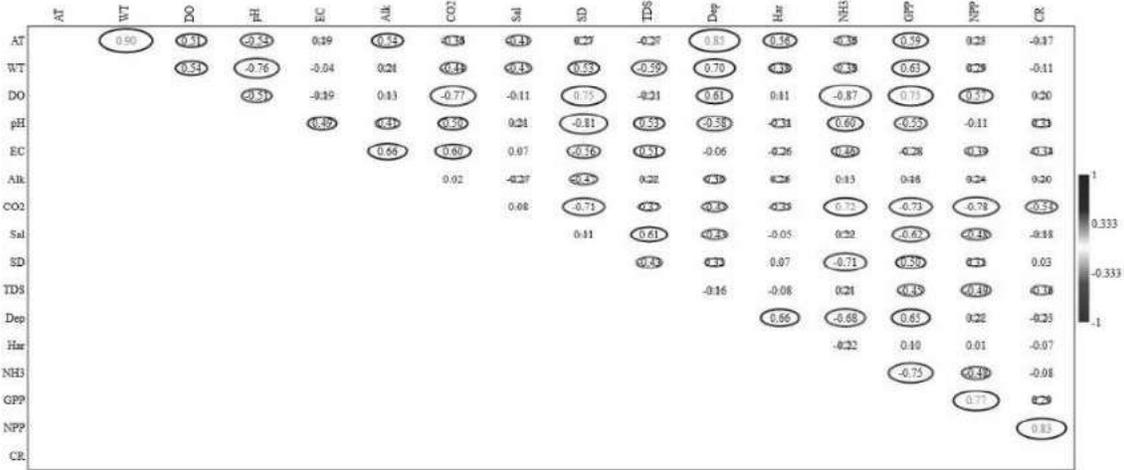


Figure 2. Pearson correlation in the pre-monsoon season.

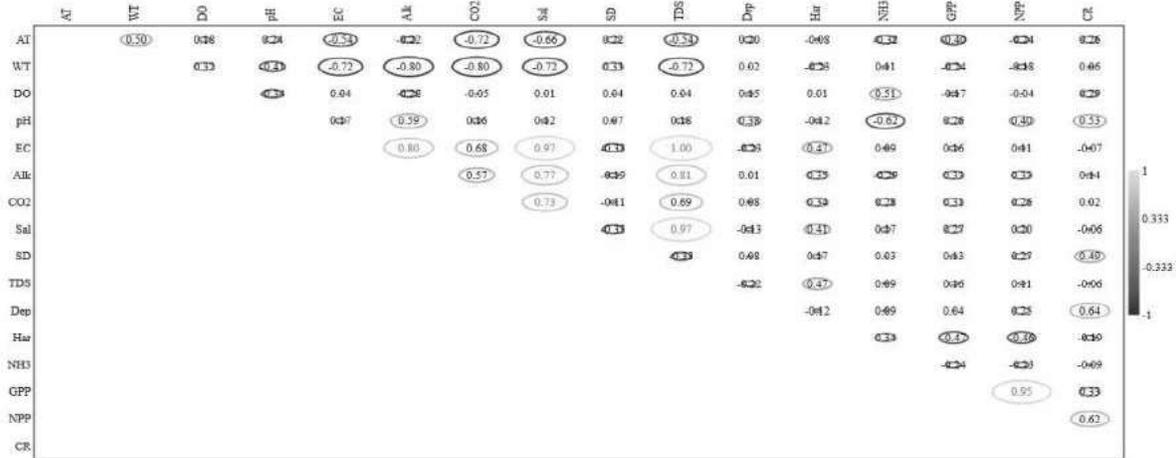


Figure 3. Pearson correlation in the monsoon season.

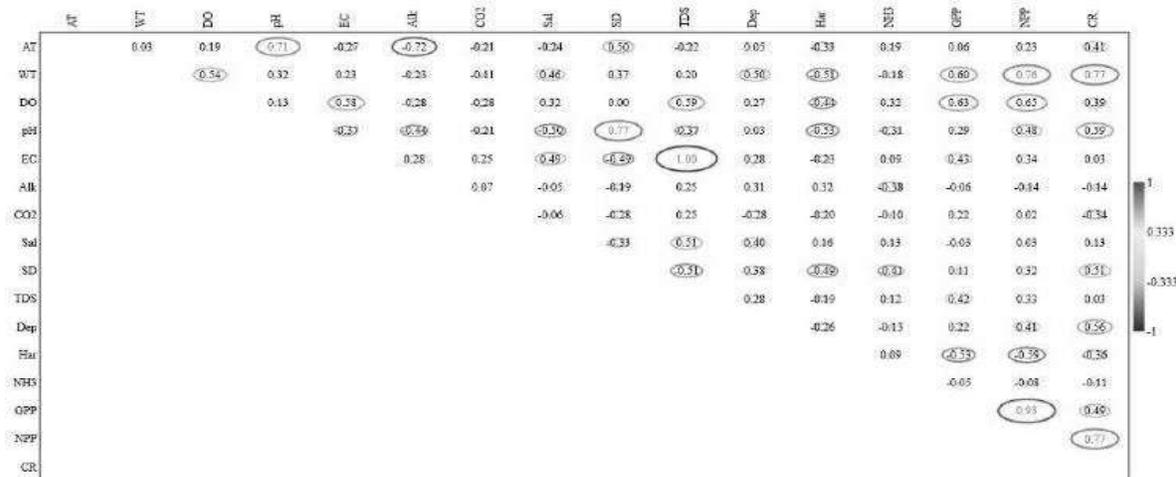


Figure 4. Pearson correlation in the post-monsoon season.

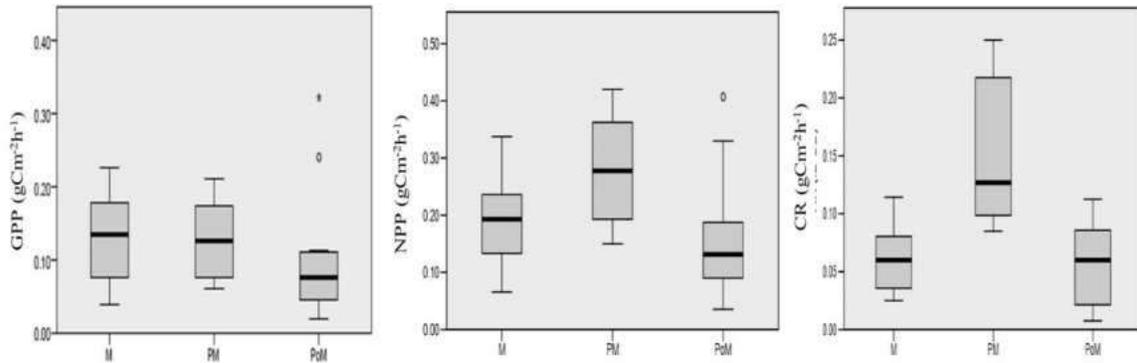


Figure 5. Seasonal variation of primary productivity in the Kaptai Lake.

Phytoplankton abundance was significantly varied ($p < 0.01$) seasonally, ranged ($0.60-2.47 \times 10^6$) and the highest (2.47×10^6 cellsL⁻¹) was recorded in the pre-monsoon season (Figure 6a). Zoo-plankton abundance was varied ($p < 0.05$) seasonally, ranged ($0.07-2.38 \times 10^5$ cellsL⁻¹) with the highest value recorded (2.38×10^5 cellsL⁻¹) in the pre-monsoon and showed a decreasing trend over the time (Figure 6b).

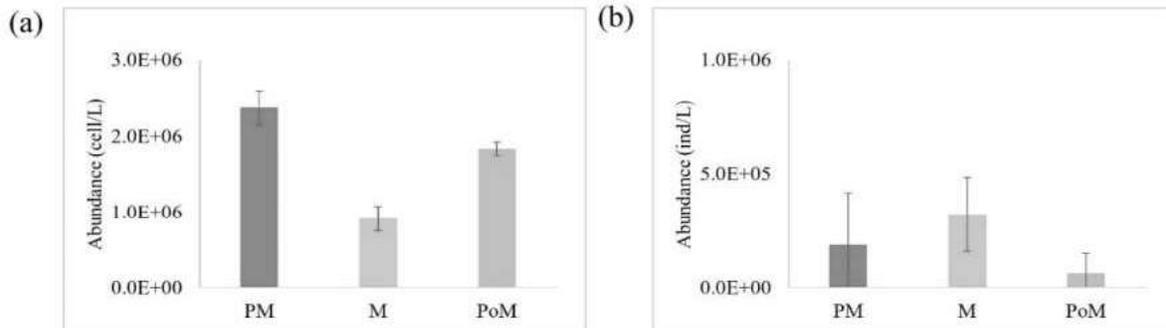


Figure 6. Seasonal variation of (a) Phytoplankton and (b) Zooplankton in the Kaptai Lake.

Water quality index

Water quality index (WQI) is conventionally used for evaluating the quality of water for water resources. WQI values is the most effective ways to communicate the information on water quality trends to the general public or to the policy makers and in water quality management. The WQI values were in good quality range with a slight increase in March, April and June (Figure 7), may be due to the reduced quantity of water in lake.

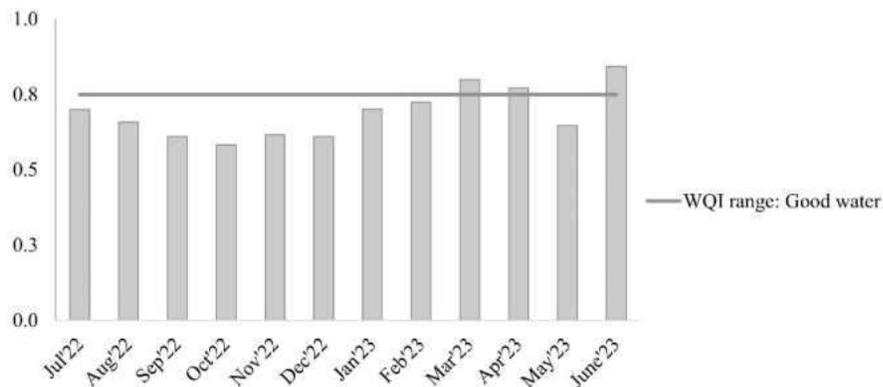


Figure 7. Monthly variation of water quality index (WQI) in the Kaptai Lake.

Experiment 2: Assessment of some important ecological fish stock in groupwise based on catch and CPUE data

Seasonal variation of fish catches composition and trend

The Kaptai lake fishery is multi-species and multi-gear fishery which is highly specialized. Per-centage composition of fish catch by families are presented in (Figure 8). Based on the fish catch data the largest group is Clupeidae (89%) (*Corica soborna*, *Gudusia chapra* and *Gonialosa man-minna*) followed by Cyprinidae (5%), Bagridae (3%) and others. Ahmed et al. (2005) recorded Clupeidae was the highest contributor accounted for 63.4% of the total catch in 2001. Similar ex-plosive growth of clupeids (e.g. *Corica goniognatus*) was found in Thai reservoirs (e.g. Sirikit, Sirinthorn and Lampao) making a significant contribution (Pawaputanon, 1986).

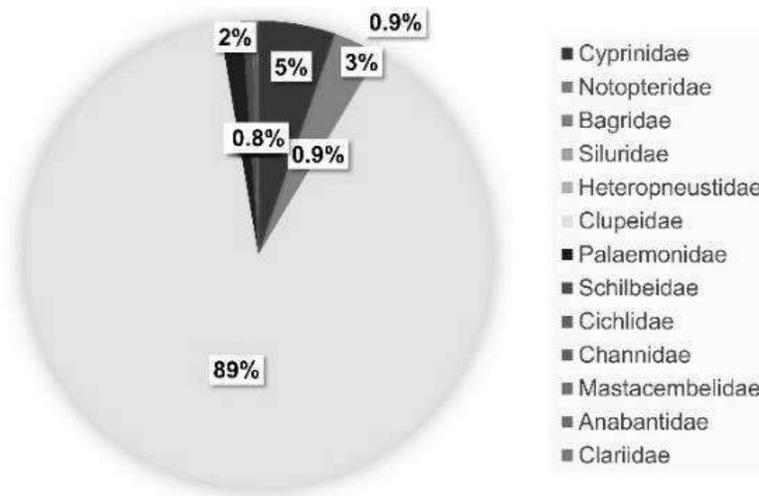


Figure 8. Catch composition (based on family) in Kaptai Lake.

Observations on the total landing of fish catch trend of 2022-23 showed that the average catch was in increasing trend with time except fish prohibition months (Figure 9a), which indicates in-cresing fishing intensity. This practice could lead to overfishing. The seasonal variation of the catch revealed that highest catch was occurred in the pre-monsoon season (Figure 9b), may be due to the reduced water level on that time. Moreover, the quantity of fishermen, fishing methods used, and management decisions all play a role in this variability.

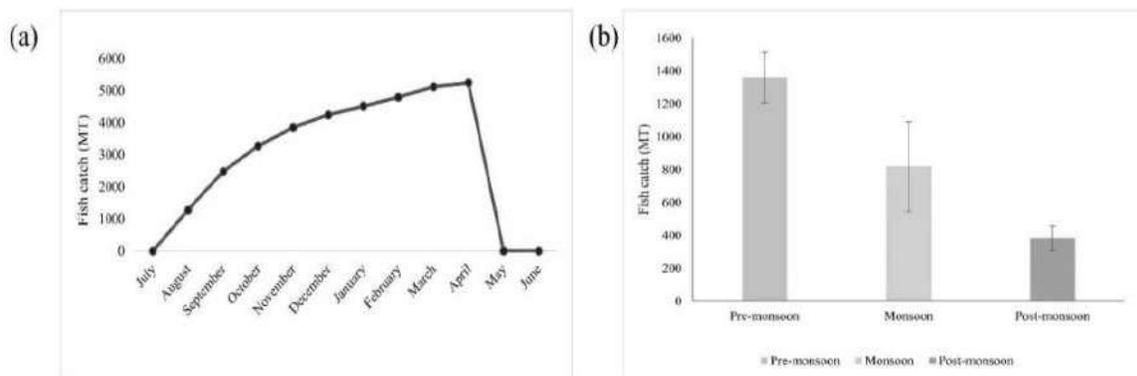


Figure 9. (a) Fishing trend and (b) seasonal variation of fishing trend in Kaptai Lake.

Catch per unit effort (CPUE)

Fishing effort is commonly expressed as a catch per unit effort (CPUE). Mean CPUE was significantly different among fishing nets (2-way ANOVA: $P < 0.05$) and fishing trap (2-way ANOVA: $P < 0.05$) (Figure 10). Mean CPUE for small meshed (SM) seine net was 18.86 ± 3.2 kg/gear/trip compared to large meshed (LM) seine net (7.03 ± 2.34), gill net (2.03 ± 0.98), lift net (0.87 ± 0.08) and push net (0.46 ± 0.09). The seine net captured the greatest number of species compared to other fishing gears, which enhanced CPUE. Similar to Ahmed and Hambrey (2005) in Kaptai Lake; Tikadar et al. (2021) in Gorai River; and Hossain et al. (2009) in Chalan Beel, Seine net had the greatest CPUE.

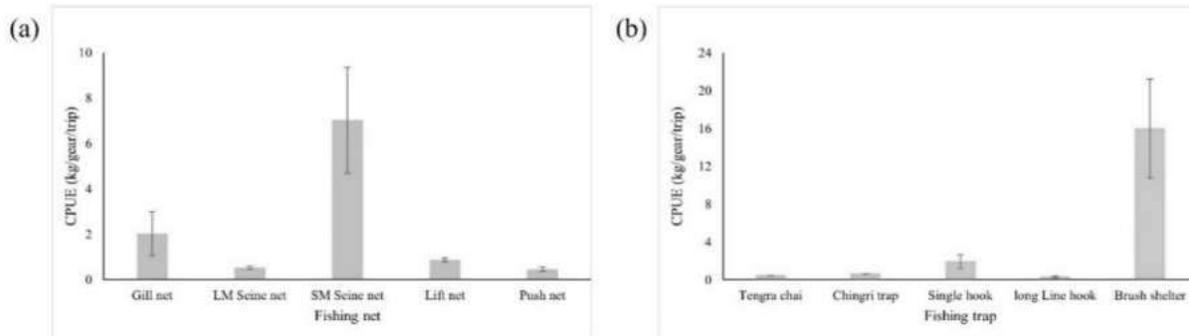


Figure 10. Catch per unit effort (CPUE) of different (a) gears and (b) traps.

Moreover, Mean CPUE was significantly different among fishing traps (2-way ANOVA: $P < 0.05$). Mean CPUE for brush shelter was 16.00 ± 5.23 kg/gear/trip compared to large tengra chai (0.50 ± 0.02), long line (0.33 ± 0.08), single line (1.96 ± 0.76) and chingri trap (0.67 ± 0.03) (Figure 10). The average catch from brush shelter was very high compared to other traps. The similar result was found in previous studies in Kaptai Lake (Ahmed and Hambrey 2005; Uddin et al., 2015).

Experiment 3. Assessment of stock of commercially significant Kaptai Lake fishes

Estimating trophic levels of fishes plays an important role in shedding light on the trophic interactions in aquatic ecosystems. The study investigated freshwater fish species feeding habits among different years on catch based data (Figure 11). It reflected the indiscriminate fishing reduced carnivorous fishes with time.

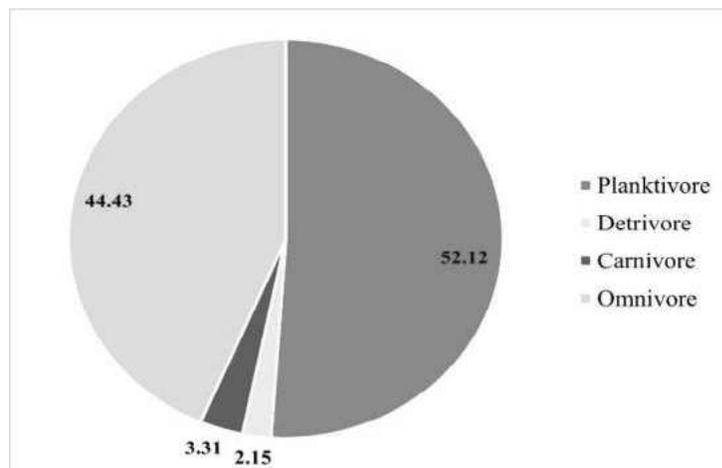


Figure 11. Trophic level of fish in different season in Kaptai Lake

Experiment 4. Formulation of the future data recording and assessment systems

Based on the findings of this ecological assessment, the following recommendations are proposed for the formulation of future data recording, which will lead to the conservation and sustainable management of inland open-water fish in Kaptai Lake:

- The introduction of artificial stocking of carnivorous fish species should be considered to balance the trophic levels
- There is a need to restrict fishing nets that sweep up detritivore fishes and destroy the bottom environment.
- The use of brush shelters and small mesh seine net requires rigorous and close monitoring.
- Proper management of habitat restoration and sanctuaries is essential for breeding of fishes.
- Promoting inland open water culture systems (e.g., cages, pens, creek culture, etc.) is advisable for the favorable water quality and high primary productivity in the Lake.
- Fishing boats need to be licensed for regulation of overfishing
- Fish catch landings must be documented based on the number of fishing vessels.
- Cyprinidae fishes must be restored, and therefore, the breeding ground areas need to be demarcated and restricted for natural spawning
- It is essential to document monthly water level and rainfall data as lake water levels can significantly fluctuate with weather conditions.
- There is a need to strengthen awareness among fishermen regarding fishing laws and regulations and how adhering to these rules can enhance their livelihoods.

Refinement and validation of culture technology of cuchia in hill tract districts

Researchers

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Objectives

- To disseminate *M. cuchia* culture in Chittagong hill tract districts
- To popularize Cuchia culture in Hill tract area

Achievement

Site selection

Site was selected from three different districts such as Rangamati, Bandarban and Khagrachhari. The experiment was conducted with two treatments in Rangamati and Bandarban; one treatment in Khagrachhari. To fulfill the objectives of the experiment, the following design was followed.

Table 1. Design of the experiment

Study area	Feed type	Stocking density
Rangamati	SIS (1.5% of BW) 3 days interval and Vermi Compost (1.5% of BW) Every day	10/m ²
Bandarban		
Khagrachori		

Pond Preparation

The experiment was conducted in 06 ponds with water area was 40m² each of ponds. Ponds were dug with (30×15×3.5) ft³. Pond bottom were covered by olythene, knotless nylon net and triple then fill-up with 08-12 inch clay mud. The ponds were protected by fencing with nylon net. The ponds were prepared by treating soil with quick lime at rate of 2kg per decimal. Ponds was filled-up with 0.6-0.8m water and then use of dolomite at the rate of 15 ppm for strengthening buffer capacity of water. After three days, the pond water was fertilized with Urea, TSP and MoP at the rate of 2.5 ppm, 3.0 ppm 1.0 ppm respectively to accelerate primary productivity. Water hyacinth and PVC pipe was used as shelter.

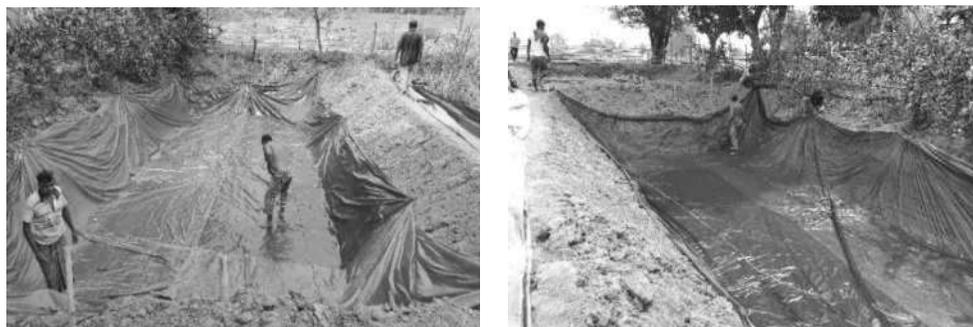




Figure 1. Pictorial view of pond preparation

Stocking cuchia fingerlings

After sufficient plankton production, Cuchia fingerlings were stocked at a density of 10 individual/m². Feeding and sampling is in progress.

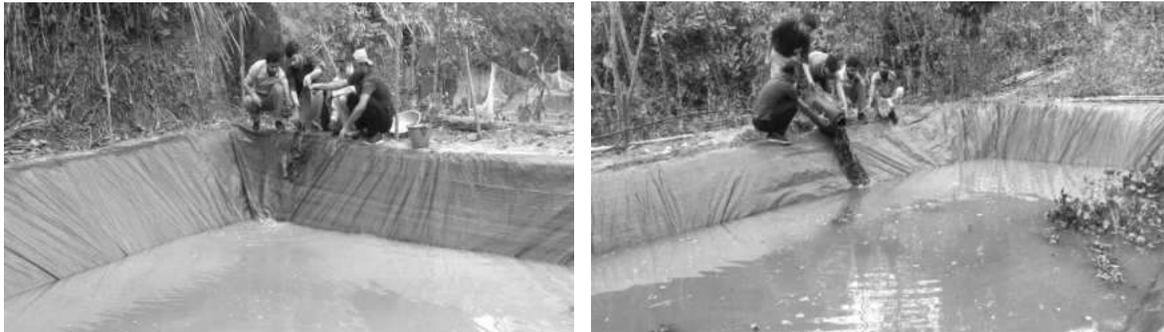


Figure 3. Stocking of Cuchia fingerling in sampling sites.

Feeding

Fingerlings and vermi compost were fed according to design. Feed was supplied at night up to satiation level. Feed was supplied by a feeding tray to check the waste of feed.

Water quality parameters

Water quality parameters of all the sampling sites were monitored monthly by using a multiparameter. All the water quality parameters were in a suitable range for Cuchia culture (Table 2).

Table 2. Water quality parameters in culture ponds.

Water quality parameters	Rangamati		Bandarban		Khagrachhari
	P ₁	P ₂	P ₁	P ₂	P ₁
Water temp. (°C)	27.84±1.09	26.6±1.2	27.2±1.6	27.75±0.9	26.75±1.7
DO (mg/l)	5.6±0.7	5.89±0.4	6.18±0.4	5.9±0.6	6.08±0.8
pH	7.77±0.4	7.15±0.67	8.1±0.6	7.87±0.35	7.48±0.47
TDS (mg/l)	39.5±2.5	36.3±2.06	36.0±3.2	69.7±1.3	33.4±2.3
Alkalinity (mg/l)	68.1±1.7	71.3±2.67	73±2.6	103.1±2.45	59.2±1.5
Ammonia (mg/l)	0.1±0.01	0.1±0.01	0.2±0.01	0.3±0.02	0.1±0.01
Hardness (mg/l)	53±1.01	53±1.03	55±2.05	57.3±1.4	65.7±2.45

Growth performance of Cuchia

Cuchia were harvested after six months of culture period by dewatering the ponds. Highest final weight, survival rate and production were recorded in Khagrachhari district, 176.5±7.6 g, 74.7±2.7 % and 45.5±1.7 kg/decimal respectively. The lowest final weight, survival rate and production were recorded in Rangamati district, 159.75±7.05 g, 70.2±3.11 % and 39.29±2.2 kg/decimal respectively (Table 3).

Table 3. Production performance of cuchia (*Monopterus cuchia*).

Location	Pond	Initial		Final		Survival (%)	Production (kg/decimal)
		Length (cm)	Weight (g)	Length (cm)	Weight (g)		
Rangamati	P ₁	33.6±4.4	51.05±5.02	52.2±5.7	158.3±7.7	69	38.23
	P ₂	34.2±3.7	50.26±5.74	54.5±6.2	161.2±6.4	71.4	40.34
	Mean±SD	33.9 ±4.05	50.66 ±5.38	53.35 ±5.95	159.75 ±7.05	70.2 ±3.11	39.29 ±2.2
Bandarban	P ₁	34.6±3.5	52.3±5.67	56.7±5.3	166.8±7.3	71.2	41.1
	P ₂	34.38±2.7	51.85±4.43	54.2±7.9	170.5±8.8	70.5	42.5
	Mean±SD	34.49 ±2.71	52.08 ±5.05	55.45 ±6.6	168.65 ±8.5	70.85 ±1.49	41.8 ±0.99
Khagrachhari	P ₁	33.46±3.67	50.0±4.99	58.7±6.2	176.5±7.6	74.7±2.7	45.5±1.7
	Mean±SD	33.46 ±3.67	50.0 ±4.99	58.7 ±6.2	176.5 ±7.6	74.7 ±2.7	45.5 ±1.7

Adoption of Culture Techniques and Bioactive Compound Analysis of Commercially Important Seaweeds in the Mid-Southern Coast of Bangladesh

Researchers

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Objectives

- To demonstrate the culture techniques of commercially important seaweeds on the Kuakata coastline.
- To analyze the proximate composition and mineral content of commercially important seaweeds in Bangladesh.
- To determine and isolate bioactive compounds of commercially important seaweeds of Bangladesh.

Achievements

Experiment 1. Potentiality of seaweed, *Gracilaria verrucosa* culture in the Kuakata coastline

Water quality parameters

Table 1 shows the results of water quality parameters in the culture sites of the Kuakata coast, Bangladesh. All the water quality parameters range from 42-68 cm water transparency, 14-20 ppt salinity, 23-30 °C water temperature, 7.48-8.02 pH, and 5.70-7.15 mg/L DO. However, the salinity level was slightly lower than the optimum level.

Table 1. Water quality parameters (mean \pm SD) of seaweed culture sites, Kuakata.

Parameters	Gangamati Estuary	Optimum
Water transparency (cm)	54.65 \pm 0.5	30–100 (Zafar, 2005)
Salinity (ppt)	18.50 \pm 0.8	24–34 (Aslan, 1998)
Water temperature (°C)	28.20 \pm 0.3	22.8–29.2 (Neish, 2008)
pH	7.63 \pm 0.2	7.5–8.5 (Zafar, 2005)
DO (mg/L)	6.20 \pm 0.2	> 5 (Aslan, 1998)

Daily growth rate (DGR)

The maximum daily growth rate (2.31 %/day) was found on the 45th day in the floating raft culture, while the minimum daily growth rate (1.22 %/day) was found on the 15th day in the long-line culture (Figure 1). The DGR of the two culture methods was attributed to significant changes ($p < 0.05$).

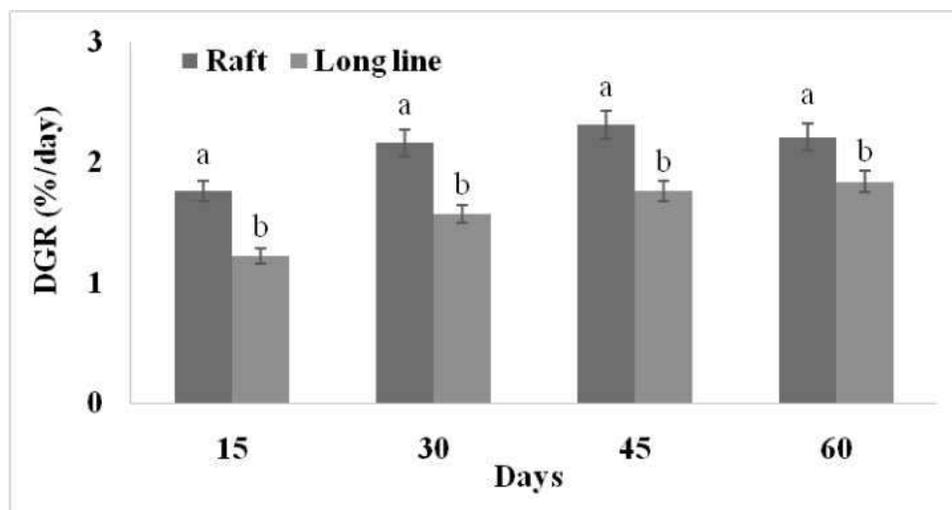


Figure 1. Daily growth rate (%/day) of *Gracilaria verrucosa* in different culture methods.

Production

The biomass production was significantly higher ($p < 0.05$) in the floating raft culture method (Table 2).

Table 2. Production of *Gracilaria verrucosa* in different culture methods.

Production	Floating raft method	Long line method
kg/m ²	3.9±0.12 ^a	3.0±0.07 ^b

Experiment 2. Proximate composition and mineral content analysis of commercially important seaweeds in Bangladesh

Proximate composition

The proximate composition of three seaweed species is given in Table 3. *Gracilaria verrucosa* had a significantly higher ($p < 0.05$) amount of protein but *P. tetrastromatica* had a significantly higher ($p < 0.05$) amount of lipid content.

Table 3. Proximate composition of three commercially important seaweeds in Bangladesh.

Parameters	Seaweed species		
	<i>G. verrucosa</i>	<i>P. tetrastromatica</i>	<i>U. intestinalis</i>
Moisture	90.24±0.52 ^b	92.27±0.48 ^a	89.57±0.64 ^b
Protein (% DW)	30.63±0.90 ^a	8.30±0.37 ^c	17.51±0.54 ^b
Lipid (% DW)	1.49±0.05 ^b	3.75±0.08 ^a	1.36±0.06 ^c
Ash (% DW)	22.25±1.10 ^b	24.58±1.18 ^b	30.50±1.27 ^a
Carbohydrate (% DW)	30.45±0.80 ^c	49.39±1.62 ^a	41.52±1.36 ^b

Different superscript in a row differs significantly ($p < 0.05$).

Mineral content

Table 4 lists the mineral content (%) of three studied seaweed species gathered from the Bay of Bengal, Bangladesh coast. Except for sulfur, every mineral content in *G. verrucosa* was considerably higher ($p < 0.05$). In *U. intestinalis*, the sulfur content was substantially higher ($p < 0.05$).

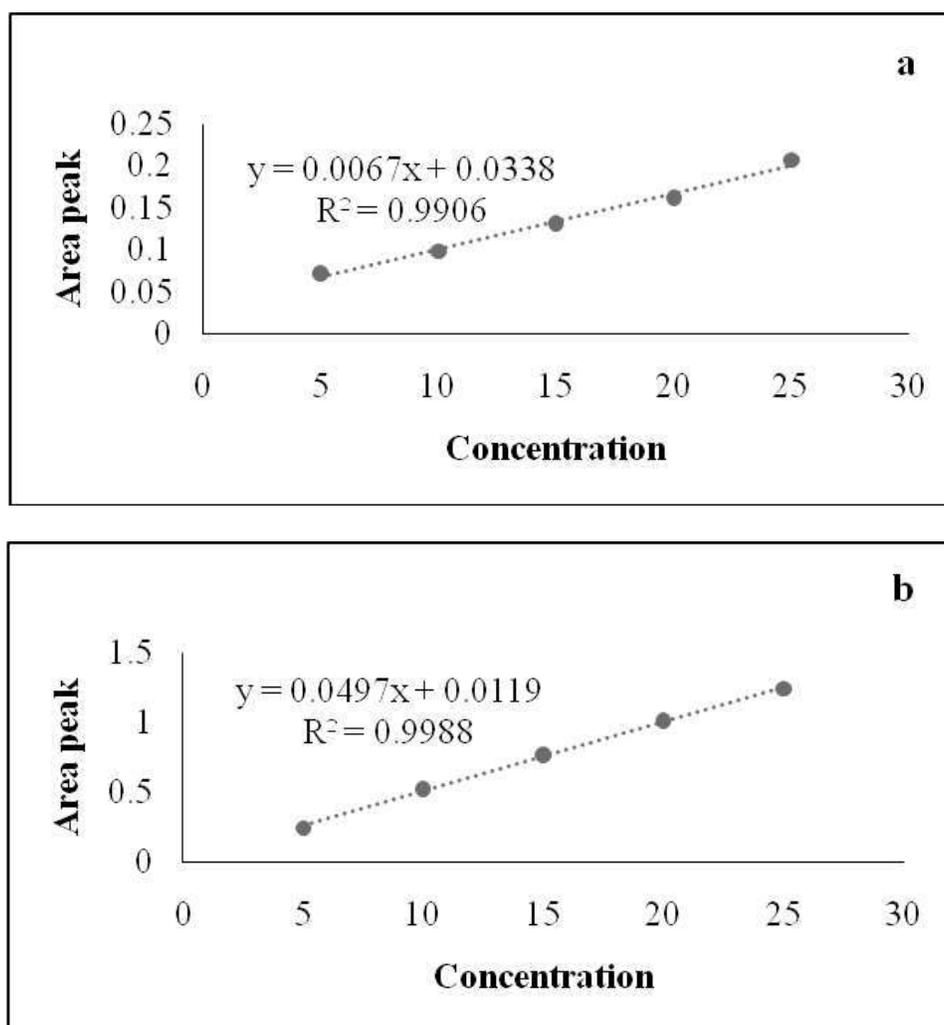
Table 4. The mineral content of three commercially important seaweeds in Bangladesh.

Parameters	Seaweed species		
	<i>G. verrucosa</i>	<i>P. tetrastrumatica</i>	<i>U. intestinalis</i>
Sodium (%)	0.82±0.02 ^a	0.83±0.02 ^a	0.60±0.02 ^b
Potassium (%)	4.47±0.05 ^a	2.41±0.03 ^b	2.20±0.04 ^c
Calcium (%)	2.54±0.04 ^a	1.11±0.02 ^b	0.67±0.02 ^c
Magnesium (%)	0.58±0.02 ^a	0.34±0.01 ^b	0.59±0.01 ^a
Phosphorus (%)	0.31±0.03 ^a	0.07±0.00 ^c	0.18±0.01 ^b
Sulfur (%)	1.56±0.05 ^b	0.95±0.03 ^c	3.90±0.06 ^a
Na/K	0.18±0.01 ^c	0.34±0.01 ^a	0.27±0.01 ^b

Different superscript in a row differs significantly ($p < 0.05$).

Experiment 3. Determination of phenolic and flavonoid content of commercially important seaweeds of Bangladesh

The total phenolic content (Gallic acid) and total flavonoid content (Quercetin) linear calibration curve is given in Figure 2.

**Figure 2.** Calibration curve of (a) gallic acid and (b) quercetin standard.

In the case of *Gracilaria verrucosa*, total phenolic content was significantly higher ($p < 0.05$) in 100% methanol solvent in the freeze-dried sample (Table 5) and total flavonoid content was significantly higher ($p < 0.05$) in 100% acetone and 100% methanol solvent in the freeze-dried sample (Table 6).

Table 5. Total phenolic content of the different solvent and solvent fractions (methanol, ethanol, acetone, and water) of *Gracilaria verrucosa*.

Solvents	Total phenolic content (mg GAE/g dry weight)		
	Freeze-dried	Oven-dried	Sun-dried
50% methanol	27.13±0.85 ^g	22.88±0.92 ^f	21.37±0.83 ^e
70% methanol	33.62±1.76 ^e	25.34±0.85 ^e	23.72±0.78 ^e
100% methanol	88.70±2.19 ^a	81.53±2.38 ^a	73.85±2.27 ^a
50% ethanol	29.82±0.98 ^f	24.44±0.79 ^e	21.51±0.71 ^e
70% ethanol	37.43±1.52 ^d	22.20±0.71 ^f	26.63±0.91 ^d
100% ethanol	43.02±1.38 ^c	40.56±1.06 ^c	37.27±1.15 ^c
50% acetone	36.76±0.92 ^d	24.00±0.97 ^e	22.50±0.72 ^e
70% acetone	39.89±1.05 ^c	21.76±0.80 ^f	27.05±0.98 ^d
100% acetone	70.34±1.78 ^b	68.32±1.59 ^b	61.53±1.27 ^b
Water	40.56±1.36 ^c	31.38±1.01 ^d	28.17±0.86 ^d

Different superscript in a column differs significantly ($p < 0.05$).

Table 6. Total flavonoid content of the different solvent and solvent fractions (methanol, ethanol, acetone, and water) of *Gracilaria verrucosa*.

Solvent	Total flavonoid content (mg QE/g dry weight)		
	Freeze-dried	Oven-dried	Sun-dried
50% methanol	22.76±0.78 ^d	19.71±0.67 ^g	14.65±0.75 ^g
70% methanol	32.89±1.14 ^d	29.73±0.92 ^e	22.47±0.81 ^e
100% methanol	71.46±2.17 ^a	69.55±2.51 ^b	60.16±1.97 ^b
50% ethanol	17.51±0.83 ^e	12.40±0.62 ^h	13.73±0.68 ^g
70% ethanol	23.76±0.91 ^d	19.89±0.75 ^g	14.50±0.72 ^g
100% ethanol	42.51±1.42 ^c	34.78±1.03 ^d	28.93±0.83 ^d
50% acetone	23.08±0.96 ^d	21.90±0.86 ^f	18.04±0.75 ^f
70% acetone	41.37±1.15 ^d	38.04±0.98 ^c	31.48±0.91 ^c
100% acetone	75.06±2.47 ^a	74.70±2.63 ^a	65.18±1.99 ^a
Water	49.27±1.56 ^b	21.26±0.85 ^f	19.38±0.82 ^f

Different superscript in a column differs significantly ($p < 0.05$).

In the case of *Padina tetrastromatica*, total phenolic content was significantly higher ($p < 0.05$) in 100% acetone solvent in the freeze-dried sample (Table 7) and total flavonoid content was also significantly higher ($p < 0.05$) in 100% acetone solvent in the freeze-dried sample (Table 8).

Table 7. Total phenolic content of the different solvent and solvent fractions (methanol, ethanol, acetone, and water) of *Padina tetrastromatica*.

Solvent	Total phenolic content (mg GAE/g dry weight)		
	Freeze-dried	Oven-dried	Sun-dried
50% methanol	24.52±0.73 ^g	20.71±0.85 ^h	16.37±0.72 ^g
70% methanol	40.05±0.97 ^e	36.38±1.76 ^e	29.94±0.96 ^{de}
100% methanol	68.74±1.95 ^b	62.80±2.19 ^b	57.69±1.73 ^b
50% ethanol	19.50±0.81 ^h	25.04±0.98 ^g	15.50±0.64 ^g
70% ethanol	39.68±0.99 ^e	45.49±1.52 ^d	28.61±0.86 ^e
100% ethanol	61.16±2.52 ^c	57.58±1.38 ^c	51.90±1.71 ^c
50% acetone	32.59±1.03 ^f	29.79±0.92 ^f	21.46±0.85 ^f
70% acetone	48.06±1.61 ^d	37.40±1.05 ^e	33.84±0.91 ^d
100% acetone	73.81±2.16 ^a	68.17±1.78 ^a	61.81±2.45 ^a
Water	41.49±0.96 ^e	35.34±1.36 ^e	31.06±0.84 ^d

Different superscript in a column differs significantly ($p < 0.05$).

Table 8. Total flavonoid content of the different solvent and solvent fractions (methanol, ethanol, acetone, and water) of *P. tetrastromatica*.

Solvent	Total flavonoid content (mg QE/g dry weight)		
	Freeze-dried	Oven-dried	Sun-dried
50% methanol	18.67±0.75 ^h	15.22±0.63 ^h	13.53±0.41 ^f
70% methanol	29.27±0.81 ^e	23.78±0.86 ^f	19.89±0.75 ^e
100% methanol	58.15±2.05 ^b	53.49±1.75 ^b	49.50±1.27 ^b
50% ethanol	17.99±0.58 ^h	12.68±0.67 ⁱ	13.61±0.56 ^f
70% ethanol	37.61±0.91 ^d	34.72±1.02 ^e	28.36±0.83 ^d
100% ethanol	51.09±2.10 ^c	48.66±1.58 ^c	45.02±0.98 ^c
50% acetone	21.50±0.72 ^g	20.17±0.81 ^g	19.26±0.58 ^e
70% acetone	38.75±0.86 ^d	41.00±0.95 ^d	43.58±0.81 ^c
100% acetone	63.18±2.41 ^a	58.44±1.67 ^a	55.67±1.05 ^a
Water	24.74±0.95 ^f	22.53±0.72 ^f	20.17±0.62 ^e

Different superscript in a column differs significantly ($p < 0.05$).

In the case of *Ulva intestinalis*, total phenolic content was significantly higher ($p < 0.05$) in 100% methanol solvent in the freeze-dried sample (Table 9) and total flavonoid content was also significantly higher ($p < 0.05$) in 100% methanol solvent in the freeze-dried sample (Table 10).

Table 9. Total phenolic content of the different solvent and solvent fractions (methanol, ethanol, acetone, and water) of *Ulva intestinalis*.

Solvent	Total phenolic content (mg GAE/g dry weight)		
	Freeze-dried	Oven-dried	Sun-dried
50% methanol	3.52±0.37 ^f	1.84±0.32 ^d	1.37±0.33 ^f
70% methanol	5.62±0.76 ^d	2.41±0.35 ^d	2.32±0.38 ^e
100% methanol	12.59±1.07 ^a	8.58±0.98 ^a	8.02±0.87 ^a
50% ethanol	2.35±0.58 ^g	1.04±0.29 ^e	0.97±0.28 ^f
70% ethanol	4.81±0.82 ^e	2.27±0.31 ^d	2.03±0.31 ^e
100% ethanol	7.02±0.78 ^e	5.07±0.36 ^c	4.29±0.35 ^d
50% acetone	2.76±0.42 ^g	1.72±0.40 ^d	1.50±0.32 ^f
70% acetone	5.14±0.45 ^d	2.42±0.38 ^d	2.25±0.38 ^e
100% acetone	10.47±0.78 ^b	7.32±0.59 ^b	6.59±0.37 ^b
Water	7.68±0.66 ^e	5.32±0.63 ^c	5.17±0.41 ^c

Different superscript in a column differs significantly ($p < 0.05$).

Table 10. Total flavonoid content of the different solvent and solvent fractions (methanol, ethanol, acetone, and water) of *Ulva intestinalis*.

Solvent	Total flavonoid content (mg QE/g dry weight)		
	Freeze-dried	Oven-dried	Sun-dried
50% methanol	0.95±0.18 ^{ef}	0.91±0.17 ^f	0.90±0.15 ^e
70% methanol	1.79±0.24 ^d	1.53±0.22 ^e	1.57±0.21 ^d
100% methanol	7.92±0.97 ^a	6.03±0.51 ^a	6.16±0.47 ^a
50% ethanol	0.61±0.23 ^f	0.58±0.12 ^g	0.63±0.18 ^e
70% ethanol	1.26±0.21 ^e	1.15±0.15 ^f	1.05±0.22 ^e
100% ethanol	4.37±0.32 ^c	3.78±0.23 ^c	3.62±0.33 ^c
50% acetone	0.78±0.26 ^f	0.69±0.26 ^{fg}	0.64±0.25 ^e
70% acetone	1.57±0.25 ^d	1.38±0.28 ^e	1.42±0.21 ^d
100% acetone	5.86±0.47 ^b	4.89±0.43 ^b	4.18±0.29 ^b
Water	4.27±0.56 ^c	2.96±0.35 ^d	3.38±0.22 ^c

Different superscript in a column differs significantly ($p < 0.05$).

Domestication and Captive Breeding of Brackishwater Finfish Species of Bangladesh

Researchers

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Objectives

- To study the food and feeding habit and reproductive biology of *Otolithoides pama*, *Gagata gagata*, *Sillaginopsis panijus* and *Coilia dussumieri*.
- To domesticate and brood development of *Otolithoides pama*, *Gagata gagata*, *Sillaginopsis panijus* and *Coilia dussumieri*.
- To develop the breeding and larval rearing techniques of *Otolithoides pama*, *Gagata gagata*, *Sillaginopsis panijus* and *Coilia dussumieri*.

Achievement

Name of the experiment/study: To study the food and feeding habit and reproductive biology of *Otolithoides pama*, *Gagata gagata*, *Sillaginopsis panijus* and *Coilia dussumieri*.

Relative Length of Gut (RLG)

Table 1. RLG value of collected fish species

Species	Relative Length of Gut (RLG) (mean±SD)
<i>Otolithoides pama</i>	0.85±0.04
<i>Gagata gagata</i>	0.94±0.06
<i>Sillaginopsis panijus</i>	0.84±0.09
<i>Coilia dussumieri</i>	0.41±0.12

The RLG value of four fish species implies that all the species are carnivorous in nature.

Gastroscopic Index (GaSI)

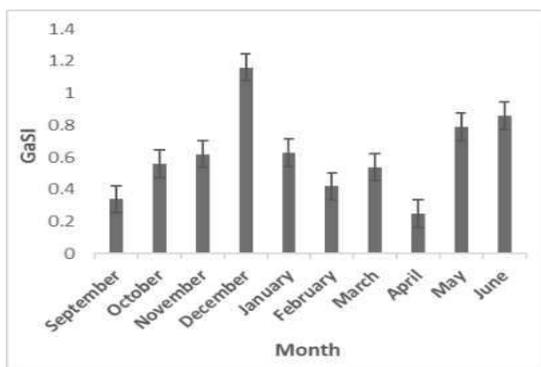


Figure 1. Month wise GaSI of *O. pama*

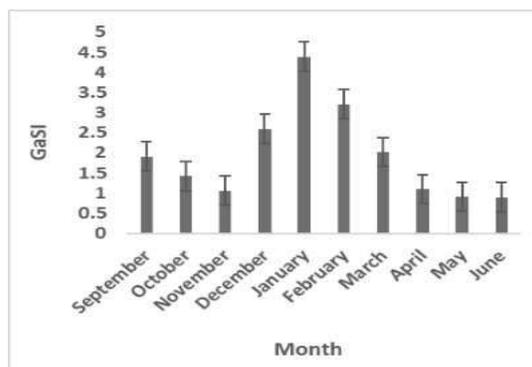


Figure 2. Month wise GaSI of *G. gagata*

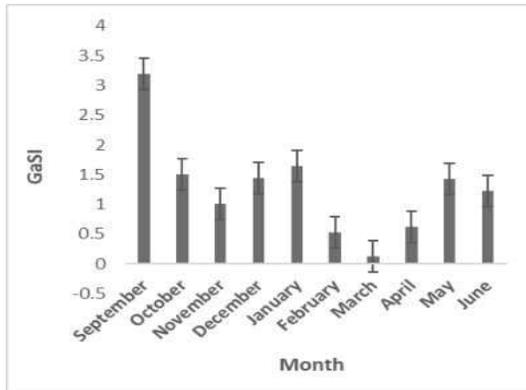


Figure 3. Month wise GaSI of *S. panijus*

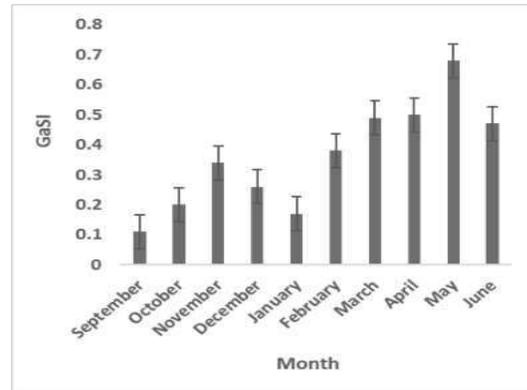


Figure 4. Month wise GaSI of *C. dussumieri*

Table 2. Prey consumed by *O. pama*, *G. gagata*, *S. panijus*, *C. dussumieri*

Groups	<i>O. pama</i>	<i>G. gagata</i>	<i>S. panijnus</i>	<i>C. dussumieri</i>
Fish	<i>Trypauchen vagina</i> <i>Glossogobius giuris</i> <i>Coilia dussumieri</i> <i>Otolithoides Pama</i> <i>Setipinna</i> sp. <i>Polynemus paradiseus</i>	Fish larvae	<i>Trypauchen vagina</i> <i>Glossogobius giuris</i> <i>Coilia dussumieri</i> <i>Setipinna</i> sp. <i>Polynemus paradiseus</i>	Fish larvae
Crustacean	<i>Squilla</i> sp., <i>Actes</i> sp., <i>Scylla</i> sp.		<i>Actes</i> sp., <i>Scylla</i> sp.	<i>Actes</i> sp.
Others	Fish scale, Shrimp shell	Sand, Debris	Fish scale, Crab shell	

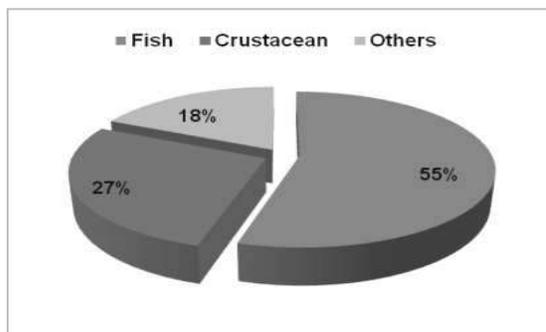


Figure 5. Prey (%) consumed by *O. pama*

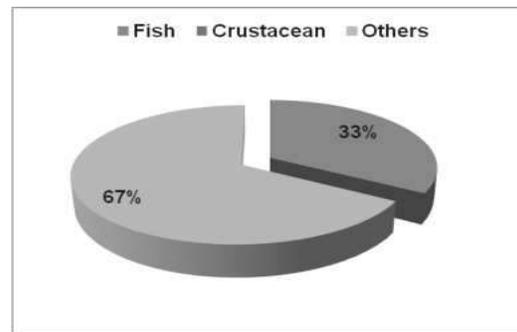


Figure 6. Prey (%) consumed by *G. gagata*

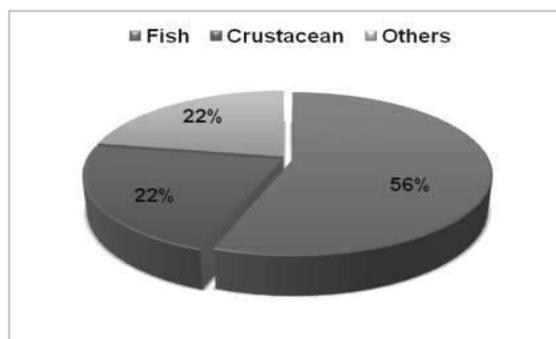


Figure 7. Prey (%) consumed by *S. panijus*

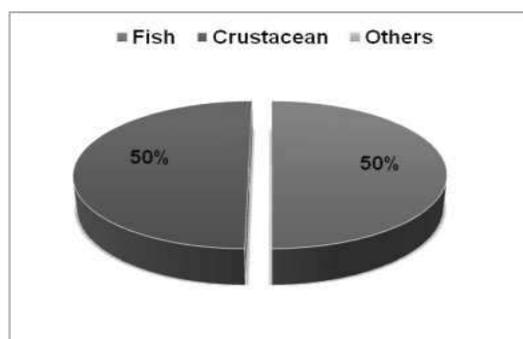


Figure 8. Prey (%) consumed by *C. dussumieri*

Gonadosomatic Index (GSI)

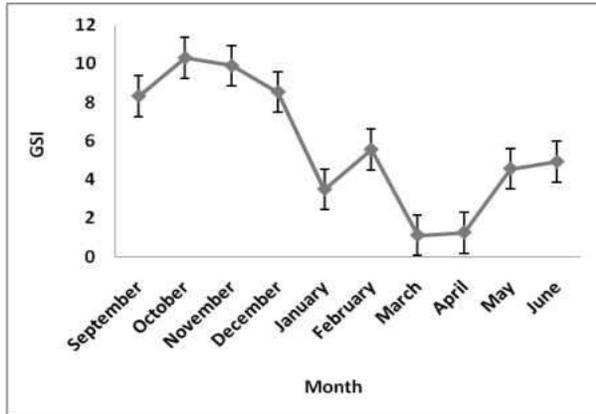


Figure 9. Month wise GSI of *O. pama*

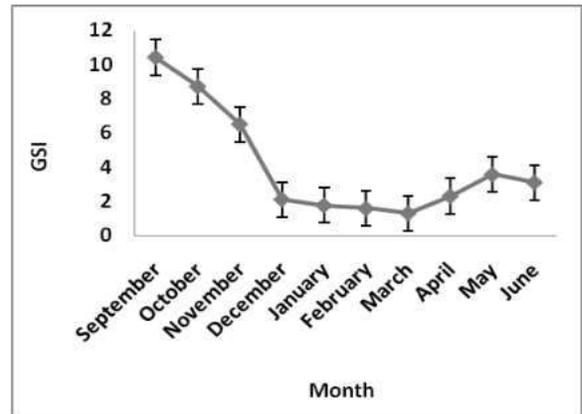


Figure 10. Month wise GSI of *G. gagata*

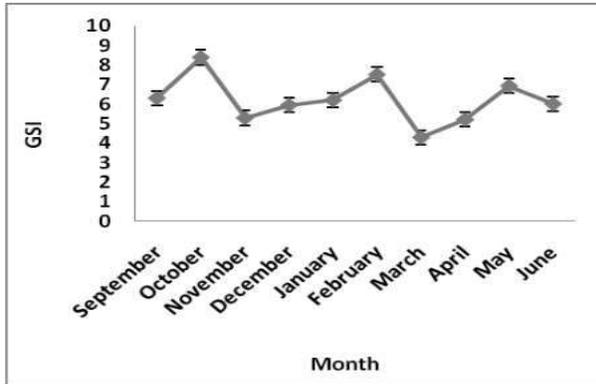


Figure 11. Month wise GSI of *S. panijus*

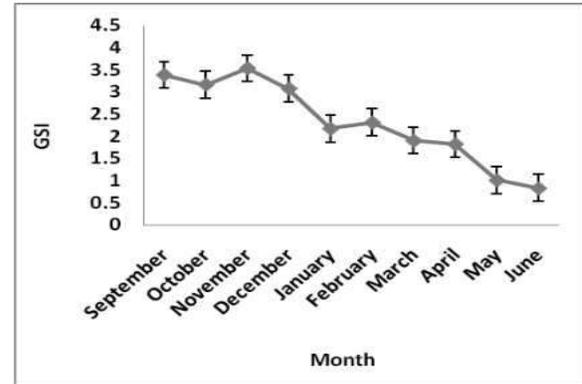


Figure 12. Month wise GSI of *C. dussumieri*

Fecundity

Table 3. Fecundity of collected fish species

Species	Fecundity (range)
<i>Otolithoides pama</i>	52640-63467
<i>Gagata gagata</i>	2700-39500
<i>Sillaginopsis panijus</i>	195000-439500
<i>Coilia dussumieri</i>	6100-12500

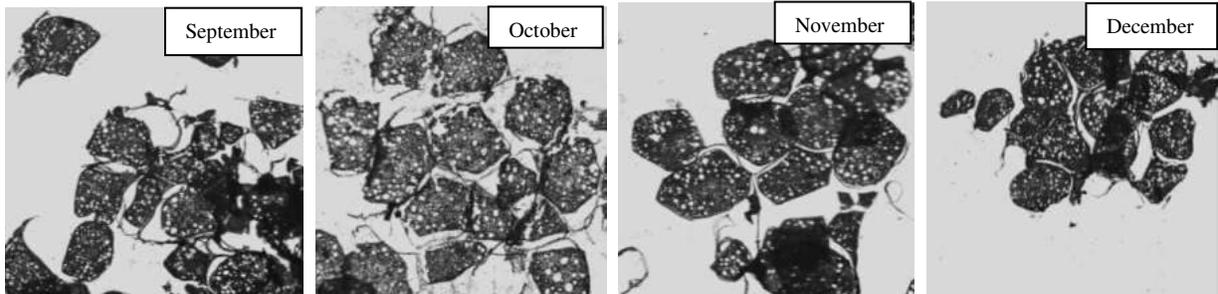


Figure 13. Histological section of *Sillaginopsis panijus* ovary

Name of the experiment/study: Domestication and brood development of *Otolithoides pama*, *Gagata gagata*, *Sillaginopsis panijus* and *Coilia dussumieri*.

Collection and stocking of Brackish water finfish fry:

Fingerlings and sub-adults of *Otolithoides pama*, and *Gagata gagata* were collected from the adjacent river Andharmanik and stocked in the RSS, Khepupara pond.



Figure 14. Collection and stocking of Brackishwater finfish species

Feed and feeding

The fish were fed with live feed (fish larvae, shrimp larvae) @ 3-5% of their body weight, twice daily.

Length-weight relationship

Length-weight relationship of cultured *O. pama* and *G. gagata* shows negative allometric growth for both species.

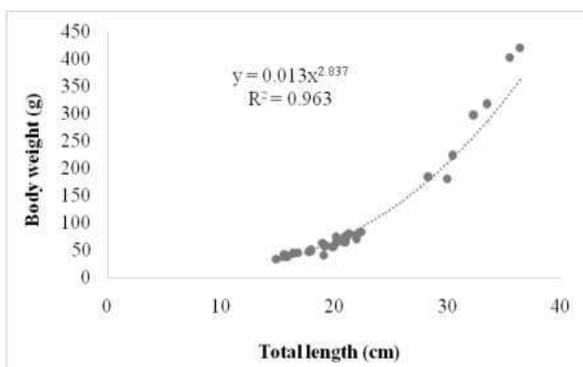


Figure 15. Length-weight relationship of *O. pama*

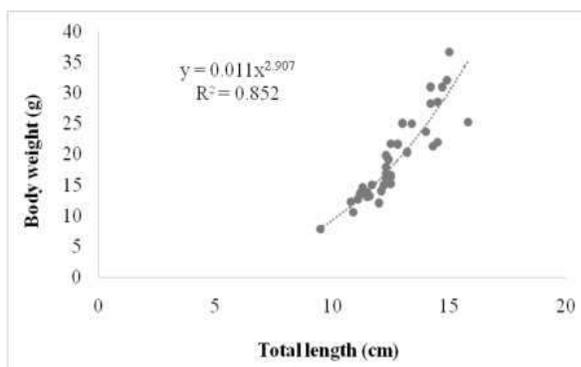


Figure 16. Length-weight relationship of *G. gagata*

Water quality parameters monitoring

Monthly monitoring of water quality parameters (Water Temperature, pH, Dissolve Oxygen, Salinity, TDS, Conductivity, ORP) was conducted. All the parameters were found congenial in range.

Table 4. Water quality parameters in earthen pond

Month	Water Temperature (°C)	p ^H	DO (ppm)	Salinity (ppt)	TDS (ppm)	Conductivity (µs/cm)	ORP (mv)
December	26.2	7.5	6.25	1.12	1096	2193	161.3
January	23.5	8.0	5.87	2.49	2332	4530	103.2
February	25.0	7.7	6.61	2.64	2452	4904	101.0
March	29.4	8.3	6.54	1.26	1230	2470	115
April	33.3	8.2	6.23	4.2	3872	7846	107
May	33.4	8.0	6.12	7.8	6880	13620	95
June	36.9	7.8	5.95	6.7	5953	11882	103
Mean±SD	29.4±4.7	7.9±0.3	6.2±0.3	3.3±2.7	3050.8 ±2324.3	6071.4±4630.7	108.2 ±9.6

Development of Mariculture Practice of Seabass (*Lates calcarifer*) in the South-West Coast of Bangladesh (Component-C)

Researchers

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Objectives

- To develop cage culture technique of Seabass in coastal water of Bangladesh
- To study the growth and survival rate of Seabass in net cages and pond

Achievements

Experiment 1. Culture of Seabass (*Lates calcarifer*) in floating net cages in a tidal river

Design and construction of net cages

The net cages were attached to wooden, GI pipe and bamboo frames. Cages were kept afloat by floating materials such as metal, plastic, foam drum. The shape of the cage was maintained with the use of concrete weights attached to the corners of the cage's bottom. The volume of a floating cage was 64 m³. Six (06) Cages were constructed with mesh size (1 cm) knotless polythene nylon net. Cages were set in the Andhermanik River.

Stocking of Seabass juveniles in cages

Prior to stocking seabass juveniles in the cages, fish were acclimatized to the ambient temperature and salinity prevailing in the cages. Stocking was done following the experimental design denoted 1 ind./m³ as T₁, 1.5 ind./m³ as T₂, and 2 ind./m³ as T₃. Seabass juveniles were stocked in cages on October 15, 2022.



Figure 1. Cage setting and establishment in the Andhermanik river

Feed and feeding

Live feed (tilapia fry, silver carp fry, shrimp, etc.) was supplied at 10% of total biomass. Feeding was done twice daily in the morning at 08:00 hours and afternoon at 17:00 hours. After two months of culture, 30% of live feed was replaced by formulated feed.

Water quality parameters of the cage site of the Andhermanik river

Water quality parameters of the cage site of the Andhermanik river are shown in Table 1.

Table 1. Water quality parameters of Andharmanik river

Month	Water Temperature (°C)	P ^H	Ammonia (ppm)	Salinity (ppt)	DO (ppm)
Oct 22	30.7	7.26	0.01	4.74	5.36
Nov 22	26.7	7.75	0.02	6.65	5.32
Dec 22	23.8	7.43	0.01	8.82	6.21
Jan 23	21.5	7.61	0.02	11.54	5.47
Feb 23	22.84	7.8	0.02	12.65	5.53
Mar 23	26.43	7.41	0.03	11.78	6.32
Apr 23	31.6	7.62	0.02	9.62	6.27
May 23	32.8	7.50	0.01	6.9	6.58
June 23	33.9	7.46	0.01	6.1	5.67
Mean±SD	27.21 ±3.93	7.54 ± 0.23	0.01±0.005	9.08±4.64	5.88±0.47

Growth performances of Seabass in the net cages

From the results, it was observed that stocking density had an effect on the growth of Seabass (Table 2). The highest mean weight was obtained in T₁ (906 g) than in other treatments.

Table 2. Growth performances of Seabass in the net cages in the Andharmanik river

Parameters	T ₁ (1 fish./m ³)	T ₂ (1.5 fish./m ³)	T ₃ (2 fish./m ³)
Culture period (days)	240	240	240
Total stocked fingerling	64	96	128
Initial avg. length (cm)	7.6±2.6	7.6±2.3	7.6±2.4
Final avg. length (cm)	29.2±4.56	27±5.12	26.8±4.16
Initial avg. weight (g)	25.6±7.56	25.6±6.84	25.6±6.13
Final avg. weight (g)	906.69±121.84	753±115.78	695±113.76
Length gain (cm)	21.6±3.25	19.4±2.96	19.2±2.85
Weight gain (g)	881.09±105.38	727.40±97.72	669.30±114.58
SGR (%)	1.81	1.68	1.66
Survival rate (%)	96.87±1.45	93.75±2.71	84.37±3.63
Production (Kg/m ³)	0.93±0.13	1.06±0.21	1.10±0.26

Experiment 2. Culture of Seabass (*Lates calcarifer*) using net cages in Brackishwater ponds

Pond preparation

Ponds were prepared following the standard method before stocking seabass fry. To get rid of unwanted fish species, the pond's bottom was dried out. Drying ensured that hazardous compounds were oxidized and organic matter was mineralized. Floods can carry away the pond's fish during the rainy season, which

is a common problem for most ponds. Despite the pond's proximity to a river or stream, it required a taller embankment or dike. While excavating or de-mudding, this was achieved quickly and effortlessly. For the pond system to work properly, it needed an effective inlet and outlet system. The pond's entry system shape of a pipe through which water enters and departs the system was kept slightly higher than the output system to achieve maximum water flow. The removal of cannibalistic and undesired fish was very important in the pond preparation process. Cannibalistic fish such as shol, gozar, boal, taki were eradicated from the pond by drying it out. Lime was applied at 500g/decimal in two experimental ponds during pond preparation. Fertilizers were also applied in those experimental ponds, urea and TSP at 150 and 75 g/decimal, respectively.

Collection and stocking of Seabass fry

Seabass fry was collected from the Kauwar Char, Kuakata under the Patuakhali district. After acclimation, fry of the same size (27.2 g) was stocked into the ponds on October 15, 2022, at a stocking density of 10, 15, and 20 fry/decimal.

Feed and feeding of Seabass fry

Live feed (tilapia fry, silver carp fry, shrimp etc.) was applied @ 10% of the total biomass of the Seabass fry. Feeding was done twice daily in the morning at 08:00 hours and afternoon at 17:00 hours.

Water quality parameters monitoring

Water quality parameters viz., pH, dissolved oxygen, salinity, and ammonia of pond water were measured fortnightly using a multiparameter water test kit (HANNA, HI98194) recorded.

Growth parameters monitoring

The growth of Seabass was monitored monthly. The length of the fish was measured by a measuring scale and weighed by a digital weighing machine.

Water quality parameters

All the water quality parameters of Seabass rearing ponds were presented in Table 3.

Table 3. Water quality parameters of Seabass rearing ponds

Month	Water Temperature (°C)	pH	Ammonia (ppm)	Salinity (ppt)	DO (ppm)
Oct/22	30.63	7.33	0.01	0.89	5.38
Nov/22	26.7	7.55	0.02	3.00	4.37
Dec/22	23.54	7.43	0.03	5.56	4.69
Jan/23	21.59	7.2	0.02	2.05	5.88
Feb/23	22.84	7.3	0.03	1.99	4.53
Mar/23	26.01	7.87	0.07	2.87	5.45
Apr/23	30.9	8.1	0.03	2.14	6.4
May/23	32.2	7.64	0.06	1.67	5.71
June/23	33.8	7.47	0.04	1.14	5.61
Mean±SD	27.57±4.14	7.54±0.49	0.03±0.008	2.37±1.89	5.335±0.58

Growth performances of Seabass fry in the ponds

The mean initial weight of Seabass fry was 27.2 ± 2.56 , 27 ± 5.15 , and 26.8 ± 2.12 g in T₁, T₂, and T₃, respectively. The final mean weight in T₁, T₂, and T₃ were 760.69 ± 121.84 , 597 ± 115.78 , and 569 ± 113.76 g, respectively (Table 4).

Table 4. Growth performances of Seabass fry in ponds

Parameters	T ₁	T ₂	T ₃
Culture period (days)	240	240	240
Total nos. stocked fingerling	200	300	400
Initial avg. length of fish (cm)	7.60 ± 2.2	7.60 ± 2.7	7.60 ± 2.5
Final avg. length (cm)	30.4 ± 4.51	27.6 ± 5.15	26.1 ± 2.12
Initial avg. weight of fish (g)	25.6 ± 7.56	25.6 ± 6.84	25.6 ± 6.16
Final avg. weight (g)	963.57 ± 115.84	754 ± 105.78	655.06 ± 96.78
Length gain (cm)	22.8 ± 3.16	20 ± 2.86	18.5 ± 3.71
Weight gain (g)	935.17 ± 95.41	726.3 ± 98.62	628.26 ± 91.38
SGR (%)	1.94	1.82	1.76
Survival rate (%)	71.5 ± 3.1	66 ± 4.8	53.25 ± 3.5
Production (Kg/decimal)	6.48 ± 0.73	7.45 ± 0.81	7.40 ± 0.59

Comparison between ponds and net cages

Length gain was higher in T₁ (22.8 g) in the pond. The weight gain was higher in the pond and specifically in T₁ (935.17 g). SGR (%) was higher in the pond and specifically in T₁ (1.94). The survival rate was higher in the cage in all three treatments.

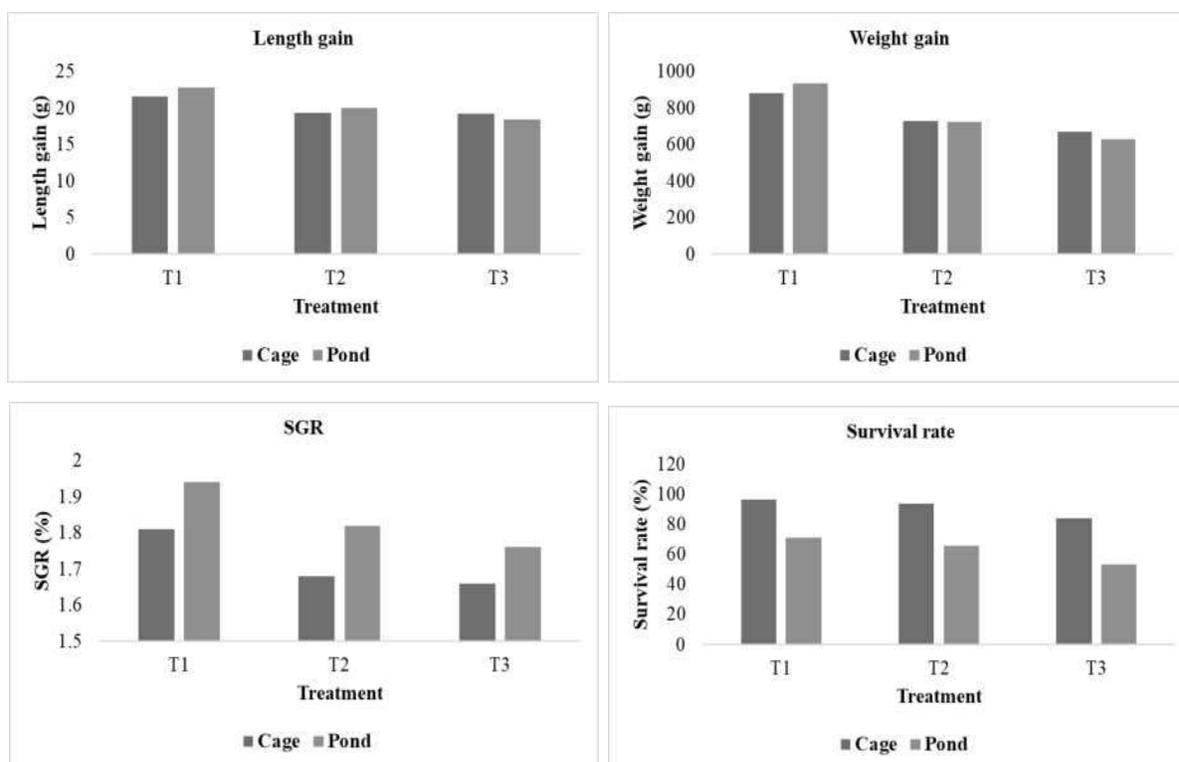


Figure 2. Comparison of weight gain, length gain, SGR (%), and survival rate of pond and cage culture.

Development of Integrated Multi-trophic Aquaculture Systems in South-west coast of Bangladesh

Researchers

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Objectives

- To develop IMTA based shrimp-fish-aquatic weed-mollusks culture to reduce feed cost
- To optimize species combination and stocking density targeting sustainable production in a IMTA system
- To study environmental and economic benefits from IMTA system in local condition

Achievements

Experiment 1: Finding out suitable combination for multi-trophic species aquaculture at brackishwater ghers/ponds

For developing low environmental impacts with minimum economic inputs of optimal IMTA system of tiger shrimp with other brackishwater species in coastal ghers or ponds an experiment was conducted from March 2023 to July 2023 in BS station. Ponds under T₂, T₃, T₄ and C/T₁ were stocked with *Penaeus monodon* at 50000 No/ha as the targeted species. *Oreochromis niloticus*, *Planiliza parsia* and *Mystus gulio* was stocked at 5000, 10000 and 10000 No/ha, respectively in T₂, T₃ and T₄ as fed-species. In addition, T₂ and T₄ contained common water nymph (*Najas gramenia*) at 15% A/ha, while T₃ and T₄ perceived blood cockles (*Anadara granosa*) at 2000 No/ha as extractive species. Each of the treatment had 4 replications and the duration of experiment was 120 days (Table 1). Experimental animals were fed with pellet feed (Crude protein 36%) at 3-5% body weight in three times daily. After 120 days of culture, harvesting was done and biometric parameters (growth, survival, SGR, FCR and BCR) were calculated.

Table 1. Detailed experimental design under IMTA in brackishwater ponds

<i>Species</i>	<i>C/T₁</i>	<i>T₂</i>	<i>T₃</i>	<i>T₄</i>	<i>Cage/T₅</i>
Tiger Shrimp (<i>P. monodon</i>), (No/ha)	50000	50000	50000	50000	50000
Nile Tilapia (<i>O. niloticus</i> , (No/ha)	-	5000	5000	5000	5000
Gold Spot mullet (<i>P. parsia</i> , (No/ha)	-	10000	10000	10000	10000
Long whiskers catfish, (<i>M. gulio</i>), (No/ha)	-	20000	20000	20000	20000
Common water nymph (<i>N. gramenia</i>), (%A/ha)	-	15	-	15	15
Blood cockles (<i>A. granosa</i> , (No/ha)	-	-	2000	2000	2000
Replications	4	4	4	4	4

The initial weight of *P. monodon* was 0.04±0.02 g at stocking and average body weight increased to 41.6±5.91g, 6.3±0.67g, 5.83±0.92g and 6.95±0.71g, with a specific growth rate (SGR) of 5.8±0.47%, 4.33±0.52%, 4.2±0.42% and 4.39±0.55% in T₁, T₂, T₃ and T₄, respectively (Table 2). The survival of shrimp was 70±2%, 72±7%, 80±6% and 75±8% in T₁, T₂, T₃ and T₄, respectively was similar, whereas the final body weight was significantly higher in T₁ than other three IMTA treatments (Table 2).

The stocking weight of *O. niloticus* was 0.29±0.11g in all the treatments and the average body weights increased to 287.9±47.30g, 310.6±43.59g, and 331.3±67.26g, with a specific growth rate of 5.75±0.21%,

5.8±0.28%, and 5.8±0.21% in T₂, T₃ and T₄, respectively (Table 2). The recorded survival of Nile tilapia was 64±5%, 59±6%, 65±9% in T₂, T₃ and T₄, respectively (Table 2). Highest body weight of Nile tilapia was recorded in T₄ followed by T₃ and T₂.

M. gulio had the initial weight of 3.2±0.91g at stocking and reached to 21.9±3.84g, 20.8±4.04g and 21.3±5.33g with the specific growth rate (SGR) of 1.62±0.14%, 1.58±0.13%, and 1.63±0.60% in T₂, T₃ and T₄, respectively. The survival of *M. gulio* was recorded as 88±7%, 86±5% and 90±6% in T₂, T₃ and T₄, respectively (Table 2). The final body weight and survival was more or less similar in all the treatments and had no significant different.

The initial weight of *P. parsia* was same (1.03±0.55g) at stocking (Table 2). After 120 days of culture, the recorded average body weight was 10.40±1.71g, 10.15±1.33g and 10.66±1.22g, with the specific growth rate of 2.0±0.57%, 1.95±0.71% and 2.20±0.67% in T₂, T₃ and T₄, respectively. The survival was 67±6%, 55±2%, 82±3% in T₂, T₃ and T₄, respectively (Table 2). The final body weight was very similar in all the treatments but significantly higher survival was noticed in T₄ followed by T₂ and T₁ (Table 2).

Table 2. Details of growth, survival, SGR, and production under IMTA systems in brackishwater pond conditions

Parameters/ Treatments	Initial length (cm)	Final length (cm)	Initial weight (g)	Final weight (g)	Production (kg/ha)	Survival (%)	SGR (%/day)
Species	Tiger shrimp (<i>P. monodon</i>)						
C./T ₁	0.99±.24	19.7 ±1.95	0.04±.02	41.6±5.91	1457±349.3	70±2	5.8±0.47
T ₂	0.99±.24	9.41±0.71	0.04±.02	6.3±0.67	241.4±45.92	72±7	4.33±.52
T ₃	0.99±.24	9.15±0.69	0.04±.02	5.83±0.92	234±75.66	80±6	4.2±.42
T ₄	0.99±.24	9.60±0.55	0.04±.02	6.95±0.71	262.5±78.48	75±8	4.39±.55
Species	Nile Tilapia (<i>O. niloticus</i>)						
T ₂	0.74±0.18	22.90±2.51	0.29±0.11	287.9±47.30	920.5±311.83	64±5	5.75±.21
T ₃	0.74±0.18	23.6±2.06	0.29±0.11	310.6±43.59	897.50±337.278	59±6	5.8±.28
T ₄	0.74±0.18	23.5±1.71	0.29±0.11	331.3±67.26	1092.65±513.14	65±9	5.8±.21
Species	Long whiskers catfish, (<i>M. gulio</i>)						
T ₂	6.53±0.94	11.95±0.68	3.2±0.91	21.9±3.84	332.2±110.0	88±7	1.62±.14
T ₃	6.65±0.88	10.84±1.62	3.2±0.96	20.8±4.04	303.8±101.3	86±5	1.5±.13
T ₄	6.44±0.90	11.24±2.27	3.1±.72	21.3±5.33	328.5±132.6	90±6	1.6±.60
Species	Gold spot mullet (<i>P. parsia</i>)						
T ₂	3.3±1.05	9.67±1.12	1.03±0.55	10.40±1.71	61.75±17.46	67±6	2.0±.57
T ₃	3.7±2.25	9.81±1.35	1.03±0.43	10.15±1.33	49.4±20.79	55±2	1.95±.71
T ₄	3.2±1.51	10.11±0.86	0.94±0.21	10.66±1.22	81.5±25.71	82±3	2.0±.67

Production of shrimp and other species under IMTA system has been stipulated in Fig. 1. Nile tilapia contributed highest in all the IMTA treatments, whereas catfish (Tengra) stood in second. Lowest production in IMTA system was observed for that of the mullet. Shrimp in all the IMTA treatment augmented similar and low production, whereas shrimp production (1482 kg/ha) in the control treatment (T₁) was significantly higher (p<0.05) than all the IMTA treatments. Shrimp was the targeted species of this experiment, but production of shrimp was severely affected in all the IMTA treatments in comparison to that of the control (only shrimp). Production of shrimp was tremendous in T₁ (control) as a single

species. Highest total production was recorded in T₄ (1967 kg/ha) followed by T₂ (1685 kg/ha), T₃ (1163 kg/ha) and T₁ (Figure 1).

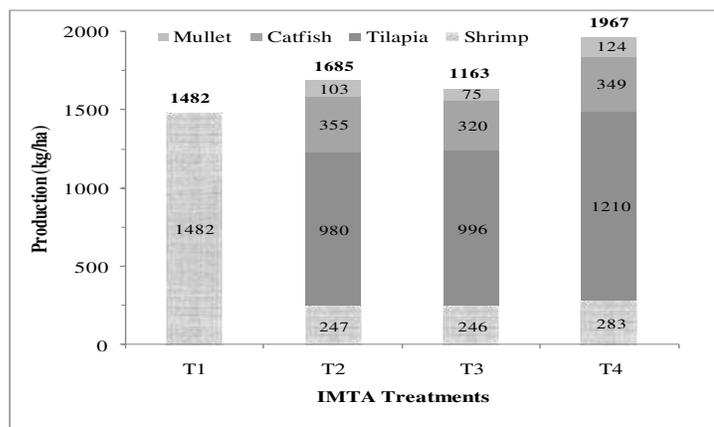


Figure 1. Comparison of production performance of different species under IMTA system in brackishwater ponds

The mean FCR value was 1.5 ± 0.47 , 1.33 ± 0.07 , 1.37 ± 0.06 and 1.14 ± 0.05 in T₁, T₂, T₃ and T₄, respectively (Figure 2). Despite the same feeding regimen and rate, higher FCR value in T₁ happened due to absent of other species in this treatment and augmentation of higher production from other species in all the IMTA treatments (Figure 1). Practically fast growth and higher body weight of tilapia and catfish enhanced the production in T₂, T₃ and T₄. On the other hand, fast and voracious nature of both tilapia and catfish remarkably reduced the weight and production of shrimp in the respective treatments due to high feed competition and consumption of majority of the supplied feed.

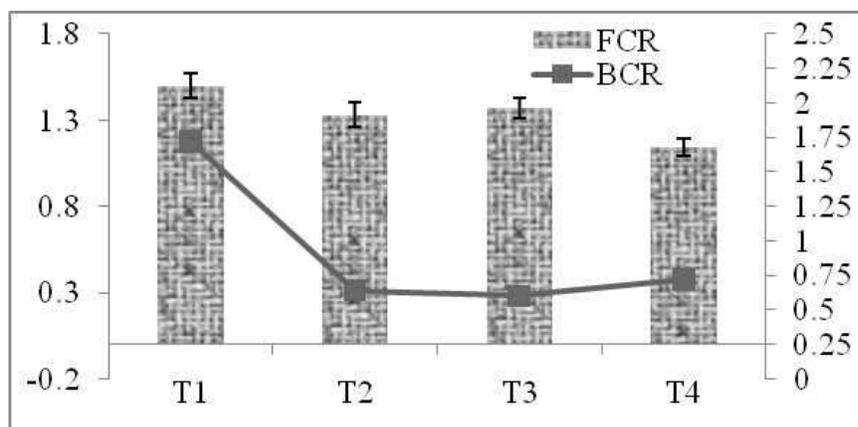


Figure 2. Comparison of FCR and BCR of different treatments under IMTA system in brackishwater ponds

To know the impacts of IMTA systems on sediments profile, bottom sediment samples were collected before stocking, middle of culture and at the end of culture. Sediment samples were processed and analyzed from SRDI (Soil Resource Development Institute), Khulna. Higher amount of Fe 51.14 ± 57.40 ($\mu\text{g/g}$) and 51.01 ± 61.07 ($\mu\text{g/g}$) was noticed in T₁ and T₂ treatments (Table 3). Whereas, the presence of sulfur was 172.27 ± 64.14 ($\mu\text{g/g}$), 84.8 ± 52.0 ($\mu\text{g/g}$), 114.54 ± 4.19 ($\mu\text{g/g}$) and 141.31 ± 33.88 ($\mu\text{g/g}$) in T₁, T₂, T₃ and T₄, respectively indicated the soil as acid sulphate in the ponds. In the case of other parameters such as pH, salinity, organic matter, total nitrogen, phosphorus, calcium and potassium, there was no significant difference among the treatments (Table 3).

Table 3: Sediments profile of IMTA systems in brackishwater ponds

Parameters	Control/T ₁	T ₂	T ₃	T ₄
pH	8.35±0.07	8.05±0.07	8.15±0.07	8.3±0.14
Salinity (ds/m)	8.6±1.27	13.2±1.20	13.6±0.63	13.1±1.41
Organic matter (%)	2.86±0.99	3.03±0.55	2.17±0.50	2.17±0.50
Nitrogen (%)	0.15±0.03	0.17±0.004	0.126±0.029	0.148±0.02
Phosphorus (µg/g)	7.79±1.31	7.53±0.30	8.69±1.36	8.2±2.36
Fe (µg/gm)	51.14±57.40	51.01±61.07	9.26±2.92	6.93±1.82
Sulfur (µg/g)	172.27±64.14	84.8±52.0	114.54±4.19	141.31±33.88
Calcium (meq/100g)	41.25±15.49	33.33±19.99	47.31±0.66	49.60±34.95
Potassium (meq/100g)	0.61±0.06	0.50±0.14	0.54±0.19	7.0±0.11

However, organic content was highly correlated with nitrogen and soil pH was inversely correlated with total nitrogen, sulfur, and zinc in three treatments (Table 03). Despite the acid sulphate soil, the recorded mean soil quality parameters were under suitable ranges for IMTA system, except Fe and Sulfur content in sediments of all treatments.

Table 4: Water quality parameters under IMTA systems in brackishwater ponds

Parameters	Control/T ₁	T ₂	T ₃	T ₄
Salinity (ppt)	15.43±1.64	15.77±1.87	15.44±1.85	15.82±2.10
Temp (°C)	32.52±2.04	32.46±2.24	32.49±2.28	32.01±1.99
pH	8.63±0.19	8.58±0.20	8.66±0.19	8.61±0.14
DO (mg/l)	7.06±2.46	6.33±2.26	6.55±2.03	6.65±2.22
Water level (m)	1.56±0.13	1.13±0.14	1.13±0.14	1.06±0.08
Ammonia(mg/l)	0.05±0.04	0.03±0.01	0.02±0.03	0.04±0.01
Alkalinity(mg/l)	145.5±9.83	152.0±14.46	149.11±15.10	151.04±13.90
TDS (mg/l)	16.44±1.61	16.26±1.48	16.39±1.69	16.96±2.08
Chlorophyll-a (µg/l)	1.09±0.60	1.26±0.66	0.90±0.65	0.89±0.66
EC (µmhos/cm)	24.67±1.47	24.42±1.17	24.59±1.10	24.53±1.56
SSG (mg/l)	6.26±0.21	6.32±0.22	6.22±0.25	6.24±0.52

Water quality parameters of the ponds such as temperature, pH, salinity, water level, DO (Dissolved Oxygen), NO₃-N, NO₂-N, NH₃-N, alkalinity, TDS, EC and SSG and chlorophyll-*a* was investigated in fortnightly interval following standard method (APHA, 2005; Boyd C.E, 1995). Recorded all environmental and physico-chemical variables were found within the acceptable ranges for crustacean aquaculture (Table 4). Meanwhile, water temperature fluctuated in a higher space (30-36) °C during the entire culture period (Figure 3).

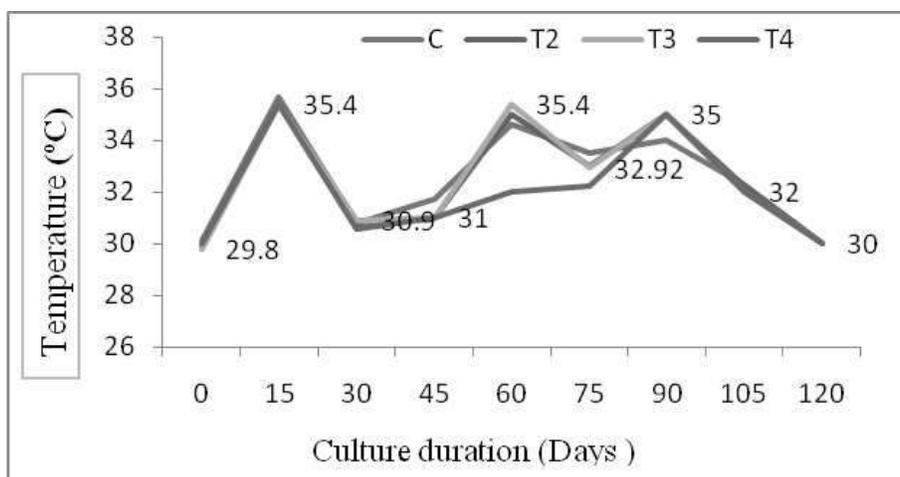


Figure 3. Fluctuation of water temperature during entire culture period under IMTA system

The temperature was recorded as $32.52 \pm 2.04^\circ\text{C}$, $32.46 \pm 2.24^\circ\text{C}$, $32.49 \pm 2.28^\circ\text{C}$ and $32.01 \pm 1.99^\circ\text{C}$ in T₁, T₂, T₃ and T₄, respectively during entire culture period. Treatment T₁ (control) faced extremely oxygen deficiencies at night period and repeatedly happened three times in a week during high temperature 36°C in July 2023. For all this reasons, certain amount of shrimp died in the respective treatment (T₁), but ponds under IMTA treatments (T₂, T₃ and T₄) was out of oxygen depletion and no mortality of shrimp occurred.

Water level 1.13 ± 0.14 m, 1.13 ± 0.14 m and 1.06 ± 0.08 m in T₂, T₃ and T₄ treatments, respectively was found similar and low than that of the water level in T₁ (Figure 4). However, water level in all the experimental ponds was within standard shrimp farming.

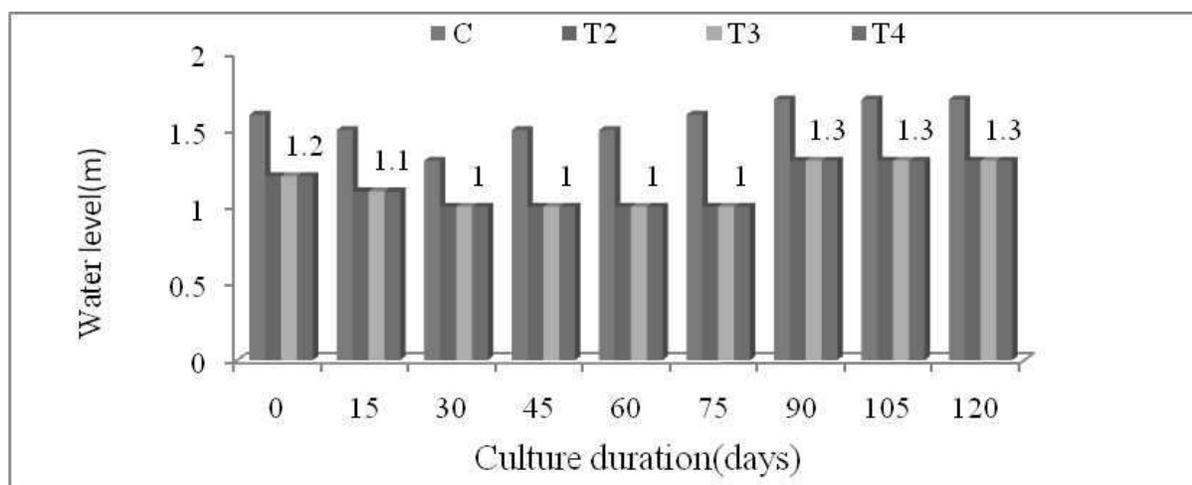


Figure 4. Water level fluctuation during total culture duration in IMTA system

Benefit-cost (BCR) analysis of IMTA system

A simple cost benefit analysis of *P. monodon*, *O. niloticus*, *P. parsia* and *M. gulio* under IMTA system in 25 decimal or 0.1 ha ponds over a culture period of 4 months in brackishwater ponds has been summarized (Table 5). The total variable cost (Tk./100 deci) of farming in this study was 2,78,000/. The average cost in all the treatment (T₁, T₂, T₃ and T₄) was as same as Tk. 69,500/. The calculated net benefit was Tk. 50500/, -24674/, -27262/ and -19294/ in T₁, T₂, T₃ and T₄, respectively. Here the control

treatment (T₁) provided highest and positive return, but all the IMTA treatment had the negative return. All these happened due to higher market price of shrimp produced in T₁. In this study, shrimp was the targeted species in all the treatments and only T₁ produced the premium grade and quality. In other treatments (IMTA) the targeted species shrimp growth was remarkably hampered by the voracious species especially by Nile tilapia. The market price of other tested species (IMTA) was very low and provided minimum return. However, species selection and density optimization might be the main concern to develop a suitable, cost effective, environmental friendly and profitable IMTA system in brackishwater ponds.

Table 5. Benefit-cost analysis of *P. monodon* with other species under IMTA system in brackishwater ponds

Item wise expenditure/costs	T ₁	T ₂	T ₃	T ₄
A. Cost (Tk)				
1. Pond renovation	11000	11000	11000	110000
2. Pond preparation (Lime, Urea, TSP, Ca(OCl)Cl, Molasses, Rice bran, Mustard oil cake, Yeast)	12500	12500	12500	12500
3. ShrimpPL, Tengra, Tilapia, Parshe Juvenile purchase	10000	10000	10000	10000
4. Feeds	35000	35000	35000	35000
5. Labor, transport etc	1000	1000	1000	1000
A. Total Cost	69500	69500	69500	69500
B. Benefits/Incomes from sell				
1. <i>P. monodon</i> (500-800 Tk/kg)	120000	12500	12000	14000
2. <i>O. niloticus</i> (150 Tk/kg)	-	14850	15000	18300
3. <i>P. parsia</i> (300 Tk/kg)	-	3096	2286	3762
4. <i>M. gulio</i> (400 Tk/kg)	-	14380	12952	14144
Total Income	120000	44826	42238	50206
Net Profit (B-A) (Tk)	50500	-24674	-27262	-19294
Benefit-Cost Ratio (BCR)	1.72	0.64	0.60	0.72

Population Dynamics of Important Fish and Shell Fishes in the Sundarbans Mangrove of Bangladesh

Researchers

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Objectives

- To assess the abundance and to estimate growth parameters of important fish and shell fish species
- To calculate the mortality rate and exploitation level of selected species
- To identify vulnerable size groups of a fish species in the Sundarbans and
- To recommend some fish stock management measures on the basis of stock assessment

Achievements

Study 1: Estimation of abundance and growth parameters of selected fish/crustacean species in the Sundarbans mangrove river

Site selection

The Sundarbans mangrove territory consist of three districts namely Bagerhat, Khulna and Shatkhira. The forest lies a little south to the Tropic of Cancer between the latitudes 21°30'N and 22°30'N, and longitudes 89°00'E and 89°55'E (Figure 1). A total of 13 major rivers flow through the Sundarbans and met to the Bay of Bengal. Among 13 rivers, the Shibsha, the Arpangasia (lower stream of the Kholpetua) and the Pashur river of Khulna, Satkhira and Bagerhat district, respectively were selected for sampling. Single sampling station/spot from each river was selected and those are, Hodda in the Sibsha river; Nildumur and Gabura at the joint between the Arpangasia and the Kholpetua river, and Karamjol spot of the Pashur river (Figure 1).

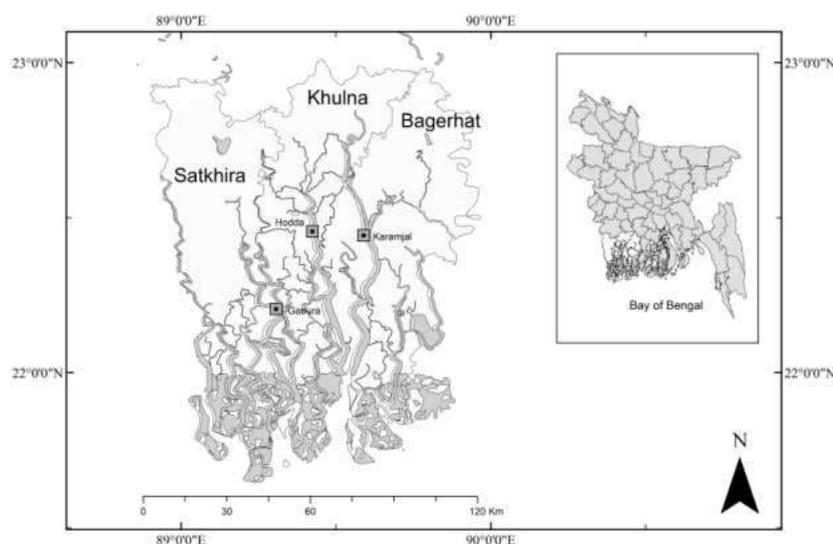


Figure 1. Location of sampling stations

Species selection

At this phase, five commercially important species were considered from three groups of the fishes i.e., fish, crustacean, and mollusk. From the fish group, spotted scat *Scatophagus argus*, tank goby *Glossogobius giuris* and grey-eel catfish *Plotosus canius* were opted again. Mud crab *Scylla olivacea* was picked up again for the next year. Thereafter, the same mollusk, blood cockle *Tegillarca granosa* was considered, by giving impotence the findings of the FGDs, for an assessment to get the important population parameters. In 2022-23, baseline data were collected regarding the five species from different literatures and respondents of FGDs (Figure 2).

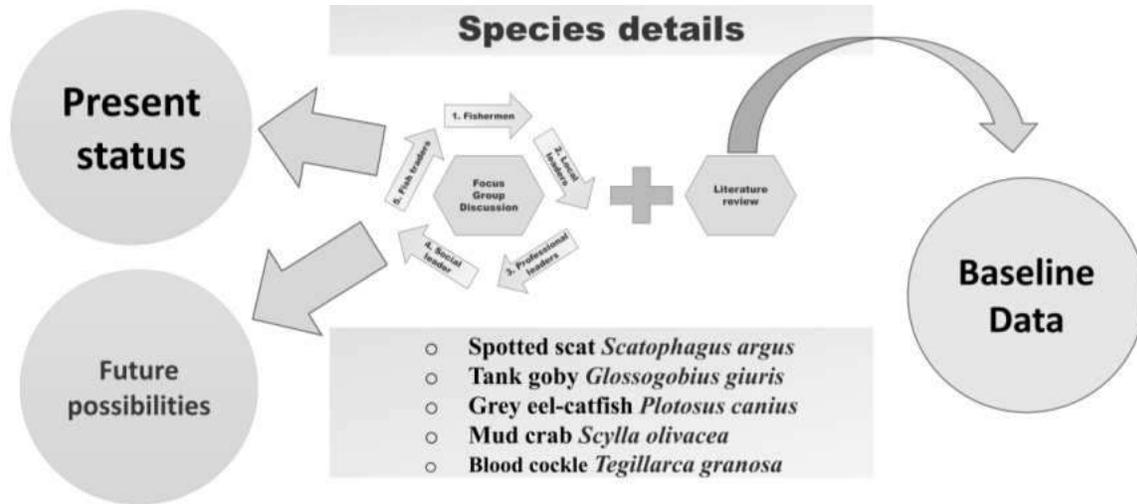


Figure 2. Procedure of collecting baseline data and clarifications of the species

Sampling procedure and frequency

Sampling has been done Monthly basis either during full moon or during new moon period (considering lunar cycle) for a period of 12 months from July 2022 to June 2023 using three types of gear such as Hooks, nets and traps were mostly used in this area for crab harvesting fish and shell-fish. Day long fishing operations were operated for understating the abundance at rivers in the Sundarbans.

Total length (TL) in cm and total body weight (BW) in g for each individual was measured using measuring scale and an electronic balance, respectively. For shellfishes, total length estimation were observed as carapase width (CW) and shell length. We calculated Length-Weight Relationship (LWR) using the equation:

$$BW = a \times TL^b \dots\dots\dots (1)$$

Where, BW is the totalbody weight (g), and TL is the total length (cm). The estimation of parameters a and b wasdone by linear regression analyses, which follows equation such as $\ln(W) = \ln(a) + b\ln(L)$. Additionally, 95% confidence interval was calculated for parameters a and b. We were also calculated the coefficient of determination (r^2). Regression analyses were performed to eliminate outliers (Froese, 2006).Statistical Product and Service Solution (SPSS) software was used to perform statistical analyses. The statistical difference from the isometric value ($b = 3$)for LWRs were determined by t-test. All statistical analyses were considered at 5%significance level ($p < 0.05$).

Generally, CPUE is estimated by dividing annual fish landing amount by a total number of fishing trips in a year. Moreover, CPUE can also be calculated by considering fishing days and vessel numbers. CPUE is

one of the important indices of species abundance (Chen and Chiu, 2009). However, it is not a firm indicator of stock abundance since it can be influenced by some factors (Harley et al., 2001). Usually, these factors affect fish harvest from the sea during fishing operation (Maunder et al., 2006). Like other factors, vessel’s capacity in gross registered tonnage (GRT) was found as a significant contributor to CPUE (Parente, 2004). In this study, a standard formula to estimate the abundance of a species as follows:

$$C_t = P_t / T_t \dots\dots\dots(2)$$

where C is the catch per unit effort (CPUE) for fish species (Kg.day⁻¹.person⁻¹). C_t is the CPUE for the year t. P_t represents fish catch for a particular season t. T_t indicates number of days of fishing with a particular fishing craft in the same season t.

Incorporated ELEFAN-I (Electronic Length Frequency Analysis) in FiSAT-II program was assigned to estimate the value of asymptotic length and growth co-efficient (K) from formula (3) of the von Bertalanffy;

$$L_t = L_\infty \left(1 - e^{-K(t-t_0)}\right) \dots\dots\dots(3)$$

Where, t indicates the age of a fish species (yr), L is the mean total length at age t (cm), t₀ is the hypothetical age when L is zero, K represents a growth coefficient (yr⁻¹). From K and L_∞ the Growth performance index (ϕ) of species were derived according to the formula of Pauly and Munro (1984);

$$\phi = \text{Log } K + 2 \text{ Log } L_\infty \dots\dots\dots(4)$$

This section was concluded with some finding such as Abundance, length-weight relationship, asymptotic length, growth coefficient, growth performance index of a stock and status of stock.

Length-Weight Relationship

Spotted scat (*Scatophagus argus*)

The relationship between total length (TL) and body weight (BW) of *S. argus* for both sexes has been displayed in Table 1. Logarithmic form of the equation (BW = a × TL^b) was considered to establish TL-BW relationship. All values of total lengths were plotted against the values of respective body weights to complete the scatter diagram for getting a curvilinear relationship (Figure 3). Parabolic curves were made by plotting the calculated value of the body weight against the total length of the *S. argus*. In contrast, the values of log total TL against their log calculated BW were plotted to get a linear line.

Table 1. TL-BW association of sampled *Scatophagus argus* from the Sundarbans of Bangladesh

Species	Size (N)	a	b	r	R ²	Allometry	p-Value
<i>Scatophagus argus</i>	1280	0.03	2.95	0.99	0.98	Negative	0.00

The estimated b value was calculated as 2.95. *S. argus* showed negative growth allometry but close to isomerism (b = 3). The Pearson correlation co-efficient (r) values was estimated as 0.99 for *S. argus*. It indicates highly significant relationships (p = 0.00) between TL and BW of this species.

Tank goby (*Glossogobius giuris*)

In Table 2, the association between total length (TL) and body weight (BW) of *G. giuris* has been shown. A TW-BW relationship was established in a form of the equation, BW = a × TL^b. All values of total lengths (TL) were plotted against the values of respective body weights (BW) to complete the scatter diagram for getting a curvilinear line (Figure 4). Parabolic curves were made by plotting the calculated value of the body weight against the total length of the *G. giuris*. In contrast, the values of log total TL against their log calculated BW were plotted to get linear lines.

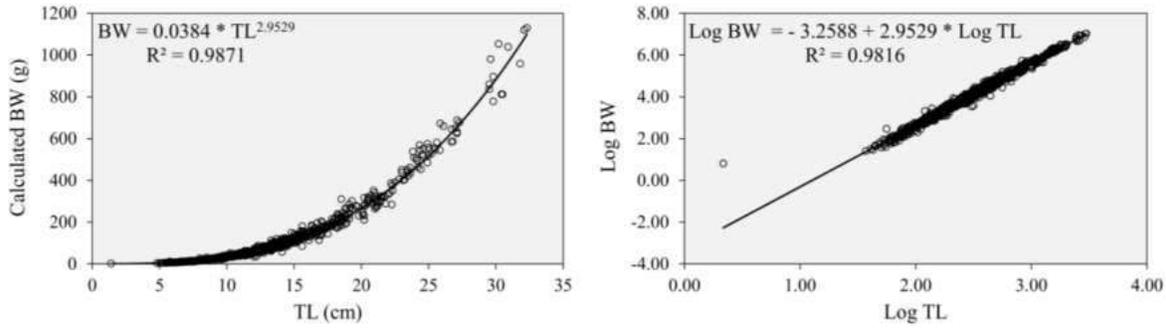


Figure 3. The relationship between Total length (TL) and body weight (BW) of *Scatophagus argus* in the Sundarbans mangrove forest of Bangladesh

Table 2. TL-BW association of sampled *Glossogobius giurus* from the Sundarbans of Bangladesh

Species	Size (N)	a	b	r	R ²	Allometry	p-Value
<i>Glossogobius giurus</i>	2003	0.009	2.96	0.97	0.95	Negative	0.00

The number of total sampled *G. giurus* was 2003. The estimated *b* value was calculated as 2.96. This species showed negative growth allometry but almost isometric. The Pearson correlation co-efficient (*r*) value was estimated as 0.97. It reveals highly positive and significant relationships (*p* = 0.00) between TL and BW of this species.

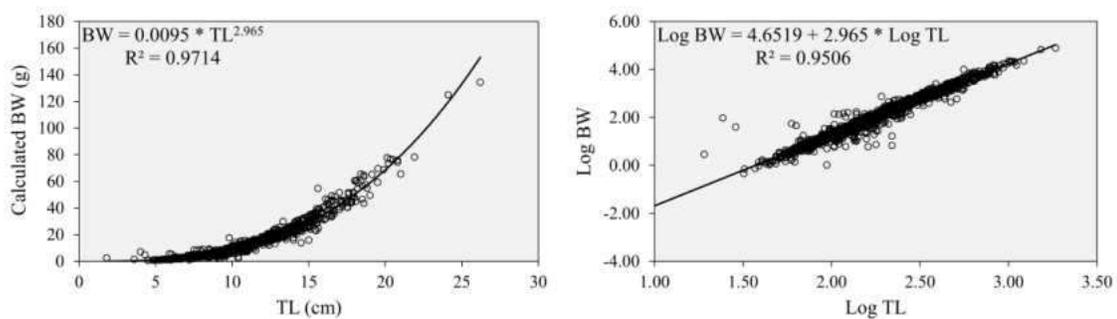


Figure 4. The relationship between Total length (TL) and body weight (BW) of *Glossogobius giurus* in the Sundarbans mangrove forest of Bangladesh

Blood cockle (*Tegillarca granosa*)

The relationship between shell length (SL) and body weight (BW) of *T. granosa* has been displayed in [Table 3](#). Logarithmic form of the equation ($BW = a \times SL^b$) was considered to establish SL-BW relationship. All values of shell length were plotted against the values of respective body weights to complete the scatter diagram for getting a curvilinear relationship (Figure 5). Parabolic curves were made by plotting the calculated value of the body weight against the shell length of the *T. granosa*. In contrast, the values of log total SL against their log calculated BW were plotted to get a linear line.

Table 3. SL-BW association of sampled *Tegillarca granosa* from the Sundarbans of Bangladesh

Species	Size (N)	a	b	r	R ²	Allometry	p-Value
<i>Tegillarca granosa</i>	4019	0.86	2.53	0.95	0.91	Negative	0.00

The number of sampled *T. granosa* was 4019. The estimated *b* value was 2.53 for the species. *T. granosa* showed negative growth allometry. The Pearson correlation co-efficient (*r*) values were estimated as 0.95

for *T. granosa*. It showed a positive and highly significant relationships ($p = 0.00$) between SL and BW of this species.

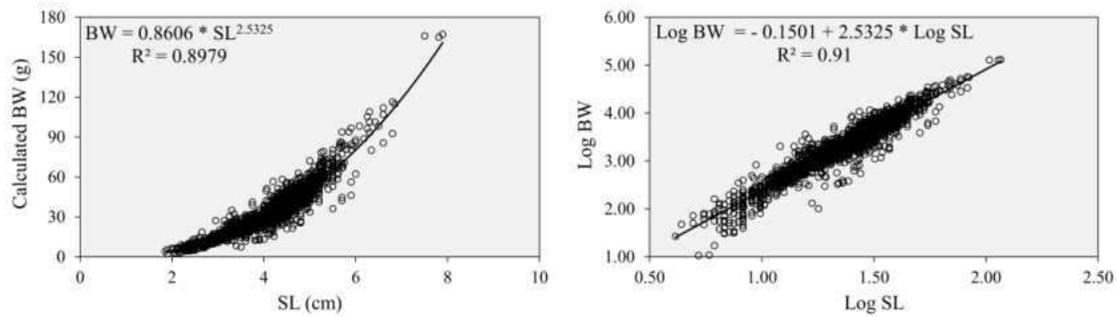


Figure 5. The relationship between shell length (SL) and body weight (BW) of *Tegillarca granosa* in the Sundarbans mangrove forest of Bangladesh

Mud crab (*Scylla olivacea*)

The relationship between carapace width (CW) and body weight (BW) of *S. olivacea* for both sexes has been displayed in Table 4. Logarithmic form of the equation ($BW = a \times CW^b$) was considered to establish CW-BW relationship. All values of carapace widths were plotted against the values of respective body weights to complete the scatter diagram for getting a curvilinear relationship (Figure 6). Parabolic curves were made by plotting the calculated value of the body weight against the carapace width of the *S. olivacea*. In contrast, the values of log total CW against their log calculated BW were plotted to get linear lines.

Table 4. TL-BW association of sampled *Scylla olivacea* from the Sundarbans of Bangladesh

Species	Size (N)	<i>a</i>	<i>b</i>	<i>r</i>	<i>R</i> ²	Allometry	p-Value
<i>Scylla olivacea</i>	2651	0.18	3.01	0.95	0.91	Isomerism	0.00

The total number of the mud crab sample size (N) was 2651. The estimated *b* values were 3.01 for *S. olivacea*. This shellfish showed isometric growth. The Pearson correlation co-efficient (*r*) values were estimated as 0.95 for both sexes of *S. olivacea*. It indicates highly significant relationships between CW and BW of this species.

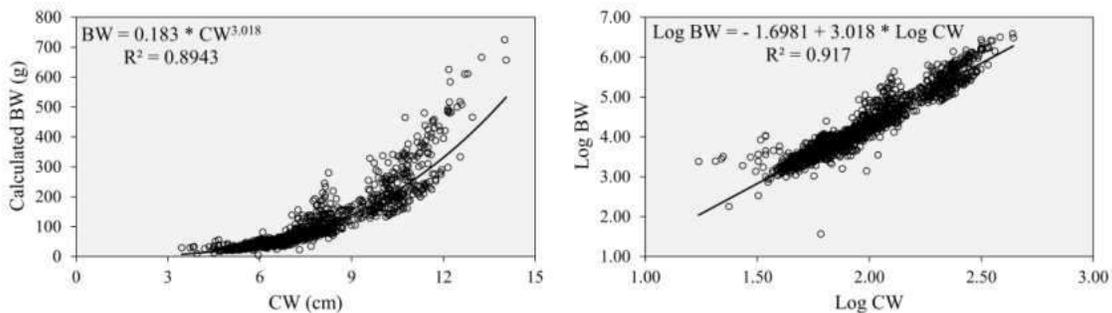


Figure 6. The relationship between carapace width (CW) and body weight (BW) of *Scylla olivacea* in the Sundarbans mangrove forest of Bangladesh

Gray eel-catfish (*Plotosus canius*)

The relationship between total length (TL) and body weight (BW) of *P. canius* for both sexes has been displayed in Table 5. Logarithmic form of the equation ($BW = a \times TL^b$) was considered to establish TL-

BW relationship. All values of total lengths were plotted against the values of respective body weights to complete the scatter diagram for getting a curvilinear relationship (Figure 7). Parabolic curves were made by plotting the calculated value of the body weight against the total length of the *P. canius*. In contrast, the values of log total TL against their log calculated BW were plotted to get a linear line.

Table 5. TL-BW association of sampled *Plotosus canius* from the Sundarbans of Bangladesh

Species	Size (N)	<i>a</i>	<i>b</i>	<i>r</i>	<i>R</i> ²	Allometry	p-Value
<i>Plotosus canius</i>	728	0.006	2.96	0.99	0.98	Negative	0.00

The estimated *b* value was calculated as 2.96. *S. argus* showed negative growth allometry but close to isomerism (*b* = 3). The Pearson correlation co-efficient (*r*) values was estimated as 0.99 for *P. canius*. It indicates highly significant relationships (*p* = 0.00) between TL and BW of this species.

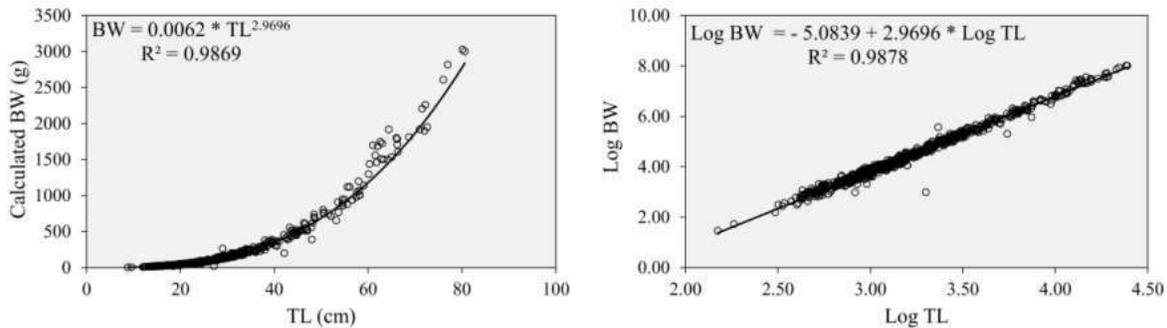


Figure 7. The relationship between total length (TL) and body weight (BW) of *Plotosus canius* in the Sundarbans mangrove forest of Bangladesh

Species-wise abundance

From the fish group, abundance of spotted scat *Scatophagus argus* (Linnaeus, 1766), tank goby *Glossogobius giuris* (Hamilton, 1822) and grey-eel catfish *Plotosus canius* were 700 gm, 400 gm and 1,100 gm per person in one day. Similarly, abundance of mud crab *Scylla olivacea* and blood cockle *Tegillarca granosa* were 2.1 kg and 18 kg per person on daily basis (Table 6).

Table 6. Species-wise abundance in the Sundarbans

Species	CPUE (weight/person/day)
Spotted scat (<i>Scatophagus argus</i>)	700 gm/person/day
Tank goby (<i>Glossogobius giuris</i>)	400 gm/person/day
Blood cockle (<i>Tegillarca granosa</i>)	18,000 gm/person/day
Mud crab (<i>Scylla olivacea</i>)	2,100 gm/person/day
Grey eel-catfish (<i>Plotosus canius</i>)	1,100 gm/person/day

Growth parameters

The von Bertalanffy asymptotic lengths were 34.65 cm, 28.35 cm, 8.93 cm, 15.75 cm and 86.10 cm and the K were 0.56 yr⁻¹, 1.60 yr⁻¹, 0.86 yr⁻¹, 0.92 yr⁻¹ and 0.86 yr⁻¹ for spotted scat, tank goby, blood cockle, mud crab, and grey eel-catfish, respectively (Table 7). The estimated growth performance index (ϕ') of spotted scat, tank goby, blood cockle, mud crab, and grey eel-catfish were observed to be 2.83, 3.10, 1.83, 2.35 and 3.80.

Table 7. Growth parameters of selected species from the Sundarbans

Species	L_{∞}	K	ϕ
Spotted scat (<i>Scatophagus argus</i>)	34.65	0.56	2.83
Tank goby (<i>Glossogobius giuris</i>)	28.35	1.60	3.10
Blood cockle (<i>Tegillarca granosa</i>)	8.93	0.86	1.83
Mud crab (<i>Scylla olivacea</i>)	15.75	0.92	2.35
Grey eel-catfish (<i>Plotosus canius</i>)	86.10	0.86	3.80

Baseline Data of Stocks:

Overall, basic characteristics of all species is shown in Table 8. All stocks were found in declining state. Selected species has a good market demand in all year long. Five years ago, spotted scat (7 kg), tank goby (1.5 kg), blood cockle (80 kg), mud crab (5 kg) and grey eel-catfish (8 kg) were sold by a fisherman in a day. Nowadays, the selling ammount of spotted scat, tank goby, blood cockle, mud crab and grey eel-catfish are declined to 1.6kg, 0.5kg, 20kg, 3kg and 3kg, respectively. the highest weights were mentioned by the respondent as 1.3 kg/pcs, 2 kg/pcs, 0.2 kg/pcs, 1.2kg/pcs and 5 kg/pcs of spotted scat, tank goby, blood cockle, mud crab and grey eel-catfish, respectively.

Table 8. Focus Group Discussion (FGD) on stock status of selected five species

Issues	Spotted scat	Tank goby	Blood cockle	Mud crab	Grey eel-catfish
Market Demand	Year-round	Year-round	Year-round	Year-round	Year-round
Selling amount (5-yr ago)	7 kg/ person/day	1.5 kg/ person/day	80 kg/ person/day	5 kg/ person/day	8 kg/ person/day
Selling amount (Present)	1.6 kg/ person/day	0.5 kg/ person/day	20 kg/ person/day	3 kg/ person/day	3kg/ person/day
Highest weight (5yr ago)	1.3 kg/pcs	2 kg/pcs	0.2 kg/pcs	1.2 kg/pcs	5 kg/pcs
Status/ Comments/ Problem	Declined	Declined	Declined	Declined	Declined

Study 2: Estimation mortality rates and exploitable level of the selected species

Mortality is a key component to understanding the population dynamics of fish species. Total mortality is often estimated from the sequential decline observed in cohorts of fish. length converted catch curve method of Beverton and Holt (1956) was applied to determine total mortality (Z). The formula of the total mortality as follows;

$$Z = F/M..... (5)$$

Where, Z indicates total mortality of the stock, F is the fishing mortality and M is the natural mortality. Natural mortality is the removal of fish from the stock due to causes not associated with fishing. Such causes can include disease, competition, cannibalism, old age, predation, pollution or any other natural factor that causes the death of fish. In fisheries model’s natural mortality is denoted by (M). Natural mortality (M) was estimated according to Pauly (1980) as follows in the formula 4;

$$\log_{10}M = -0.0066 - 0.279 \log_{10}L_{\infty} + 0.6543 \log_{10}K + 0.4634 \log_{10}T (6)$$

where, M indicates natural mortality of the stock, L_{∞} is the asymptotic length of a species, K is the growth co-efficient and T is the habitat temperature. However, fishing mortality rate is the proportion of a

fish stock removed by fishing (as opposed to predation or other causes of death). By following formula, we estimated the fishing mortality;

$$\text{Fishing mortality (F)} = Z - M \dots\dots\dots(7)$$

Applied on a fish stock, it is the proportion of the numbers or biomass removed by fishing. A 10% exploitation rate means that 10% of the available stock is being harvested within the time frame considered (per year, per month, etc.). As a measure of fishing pressure, it is proportional to fishing mortality

$$\text{Exploitation rate (E)} = F/Z \dots\dots\dots(8)$$

Mortality and exploitation

The total mortality (Z) of spotted scat, tank goby, blood cockle, mud crab, and grey eel-catfish were estimated as 2.00 yr⁻¹, 7.74 yr⁻¹, 5.47 yr⁻¹, 6.68 yr⁻¹, and 2.58 yr⁻¹, respectively, by using length converted catch curve analysis (Table 9). Fishing mortalities (F) were 1.12 yr⁻¹, 5.47 yr⁻¹, 3.38 yr⁻¹, 4.82 yr⁻¹, and 1.47 for spotted scat, tank goby, blood cockle, mud crab, and grey eel-catfish, respectively.

Table 9. Mortalities and explitations of selected species from the Sundarbans.

Species	Z	M	F	E	E _{max}
Spotted scat (<i>Scatophagus argus</i>)	2.00	1.08	1.12	0.51	0.48
Tank goby (<i>Glossogobius giuris</i>)	7.74	2.17	5.47	0.71	0.51
Blood cockle (<i>Tegillarca granosa</i>)	5.47	2.09	3.38	0.62	0.72
Mud crab (<i>Scylla olivacea</i>)	6.68	1.86	4.82	0.72	0.62
Grey eel-catfish (<i>Plotosus canius</i>)	2.58	1.11	1.47	0.57	0.45

In contrast, natural mortalities (M) of spotted scat, tank goby, blood cockle, mud crab, and grey eel-catfish were calculated as 1.08 yr⁻¹, 2.17 yr⁻¹, 2.09 yr⁻¹, 1.86 yr⁻¹, and 1.11 yr⁻¹, respectively. Thus, exproitation rate (E) of spotted scat, tank goby, blood cockle, mud crab, and grey eel-catfish were computed as 0.51, 0.71, 0.62, 0.72, and 0.57, respectively (Table 9). The maximum permissible limit of exploitation (E_{max}) values were calculated as 0.48, 0.51, 0.72, 0.62, and 0.45 of spotted scat, tank goby, blood cockle, mud crab, and grey eel-catfish. Spotted scat, tank goby, mud crab, and grey eel-catfish were exceeded the maximum permissible limit of exproitation (E_{max}) except blood cockle.

Study-3: Identifying vulnerable size groups of a fish species

Probability of capture

Probability of capture calculated from the length-converted catch curve routine was used to estimate the final values of L₂₅, L₅₀ and L₇₅ i.e., lengths at which 25%, 50% and 75% of the fish would be vulnerable to the different gears such as different nets, long lines and traps for a specific species (Pauly, 1984).

Virtual population analysis

Virtual population analysis (VPA) is a cohort modeling technique commonly used in fisheries science for reconstructing historical fish numbers at age using information on death of individuals each year. This death is usually partitioned into catch by fisheries and natural mortality. VPA is virtual in the sense that the population size is not observed or measured directly but is inferred or back-calculated to have been a certain size in the past in order to support the observed fish catches and an assumed death rate owing to non-fishery related causes.

Virtual population analysis was introduced in fish stock assessment by Gulland in 1965 based on older work. The technique of cohort reconstruction in fish populations has been attributed to several different

workers including Professor Baranov from Russia in 1918 for his development of the continuous catch equation, Professor Fry from Canada in 1949 and Drs. Beverton and Holt from the UK in 1957. Because cohort reconstruction is essentially an accounting exercise it was likely independently conceived many times. The virtual population analysis (VPA) was employed to estimate the extent of mortality on various size classes of a species. The fishing pressure on a particular sized fish species was indicated against the number of anticipated population (Figure 8).

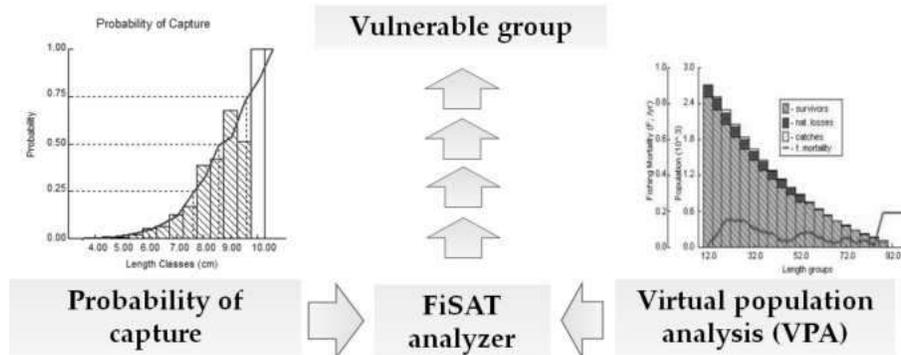


Figure 8. Strategies to calculate vulnerable size group of a species

Vulnerable size groups

Probability of capture is one of the very useful drivers in stock assessment of fisheries science. It shows the vulnerability of different sizes of fin fish and shellfish to different gears in a given location at a given time. The probabilities of capture analysis for spotted scat (*S. argus*) found that 25% of 7.71.16 cm TL, 50% of 8.57 cm TL and 75% of 9.43 cm TL were vulnerable to the gears. Therefore, it can be assumed that more than half of the harvested *S. argus* remained between the total length of 7.71 cm and 9.43 cm. In addition, VPA results reveals that a maximum fishing pressure on *S. argus* population was found between total length group of 11.01-15.00 cm and 29.01-33.0 cm.

Similarly, probabilities of capture analysis for *G. giuris* depicted that 25% of 7.93 cm TL, 50% of 8.63 cm TL and 75% of 9.33 cm TL were vulnerable to the gears. Therefore, it can be assumed that more than half of the harvested crabs remained between the carapace length of 7.93 cm and 9.33 cm. The high values of F for the species occurred within length group, ranging from 9.01 cm to 27 cm.

Again, the probabilities of capture analysis for blood cockle (*T. granosa*) showed that 25% of 3.53 cm SL, 50% of 3.77 cm SL and 75% of 04.02 cm SL were vulnerable to the gears. Therefore, it can be assumed that more than half of the harvested Blood cockle remained between the shell length of 3.53 cm and 4.02 cm. According to VPA analysis, the high values of F for the species occurred within length group, ranging from 4.51 cm to 8.50 cm.

Further, an analysis on the probabilities of capture for mud crab (*S. olivacea*) revealed that 25% of 5.70 cm CW, 50% of 6.02 cm CW and 75% of 6.34 cm CW were vulnerable to the gears. Thus, it can be assumed that more than half of the harvested crabs remained between the carapace length of 5.70 cm and 6.34 cm. In addition, VPA results reveals that a maximum fishing pressure on mud crab population was found between total length group of 6.01-8.00 cm and 11.01-15.0 cm.

Furthermore, the probabilities of capture analysis for grey eel-catfish (*P. canius*) showed that 25% of 14.67 cm TL, 50% of 15.74 cm TL and 75% of 16.81 cm TL were vulnerable to the gears. Therefore, it indicates that more than half of the harvested *P. canius* remained between the total length of 14.64 cm and 16.81 cm. In addition, VPA results indicated that the high peaks of F for *P. canius* occurred within some length groups, ranging from 17.01 cm to 37.00 cm, and 77.01 cm to 82.00.

Potentiality of Aquatic Weed as Alternative Feed Ingredients for the Development of Cost-effective Fish Feed for Coastal Aquaculture

Researchers

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Objectives

- To investigate the status of available aquatic weed in South-west region and make inventory based on morphometry and DNA barcode analysis
- To observe the nutritional status (proximate composition, macro & micro elements) of important aquatic weed
- To examine the potentials of explored weed as dietary ingredients in fish feed

Achievements

Study-1: Identification of potential aquatic weed species using morphometric characteristics and DNA barcodes

The study was conducted in the Bangladesh Fisheries Research Institute, Brackishwater Station, Paikgacha, Khulna according to the following experimental procedures:

Collection of samples from South-western Coastal Area: Sample was collected according to the methodology of the project proposal and many others respective literature review. At first sample was collected from selected four places with special emphasis on coastal gher and mangrove areas. Then the collected weeds were gently washed by water of the respective places for removing mud, dirt and unnecessary substances. Sample was collected very carefully for avoiding contamination of other species.

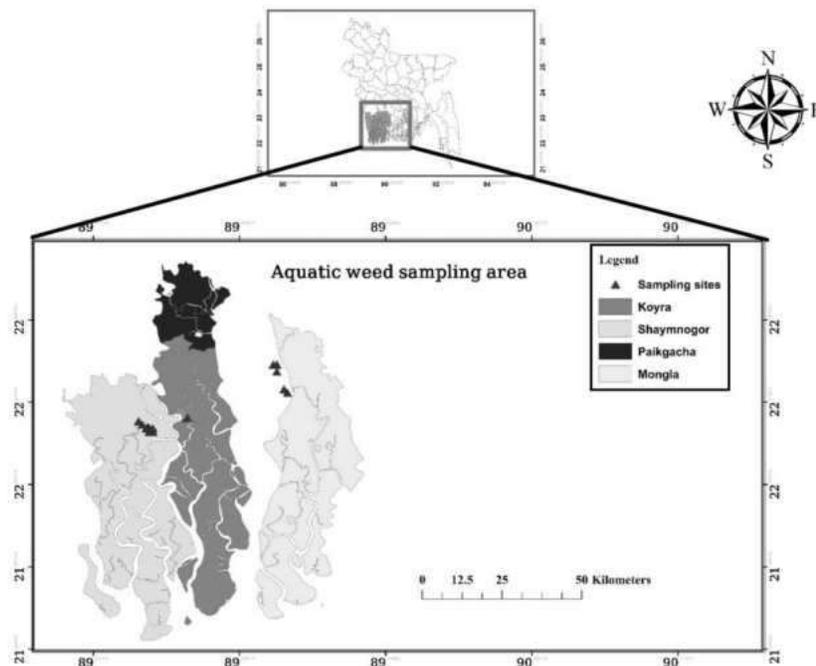


Figure 1. Sampling sites for collection of coastal aquatic weed

On spot packing for travel preservation: Every zipper bag was marked by permanent marker according to sample number recorded in data sheet. Then preliminary washed samples were inserted into zipper bag. For transportationsamples were kept in insulated ice box with ice. Ice box was also kept in cool area of traveling vehicle.

Data recording: With various devices data were taken while sample were collected. Dissolve Oxygen (mg/l) and pH were measured by DO meter and Hanna pH meter, respectively. Salinity (ppt) was taken by a hand refractometer. Total alkalinity (mg/L) was measured by titrimetric method. GPS location (longitude and latitude) was taken by android apps “My GPS Location”. Ecological information was recorded in the field note book.

Weed processing: After reaching at station, samples were taken out from insulated box carefully. Then the collected weeds were washed vigilantly with tap water as morphological characteristics remain same as they were taken from nature. After washing samples were kept in water absorbing foam for removing excessive water. After 30 minutes morphological characteristics such as color, root, branch, cell type, microscopically view of cell, leaf number, appearance etc. were carefully observed and noted down. Then the samples were kept overnight on blotting paper for removing rest of water.

Weed drying and preservation: After 8-10 hours, weed was dried under sun in the weed dryer made by BS technology. After 1-2 days when samples as the weed totally dried were taken out from dryer and preserved in the zipper bags. Zipper bags were marked according to data sheet number before keeping sample. The samples was tagged and kept in a plastic box and placed in a shaded area for further study of nutritional factors as well as subsequent molecular identification through DNA barcoding.

Morphological identification: Each sample was identified morphologically by assessing morphometric characteristics. Different taxonomic book, standard monographs of Boergesen, (1913); Islam, (1976); Sen and Naskar (2003) and Encyclopeia of Flora and Fauna of Bangladesh was used for morphological study. (Figure 2) describes the whole working protocol.

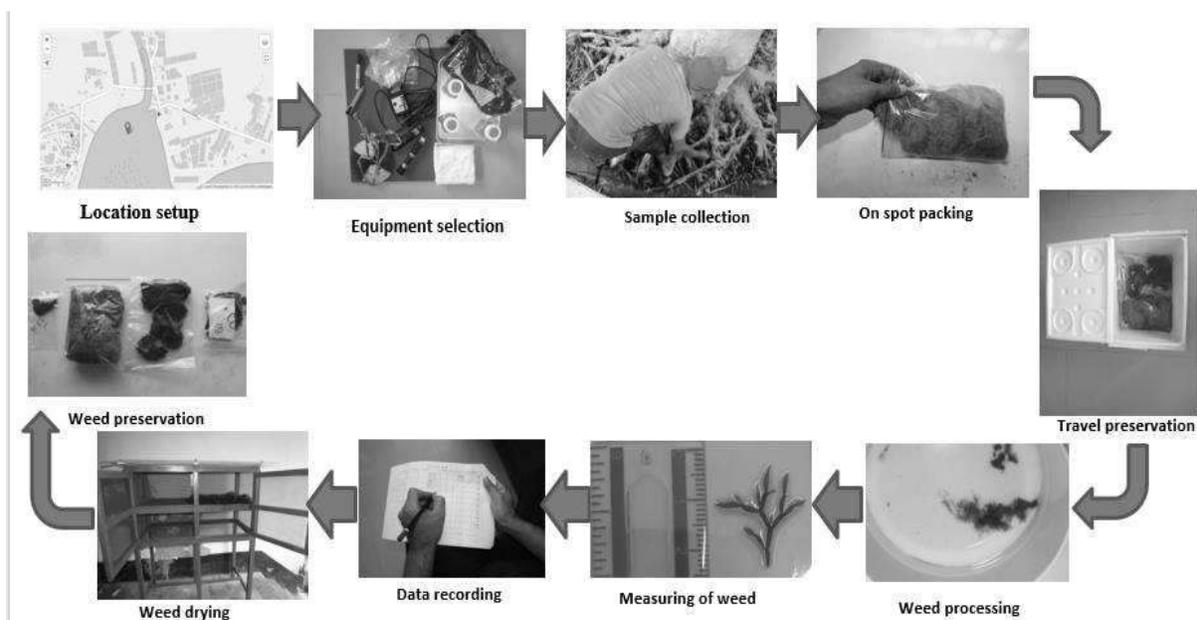


Figure 2. Flowchart of working protocol

DNA extraction, PCR amplification and sequencing: The process of identification of aquatic weed using DNA bar code is on-going. DNA was extracted from collected samples using commercial kits for good success as high-throughput work. The target *rbcL* gene region was amplified using universal plant DNA barcoding primers (CBOL, 2009), *rbcLa*-F: 5'-ATGTCACCACAAACAGAGACTAAAGC-3' and *rbcLa*-R: 5'-GTAAAATCAAGTCCACCRCG-3'. 16S rRNA also can be used for identification of the organisms if necessary. PCR will be performed using a reaction mixture of a total volume of 25 μ l; 12.5 μ l of Taq PCR Master Mix (Invitrogen, India), 11 μ l distilled water, 0.5 μ l forward primer (10 μ M), 0.5 μ l reverse primer (10 μ M), and 0.5 μ l of the DNA template (50–80 ng/ μ l). The PCR conditions were as follows: 1 cycle (94 °C for 3 min), 35 cycles (94 °C for 1 min, 55 °C for 1 min, and 72 °C for 1 min), and 1 cycle 72 °C for 7 min. The same negative control was used during DNA extraction acted as negative control for PCR. PCR products of *rbcL* gene fragment was run and visualized by 1.5% agarose gel electrophoresis (using above protocol described in 5.2.2.) for 600bps amplicon. The purified PCR products will be sequenced by sanger sequencing method in both directions. Each unique sequence will be served as a blast query to the GenBank database to identify the most similar sequence in GenBank to the queried sequence. DNA sequencing will be performed from commercial sequencing company, Macrogen Inc. (Seoul, South Korea).

Molecular identification, genetic diversity and DNA taxonomy using bioinformatic tools: Several computer software and modern bioinformatics program such as Ultra Edit, BioEdit, Clustal X, Interactive Tree Of Life (iTOL), Molecular Evolutionary Genetic Analysis (MEGA) will be used for sequence editing, phylogenetic and population genetic study, and phylogenetic analysis using DNA sequence data by high speed computer. NCBI BLAST search and BOLD database will be used for molecular identification of the weed. The sequences will be aligned in Clustal X ver. 2.0.6 (Thompson et al., 1997) and (MEGA) ver. X will be used for phylogenetic and pair-wise distance analysis (Kumar et al., 2018). The pair-wise distance was calculated as per Kimura-2 parametric distance model (Kimura, 1980). NJ tree will be redrawn using Interactive Tree Of Life (iTOL) (Letunic and Bork, 2019) for better representation of tree based identification. Kimura-2 parameter distance model (Kimura, 1980) will calculate the distances between the sequences. All three codon positions and non-codon positions will included and all the alignment positions containing gaps and missing data will be eliminated from the analysis. MEGA X will be also used to conduct nucleotide diversity and Tajima's neutrality (Tajima, 1989; Nei and Kumar, 2000) tests.

A total of 32 specimen of aquatic weed (last year 28 and current year 4) has been collected from the coastal water body and grouped on the basis of pigmentation. Among the collected weeds, 20 was green, 9 red and 3 was brown in color (Table 1). The green, red and brown weed consisted 63 %, 28 % and 9 %, respectively of total collection (Figure 3). Amongst the 32 samples, 10 have been initially identified morphologically (Figure 4) with the help of different taxonomic books and internet sources, of which 7, 2 and 1 under green, red and brown color, respectively (Table 1).

Table 1: Morphologically Identified weeds

Pigment group	Number in pigment group	Identified number
Green weed	20	7
Red weed	9	2
Brown weed	3	1
Total	32	10

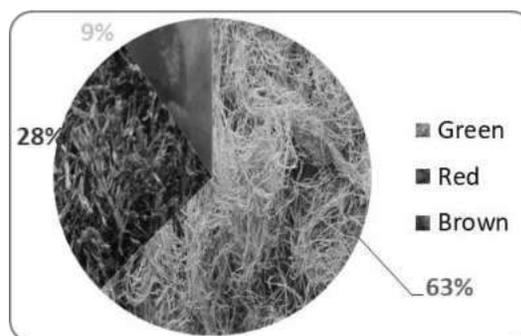


Figure 3. Percentage of identified aquatic weed

List of morphologically identified weeds:

Samples were preliminary identified according to morphometric characteristics and photo combination from ‘Sea Weed of Bangladesh Coast’ book, journals, and also from internet.

Red weed:

1. *Kappaphysis alvarezii*

Green weed:

1. *Najas graminea*
2. *Cladophora laetivirens*
3. *Ulva lactuca*
4. *Ulva compressa*
5. *Enteromorpha intestinalis*
6. *Ulva conglobate*
7. *Chara baltica*

Brown weed:

1. *Colpomenia perigrina*
2. *Colpomenia sinuosa*

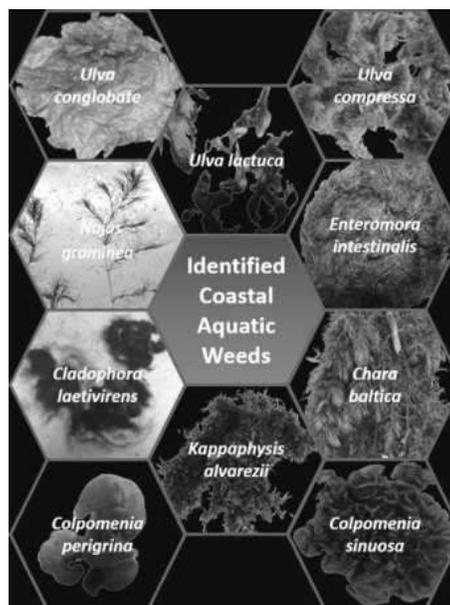


Fig 4: Morphologically identified weed

Table 2: Monthly distribution pattern of available identified aquatic weeds in the coastal region

Sl. No.	Name of weeds	Months											
		Ja	Fe	Ma	Ap	Ma	Ju	Jul	Au	Se	Oc	No	De
1	<i>Najas graminea</i>		√	√	√	√	√	√	√	√	√		
2	<i>Cladophora laetivirens</i>			√	√		√	√					
3	<i>Ulva lactuca</i>				√		√	√	√	√	√		
4	<i>Ulva compressa</i>				√		√	√	√	√	√		
5	<i>Enteromorpha intestinalis</i>				√		√	√	√	√	√		
6	<i>Ulva conglobate</i>				√		√	√	√	√	√		
7	<i>Chara baltica</i>	√	√			√			√	√	√		
8	<i>Kappaphysis alvarezii</i>					√	√	√	√	√	√	√	√
9	<i>Colpomenia perigrina</i>	√	√	√									
10	<i>Colpomenia sinuosa</i>	√	√	√		√	√	√					

In this study, *Najas graminea* was found as the mostly available weed throughout the year. Whereas, *Chara baltica* was the abundant species in terms of quantity followed by *Najas graminea*. So, this two species might be regarded as mostly available weed in coastal area. The occurrences of most of the aquatic weed were found from April to October (Table 2). All the ten identified species were not available year round. The coverage and abundance of coastal aquatic weeds in nature might have influenced by environmental parameters and seasons (Table 2 and 4).

Table 3: Quadrat analysis of mostly available weeds

Weed Species	Frequency	Coverage	No/m ²
<i>Ulva lactuca</i>	50%	87%	600
<i>Catanella</i>	88%	75%	500
<i>Colpomenia</i>	38%	50%	90
<i>Najas graminea</i>	80%	92%	450
<i>Chara baltica</i>	82%	91%	440
		Total density	2080

In this study five species were considered for quadrant analysis considering their availability. Here, mostly abundant species was *Najas graminea* (92 %). *Chara baltica* stood second (91 %) followed by *Ulva lactuca* (87 %) and *Catanella* (75 %). Whereas, among the five *Colpomenia* was the least in position (50 %) in terms of coverage (Table 3).

DNA extraction, PCR amplification and sequencing: For accurate identification of collected aquatic weeds, samples have been sent to the laboratory for barcode analysis. In the mean time, DNA extraction and PCR amplification has been completed. Sequencing is under progress and the results will be available shortly.

Study-2: Determination of macro & micronutrient elements from identified aquatic weeds

As macronutrient, proximate composition of collected six weed sample was analyzed following standard method from the feed nutrition laboratory of Bangladesh Agricultural university (BAU). Protein level ranged between 8.93 and 17.07%, lipid 1.44 and 2.33%, Ash 16.37 and 42.55%, fibre 7.45 and 8.85%, and carbohydrate between 23.95 and .33.67% (Table 5). In this report highest protein level was found in sample code 15. But in context of availability to formulate fish feed using the aquatic weed, sample code number 23 might be considered that contained an average level of macronutrients (proximate performance).

Fatty acid profiling was also explored for six available coastal aquatic weeds. Fat content was very low in all the aquatic weeds considering 24 fatty acids in three categories. Available fatty acids were palmitic acid, stearic acid (Saturated), oleic acid (Monounsaturated), and linoleic acid (PUFA). Among the weed samples, sample code 23 contained all types of fatty acid including PUFA, though the PUFA level was comparatively low in this weed (Figure 6).

Amino acid profiles as nutrient were estimated to evaluate the suitability of aquatic weeds as fish feed formulation. A total of 16 amino acids were considered of which aspartic acid, glutamic acid, threonine, leucine, histidine, proline, and lysine was mostly available in all samples. Highest abundant was aspartic acid and remains in almost all species. Meanwhile, sample code number 23 contains all the amino acid content (Figure 5).

Table 5. Proximate composition of the available collected aquatic weeds

Code	Moisture (%)	Crude lipid (%)	Crude protein (%)	Ash (%)	Crude fiber (%)	Carbohydrate (%)
13	19.15	1.44	10.57	30.58	7.80	30.46
18	14.95	2.33	15.21	29.40	8.67	29.44
15	20.00	2.33	17.07	19.26	7.67	33.67
05	28.28	1.51	13.29	16.37	7.45	33.10
20	18.92	2.57	8.93	31.33	8.34	29.91
23	13.42	1.45	9.77	42.55	8.86	23.95

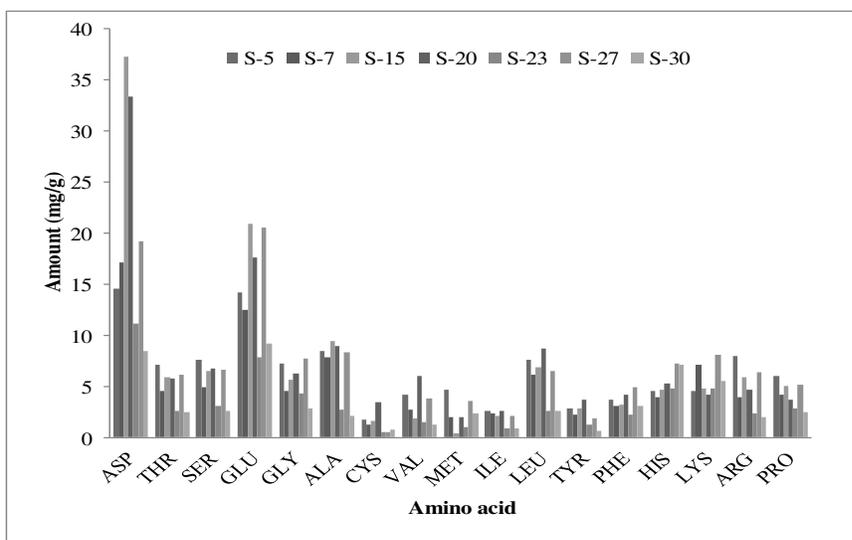


Figure 5. Amino acid profile of available coastal aquatic weeds

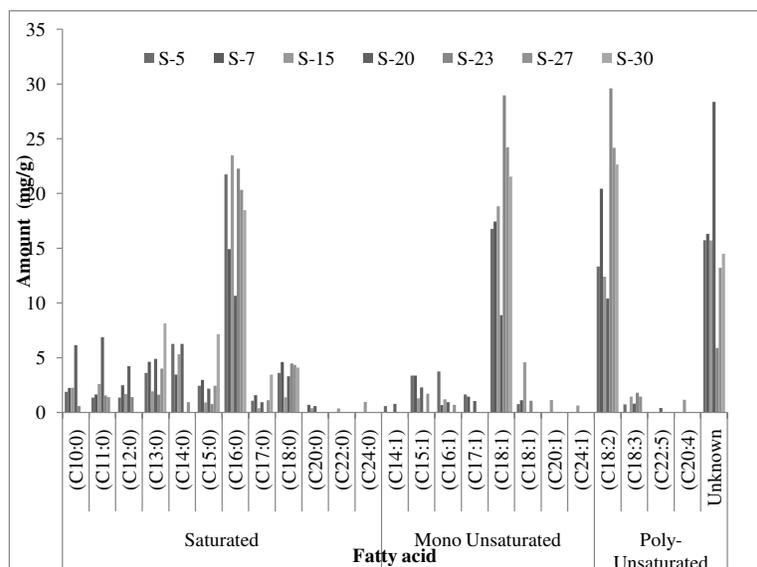


Figure 6. Fatty acid profile of available coastal aquatic weeds

As stipulated in Figure 8, mostly abundant mineral content is Ca and Fe. Highest level of Ca was observed in sample number 23. Whereas the lowest level of the same was in sample number 7. For that of the Fe, highest level was in sample number 7, but lowest level was in sample number 23. The level of Ca and Fe showed inverse relationship in all the samples. The presence of other mineral contents (Mn, Zn and Cu) was in minimum level in all the samples (Figure 7).

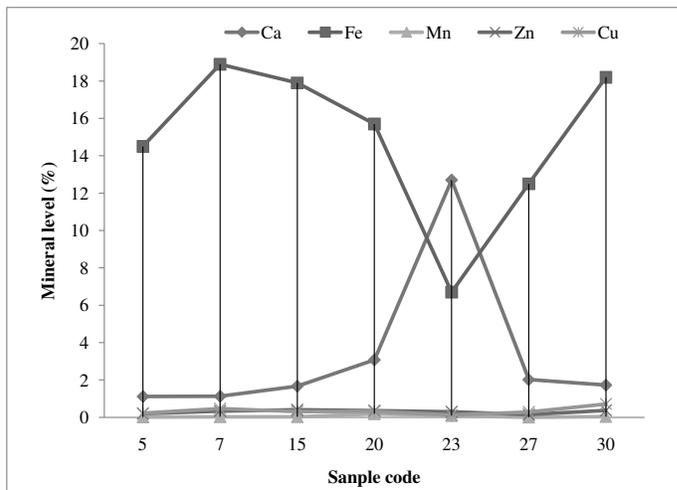


Figure 7. Mineral content in available coastal aquatic weed

Study-3: Determination of antioxidant profile and major anti-nutritional factors of identified aquatic weeds

Extraction yield of antioxidant profile was analyzed from the SRS laboratory, Bagerhat following standard analysis protocol. Rich extraction yield was observed in sample code 15 and that of poor extraction level was in sample number 5. Other aquatic weeds showed moderate to high extraction yield (Figure 8).

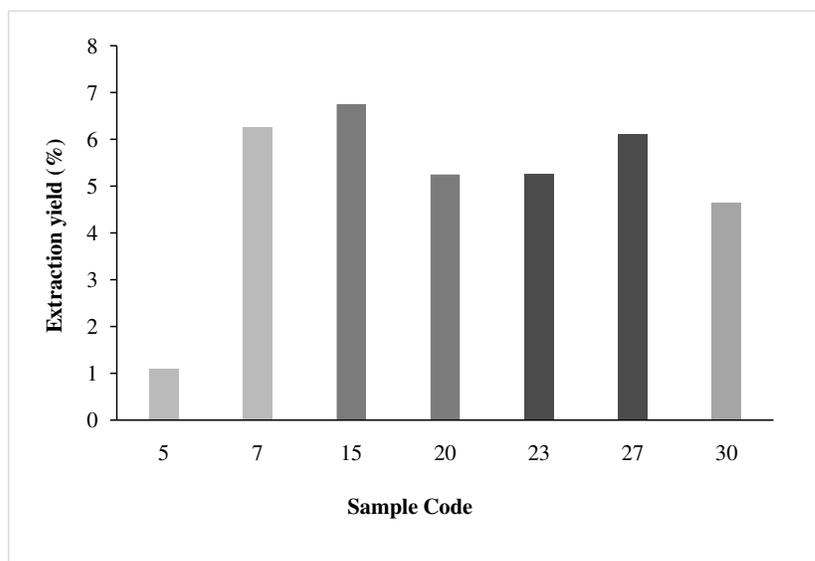


Figure 8. Extraction yield of available weed

The DPPH scavenging performance of the weeds has been shown in (Figure 9). Sample number 23 showed the best performance under 3 concentrations followed by sample number 5, whereas rest of the samples showed relatively less scavenging performance. However, sample number 23 and 5 might be the good source of anti-oxidant than other weeds.

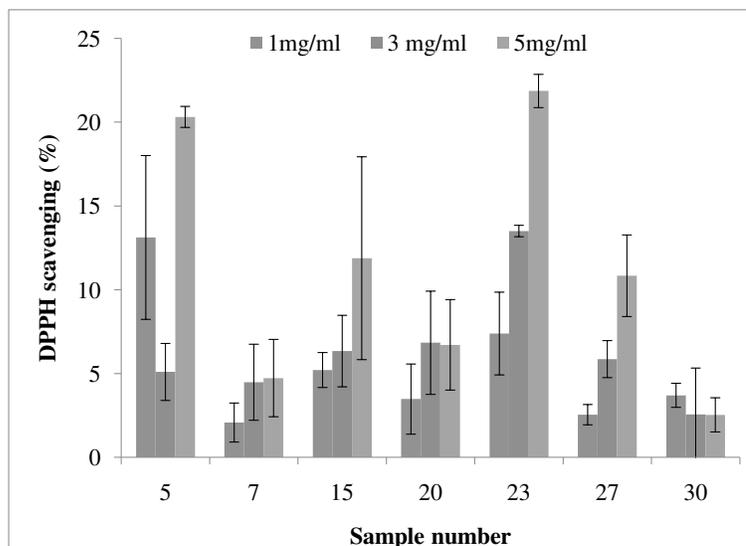


Figure 9. DPPH assay of available coastal aquatic weeds

It has been evidently mentioned in some literatures that, as less as the level of IC50 as considered as the best scavenger. In this study, highest IC50 was determined in sample number 30 and that of the lowest was in sample number 23 (Figure 10). Sample number 5, 15 and 27 contained a moderately low IC50, whereas sample number 7 and 20 had moderately high level of IC50 (Figure 10). However, sample code 23 is regarded as the best DPPH (2,2-diphenyl-1-picrylhydrazyl) scavenging performer than the other tested aquatic weed sample.

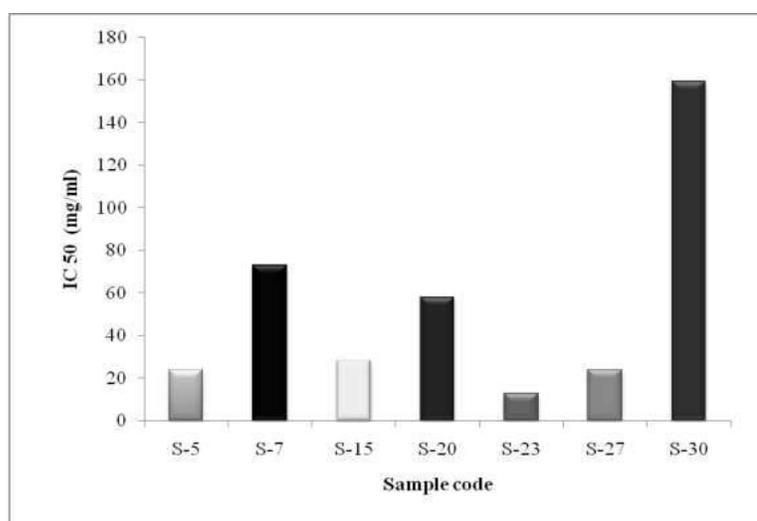


Figure 10. IC 50 of DPPH

In the case of ABTS (2,2-azino-bis-3-ethylbenzothiazoline-6-sulphonic acid) assay test, higher level of scavenging value is regarded as best antioxidant performer. In this study, sample number 5 showed

highest level of scavenging at 5 mg/ml concentration (Figure 11) but other two concentrations showed moderately higher ABTS values. Meanwhile, sample number 23 had the moderately higher ABTS values in 3 concentrations tested (Figure 11). However, the other five samples (sample number 7, 15, 20, 27 and 30) showed low to moderately high level of ABTS performance (Figure 11).

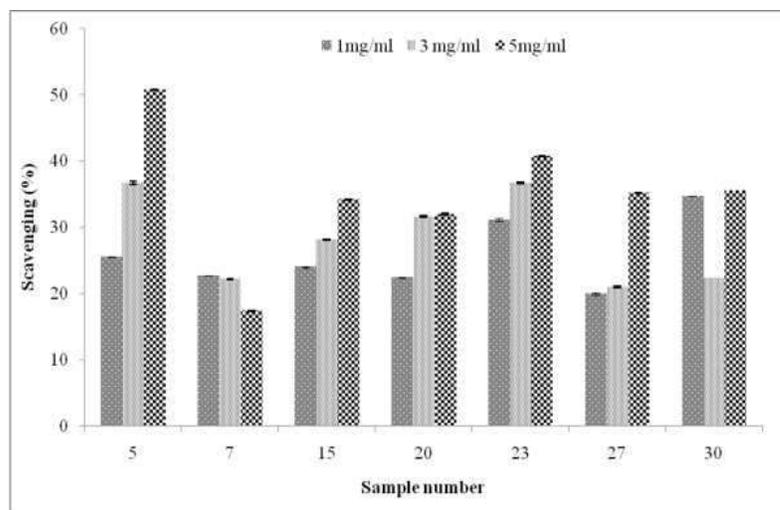


Figure 11. ABTS assay of available weed

Table 6. Up to dated achievement at a glance

Sl. No.	Sub. of achievement	Achievement status	Comment
1.	Total collected mangrove weed	32 species	
2.	Morphologically identified	10 species	
3.	Proximate composition	6 species	Mostly important samples
4.	Amino acid profile analysis	7 species	Mostly important samples
5.	Fatty acid profile	7 species	Mostly important samples
6.	Mineral content(Ca, Fe, Mn, Zn, Cu)	7 species	Mostly important samples
7.	Anti-nutritional factor	Sample ready for lab	Need more budget and lab facilities
8.	Anti-oxidant profile	7 species	Mostly important samples
9.	Barcoding	Analysis in progress	

Anti-nutritional factors :

Due to shortage in fund and lacking of laboratory facilities analysis of anti-nutritional factors was not possible in this year. Samples have been collected, processed and stored accordingly and will be analyzed next year. Following three anti-nutritional factors will be identified using universal protocol suggested by renowned researcher-

- ✓ **Total phenol :** Total phenols will be estimated by following the method of Malik and Singh (1980). A standard curve will be drawn using different concentrations of catechol (0-100 mg/ml) to calculate total phenol content and expressed as mg total phenols/100 g dry weed powder.
- ✓ **Phytic acid :** Phytic acid content will be estimated using the method of Haug and Lentzsch (1983).

C-glycosylflavone: It will be estimated by using the method of Akingbala (1991).

Domestication, Reproductive Biology, Breeding and Culture of Indigenous Brackishwater Prawns under Captive Conditions

Researchers

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 Md. Hashmi Sakib, SSO
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Objectives

- Identification of target prawn using taxonomic and barcoding approach
- To domesticate brackishwater prawns under captive condition for broodstock development
- To investigate the reproductive biology (fecundity, GSI, breeding time, embryonic development, etc.) of the prawns
- To develop breeding and larvae rearing protocol of the prawns

Achievements

Study-1: Breeding and seed production of brackishwater Khobda Chingri (*M. dayanum*)

The suitable brood of *M. dayanum* was collected from the domesticated ponds and from natural sources. Then, the brooders were fed with earthworms and protein rich pellet feeds at the rate of 5% body weight basis to trigger the reproductive maturation. Once the prawn extrudate the egg and aggregates into the abdominal flaps (turned into berried), the berried females were transferred to the incubation tank after proper disinfection with 20-50 ppm formalin solution for 30 minutes. A little portion of egg sample were collected with sterilized forceps at three days intervals and observed under stereo microscope. Fertilization rate, progress of all embryonic development stages were noted down and sufficient photographs were taken for documentation. As the colour of egg mass turned into dark grey, the berried females were transferred to the hatching tanks filled with 8-12 ppt disinfected water.

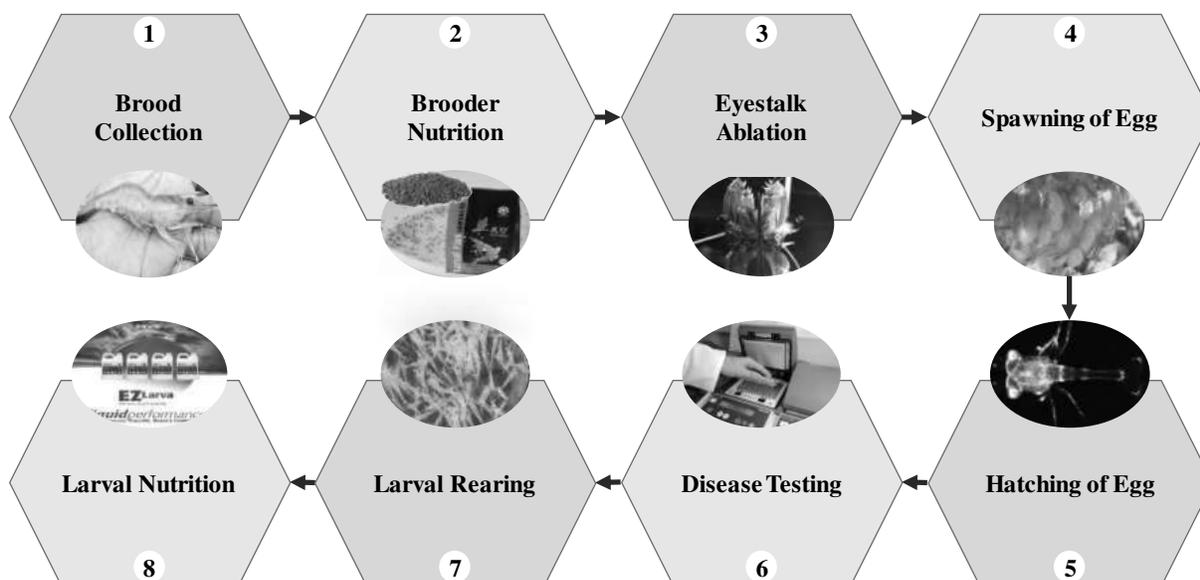
After hatching, the larvae were transferred to the prepared larvae rearing tanks and fed with live feed (rotifer and artemia). Powdered shrimp feed and artemia nauplii were provided after 7 days of hatching for larval development and nutrition. Fertilization, hatching and survival rate were calculated using the standard equations given below:

$$\text{Fertilization rate (\%)} = \frac{\text{Number of fertilized eggs in sub - sample}}{\text{Total number of eggs observed in sub - sample}} \times 100$$

$$\text{Hatching rate (\%)} = \frac{\text{Number of hatchlings}}{\text{Total number of fertilized eggs}} \times 100$$

$$\text{Survival rate (\%)} = \frac{\text{Final population (Pt)}}{\text{Initial population (Po)}} \times 100$$

The embryonic development of *Macrobrachium dayanum* is consisted of nine different stages/phases which were characterized by various notable morphological changes (Figure 1).



Flowchart: Overall breeding activities were done for *M. dayanum*

Stage 1: Fertilization of eggs (00-03 hours): Fertilization of eggs continued up to four hours from beginning of fertilization and finished just before the first cell division. Fertilized eggs were almost globular shape and consisted of a granulous mass uniform dark olive color which wrapped with a lucid chorion.

Stage 2: Cleavage (03-08 hours): Various cleavage furrows arise in the egg mass, pointing up the formation of the first embryonic cells. A translucent region found at one pole of the egg shrinking slightly the eggs inside mass. These changes occurred at the beginning of embryonic development where egg volume increased slightly.

Stage 3: Blastula (08-34 hours): Translucent area of the egg expanded gradually without remarkable changes. Consequently, two parts inside the eggs were observed where the abdominal part of the developing embryo represented by a light region and cephalic area represented by a dark olive region.

Stage 4: Gastrula (34-132 hours): After 33 hours of fertilization, the internal mass of the egg consolidated mainly in the peripheric region. The abdominal region with the presence of some abdominal segments perfectly separated from the “V” form cephalic region. This stage concluded five days after fertilization.

Stage 5: Nauplius (132-165 hours): A spacious black spot developed in the cephalic region of the embryo which continuously shortened due to the propagation of abdominal part after 140 hours of fertilization. The black spot illustrates a diagram of the embryos ocular region turned more evident. Besides, some vitellin reserve vesicles developed in the peripheric part of the cephalic region.

Stage 6: Post-nauplius with a heartbeat (165-196 hours): Previously developed optic region expanded with more pigmentation. The caudal papilla inhered with an elementary telson at the abdominal region and folded to the optic region. At the moment, remaining contents of eggs was mainly vitelline reserve slendered due to the evolution of embryonic structures and turn into dark grey color.

Stage 7: Post-nauplius with eye individualization (196-240 hours): Eyes separated from the optic region, prolonged, turn into an elliptical form and separated from the cephalic region but still stuck on their base.

Stage 8: Final post-nauplius with eye condensation (240-288 hours): Diameter of eye enlarged with color intensification and eyelashes arise above each eye. Well developed and segmented maxillipeds visible in this phase and overlapped the abdomen. Whole egg space was occupied by the embryo. The vitellin vesicles intensified and were more visible in the cephalic region of the embryo.

Stage 9: Pre hatching (288-315 hours): Cephalothoracic dark grey part reduced significantly. The heart was fully evident from the vitellin mass and compression of the heart was significantly active than the previous phases.

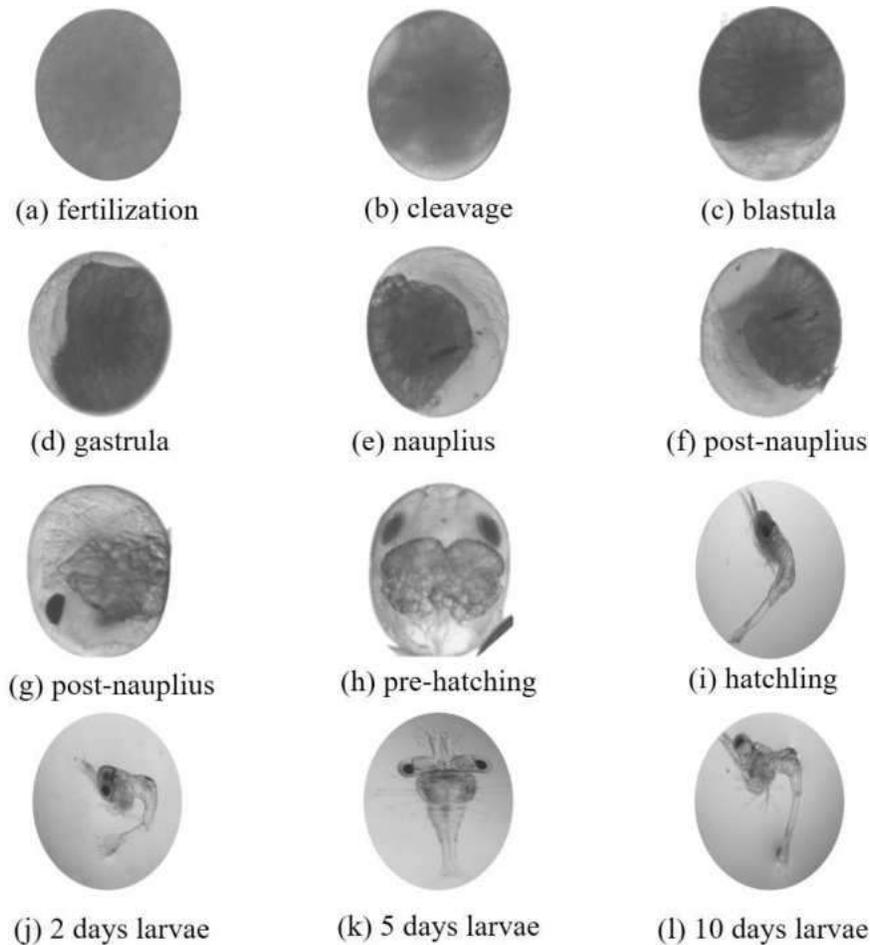


Figure 1: Embryonic developmental stages of *M. dayanum*. (a) Fertilization; (b) Cleavage; (c) Blastula; (d) Gastrula, making up of blastopores; (e) Nauplius with black spot; (f) Post-nauplius with heart beats; (g) Post-nauplius with eyes pigmentation; (h) Pre-hatching; (i) Freshly hatched larvae; (j) Two days larvae; (k) Five days larvae; (l) 10 days larvae.

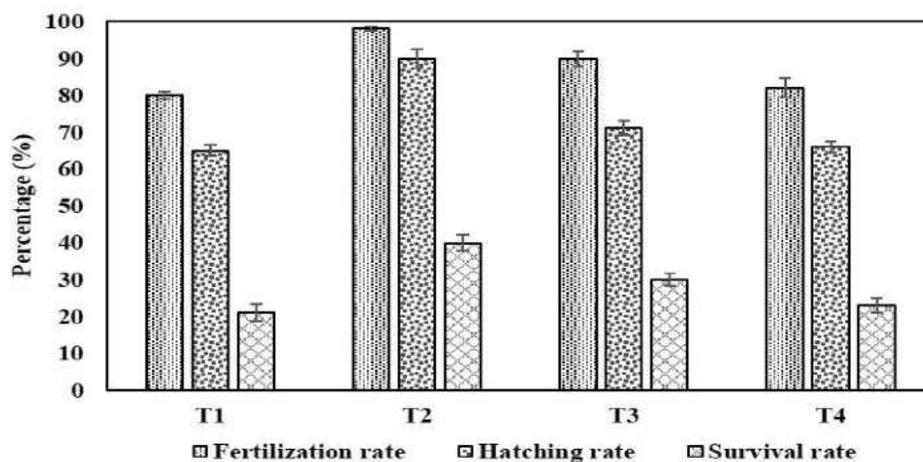
Study-2: Effects of different salinity on breeding performance and larvae survival of brackishwater Khobda Chingri (*M. dayanum*) under captive conditions

To evaluate the effects of different salinity on breeding performance and larvae survival of brackishwater Khobda Chingri, experiments were conducted with four different salinity treatments, viz, T1 (8 ppt) and T2 (10 ppt), T3 (12 ppt) and T4 (14 ppt), respectively (Table 1). The larvae were reared with standard crustacean larvae rearing protocol. The fertilization, hatching, survival rate and larval stage index were calculated and compared among the treatments accordingly.

Table 1: Design of experiment to evaluate different salinity levels on breeding performance and larvae survival of Khobda chingri (*M. dayanum*).

Treatment	Salinity	Replications
T1	8	3
T2	10	3
T3	12	3
T4	14	3

Till report 5 breeding trials were made to produce Khobda prawn PL in the hatchery complex of Brackishwater Station. The highest fertilization rate was recorded as 98.0 ± 0.5 % in T2 (10 ppt) which is significantly ($p < 0.05$) higher than T1 (80.0 ± 1.0 %), T3 (90.0 ± 2.0 %), and T4 (82.0 ± 2.5 %), respectively. Similarly, the highest hatching rate was estimated as 90.0 ± 2.5 % which is significantly ($p < 0.05$) higher than T1 (65.0 ± 1.5 %), T3 (71.0 ± 2.0 %), and T4 (66.0 ± 1.5 %), respectively. Correspondingly, the maximum survival rate was calculated as 40.0 ± 2.0 % which is significantly ($p < 0.05$) higher than T1 (21.0 ± 2.3 %), T3 (30.0 ± 1.8 %), and T4 (23.0 ± 2.0 %), respectively. The PL were stocked in the nursery pond for nursery rearing. Till report the Khobda prawn attains 3.75 ± 0.25 cm length and 0.35 ± 0.15 g body weight after 30 days rearing in the nursery pond. The water quality parameters of the breeding tank and broodstock ponds measured regularly. The broodstock inducement with enriched artificial (commercial diet) and natural feed (earthworms) are ongoing.

**Figure 2.** Effects of salinity on breeding performance and larvae survival of Khobda

Improvement of Soft-shell Mud Crab (*Scylla olivacea*) Culture Technique in South-west Coastal Region of Bangladesh

Researchers

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Objectives

- To observe the effect of environmental conditions (salinity variations and aeration) on molting efficiency of mud crab.
- To observe the effect of physical stress (limb trimming) on molting of mud crab.
- To compare the performance of soft-shell shedding between BFRI hatchery produced and natural crablets.

Achievements

Name of the experiment: Effect of water temperature on year-round soft-shell farming *Site selection*

This experiment was started with both hatchery produced and wild crablets to observe their performance against different temperature fluctuations. Therefore, adequate crablets were produced in the brackishwater station's crab hatchery by following existing protocols. The experiment was conducted in brackishwater old hatchery complex and earthen ponds. Six cemented cisterns (Each Cistern 7 m²) and required earthen ponds (0.1 ha each) were prepared for this experiment. The experiment had 3 treatments depending on temperature variations, viz., T1 (Control: indoor cisterns), T2 (No canopy on pond) and T3 (Canopy on pond). Canopy was prepared with 70% orchid nets set on the bamboo frame above water. Overall experimental design has been shown below in Table 1.

Table 1. Experimental design for the effect of water temperature on year-round soft-shell farming

Treatment	Salinity	Density	Box size (cm ³)	Crab size (g)	Replica
T1 (control: In indoor cistern)	15	1 crab/box	(25×15×15) cm ³	30-50/Existing Wild and Hatchery Size	3
T2 (No canopy on pond)	Existing	1 crab/box	(25×15×15) cm ³	30-50/Existing Wild and Hatchery Size	3
T3 (Canopy on pond)	Existing	1 crab/box	(25×15×15) cm ³	30-50/Existing Wild and Hatchery Size	3

Juvenile wild crab was collected/purchased from local market. Meanwhile, hatchery produced crab was collected from brackishwater station and was stocked according to design. Existing wild and hatchery sized crab (30-50 g) was stocked for T1 (control) with 20 crabs (1 crab/box) in each replication. In contrast, in each replication, 20 crabs (1 crab/box) of 30-50 g was stocked for T2 and T3. Chopped tilapia was used as feed at every 2-3 days interval and 30% of tank water was exchanged in every week depending on the water quality parameters. Crab shedding was monitored at every 6 hours interval with naked eye observations. Initial weight and weight after soft-shell shedding was recorded for each crab. Water quality parameter such as temperature, pH, dissolved oxygen and ammonia was monitored and recorded weekly basis. Experiment was continued until finish a single round shedding performance.

Water quality parameters

Cemented cisterns were used to conduct indoor study, whereas earthen ponds were for outdoor study for producing soft-shell mud crab. The recorded physico-chemical parameters, namely salinity, temperature, pH, dissolved oxygen, total ammonia and alkalinity of water during the culture period has been presented in Table 2. Generally, all the parameters of the cisterns were within the acceptable ranges for brackish water aquaculture of crab. The temperature values of the experimental ponds and cisterns were recorded between 28.90°C and 31.55°C. Salinity is considered as one of the most fundamental factors for mud crab culture. The salinity level was kept at 15 ppt in cistern but at 29.50-31.55 in the pond. The recorded pH of this study ranged from 8.13 to 8.93 in all environments. Ammonia, dissolved oxygen, and total alkalinity levels of the cisterns were found within a range of 0-0.5, 4.8-9.9.68, and 132-182 ppm, respectively (Table 2).

Table 2. Water quality parameters throughout the culture period to observe temperature effects

Parameters	Treatment-1 (Indoor Cistern)	Treatment-2 (No canopy)	Treatment-3 (With canopy)
Salinity (ppt)	15-15	8.52-16.46	8.52-16.46
Temperature (°C)	28.9-29.85	30.28-31.55	29.5-30.00
pH	8.13-8.95	8.44-8.93	8.44-8.93
Ammonia (ppm)	0.0-0.5	0.0-0.25	0.0-0.25
Dissolved oxygen (ppm)	5.92-6.39	4.8-9.68	4.8-9.68
Total alkalinity (ppm)	132-182	138-166	138-166

Molting duration

Figure 1 represents the overall duration of shedding performance during the experimental period. T1 and T3 showed significantly ($p < 0.5$) better response than T2. The lowest performance was observed in T2 as it took the highest days to produce soft-shell (45.11 days). Likewise, T3 showed 28.67 days for growing soft-shell in the farm. Therefore, the quickest soft-shell production was found in T1 (25.11 days).

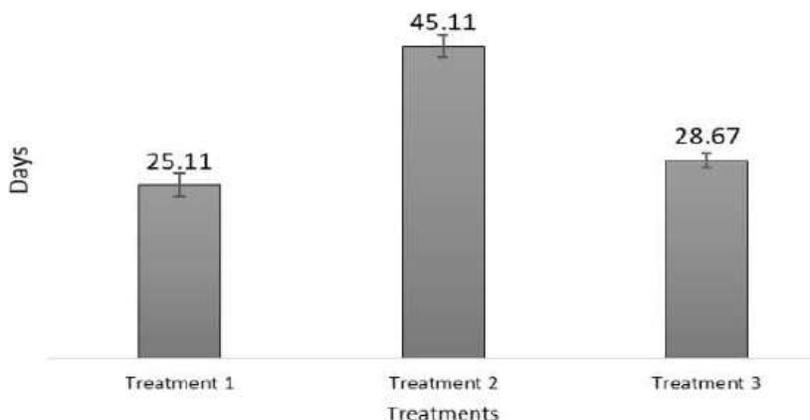


Figure 1. Effect of water temperature on shedding performance of mud crab

Growth of soft-shell crabs

Temperature has considerable effects on growth, survival rate, weight gain and duration of shedding of soft-shell. In the present study, it was found that the mean weight gain (%) and increase of carapace width (%) was 67.52 ± 11.63 and 19.75 ± 4.11 in T1; 25.54 ± 5.97 and 11.73 ± 3.06 in T2 and 42.54 ± 4.18 and 18.23 ± 1.64 in T3 (Figure 2). In T1 and T3, growth performance was significantly ($p < 0.5$) better than T2. Here, T2 exhibited the poorest performance among all these Treatments.

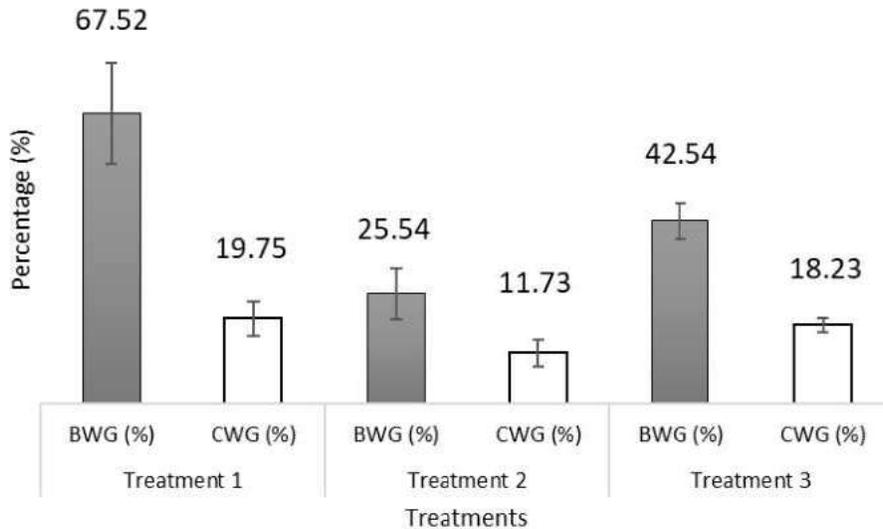


Figure 2. Effect of water temperature on body weight gain (BWG) and carapace width gain (CWG)

Survival

Effect of water temperature on overall survival rate of mud crab in different Treatments during soft-shell farming has been presented in Figure 3. The survival rate (%) of soft-shell mud crab was 85.33 ± 5.00 , 63.33 ± 7.64 , and 80.00 ± 5.00 in T1, T2 and T3, respectively. The survival rate in T2 was the lowest among all Treatments, whereas, significantly ($p < 0.5$) higher survival rate were calculated in T1 and T3.

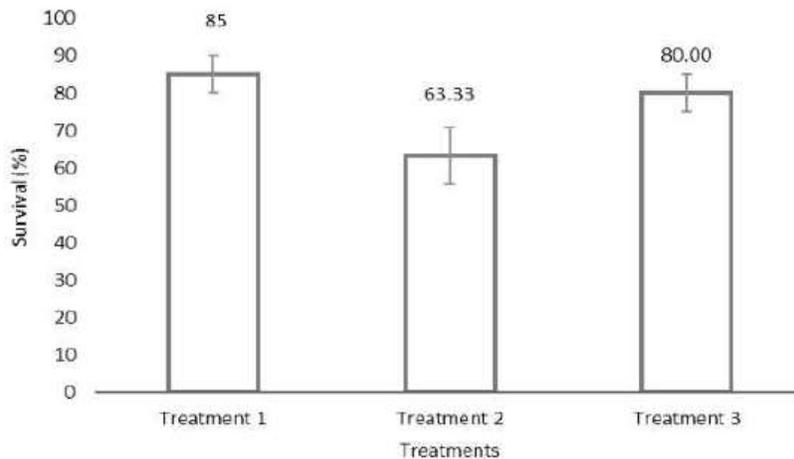


Figure 3. Effect of water temperature on survival rate of soft shell crab

Comparing survival between hatchery and wild crabs

The survival rate, shedding performance and weight gain of BFRI hatchery-produced crabs was significantly ($p < 0.5$) higher than the natural crablets (Figure 4). Survival, growth and shedding of hatchery crabs were 93.33 ± 4.71 , 46.68 ± 1.00 and $58.36 \pm 1.91\%$, respectively. The survival rate, growth and shedding rate of wild crabs were $66.67 \pm 4.71\%$, $40.23 \pm 1.12\%$ and $41.64 \pm 1.91\%$, respectively. Result of this experiment focused that, juvenile crabs from hatchery showed significantly ($p < 0.5$) better performance than wild sourced juveniles. However, hatchery-produced mud crabs were observed more adaptive in the soft-shell farming rather than wild stock.

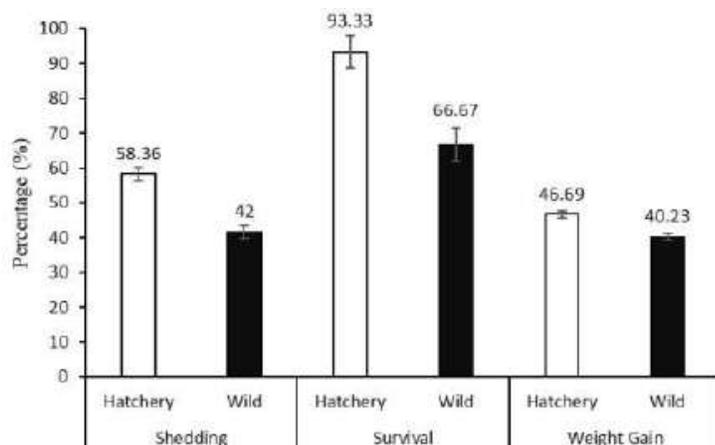


Figure 4. Comparing performances between hatchery produced and wild crabs for soft shell shedding

Name of the experiment: Effect of aeration on soft-shell shedding performance of mud crab

The experiment was conducted in brackishwater old hatchery complex and simultaneously in earthen ponds. Six cemented cisterns (each cistern 7 m²) and required earthen ponds (0.1 ha each) were prepared for this experiment. The experiment was conducted with 3 treatments depending on aeration variations, viz., T1 (Control: Aeration in a cistern), T2 (No aeration in pond) and T3 (Aeration in pond). Overall experimental design has been shown below in Table 3.

Table 3. Experimental design for the effect of aeration on soft-shell shedding performance

Treatment	Salinity	Density	Box size	Crab size (g)	Replica
T1 (Control: Aeration in a cistern)	15	1 crab/box	(25×15×15) cm ³	30-50	3
T2 (No aeration in pond)	Existing	1 crab/box	(25×15×15) cm ³	30-50	3
T3 (Aeration in pond)	Existing	1 crab/box	(25×15×15) cm ³	30-50	3

Crablets were collected/purchased from local market and were stocked according to design. A total of 20 crabs (1 crab/box) of 30-50 g each were stocked in each replica for T1, T2 and T3. Chopped Tilapia was used as feed at every 2-3 days interval at the rate of 5% body weight and 30% of tank water was exchanged in every week to keep the water quality in congenial level. Crab was monitored at every 6 hours interval for soft-shell shedding through naked eyes. Initial weight and weight after soft-shell shedding were recorded. Water quality parameter such as temperature, pH, dissolved oxygen and ammonia were monitored and recorded weekly basis. Experiment was continued until the last crab shedding in all treatments.

Water quality parameters

In the present study, the physico-chemical parameters, namely temperature, salinity, dissolved oxygen, pH, ammonia and total alkalinity of pond water were recorded in weekly basis during the culture period (Table 4). Among the other parameters, salinity is one of the key factors that contribute to the survival, osmoregulation process, phase molting and growth of soft-shell mud crab. The salinity level in the present experiment was in allowable ranges throughout the experimental period and it was in between 3.40 to 6.14 in pond and at 15 ppt in the cisterns. Similarly, temperature also has significant effects on soft-shell

crab because it acts as a controlling factor of aquatic ecosystem. It affects physiological process, metabolism, feed intake, behavior and bioaccumulation speed. Though the recorded temperature of this experiment has fluctuated slightly in every week, it ranges between 19.00 °C to 24.28 °C. In the present study, the range of dissolve oxygen was 5.52 to 8.20 ppm. The recorded values of pH, ammonia, and total alkalinity varied from 7.96 to 9.00, 0 to 0.50 ppm and 132 to 198 ppm, respectively throughout the experimental period.

Table 4. Water quality parameters under different aeration system during culture period

Treatments	Temperature (°C)	pH	Dissolve Oxygen (ppm)	Total ammonia (ppm)	Alkalinity (ppm)	Salinity (ppt)
T1	19.00–22.40	7.96–9.00	5.89–8.05	0–0.5	132–170	15
T2	23.20–21.05	8.33–8.96	5.60–8.20	0–0.5	140–198	3.40–5.35
T3	20.22–24.28	8.30-9.00	5.52-8.06	0-0.5	140-172	4.20-6.16

Molting duration

The shedding period showed better response (31.56 days) in T3 than T2 (59.78 days) and T1 (47.44 days) (Figure 5). The shedding period in T3 was the lowest among the all treatments, whereas, the highest shedding period was calculated in treatment2 where no aeration was provided.

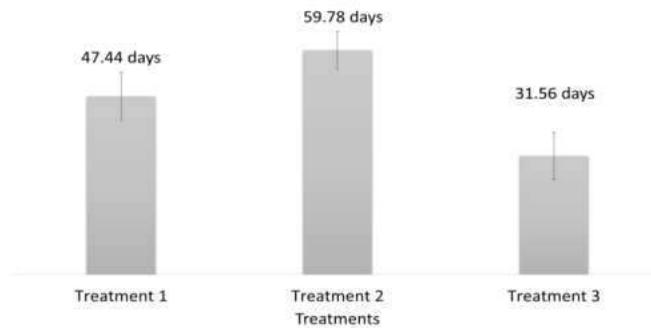


Figure 5. Duration of shedding under different aeration protocol

Growth performance

Likewise, the shedding duration, aeration has also crucial effects on growth, survival rate, weight gain of soft-shell. In the present study, it was found that the mean weight gain (%) and increase of carapace width (%) of T1 was 43.02 and 14.51, T2 was 26.69 and 8.49, and T3 was 46.71 and 23.53 (Figure 6). In T3, growth performance is better than rest of two as there was an aerator installed.

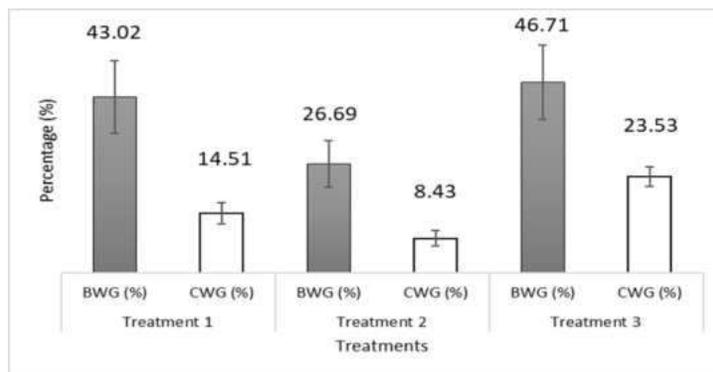


Figure 6. Carapace width and body weight gain percentage of soft-shell under different aeration protocol

Survival

Effect of aeration on survival rate of mud crab in treatments during soft-shell farming is presented in Figure 7. The overall survival rate (%) of soft-shell mud crab was 70, 55, and 81.67 in T1, T2 and T3, respectively. The survival rate in T2 was the lowest among the all treatments, whereas, the highest survival rate was calculated in treatment 3, where aeration was provided in outdoor ponds.

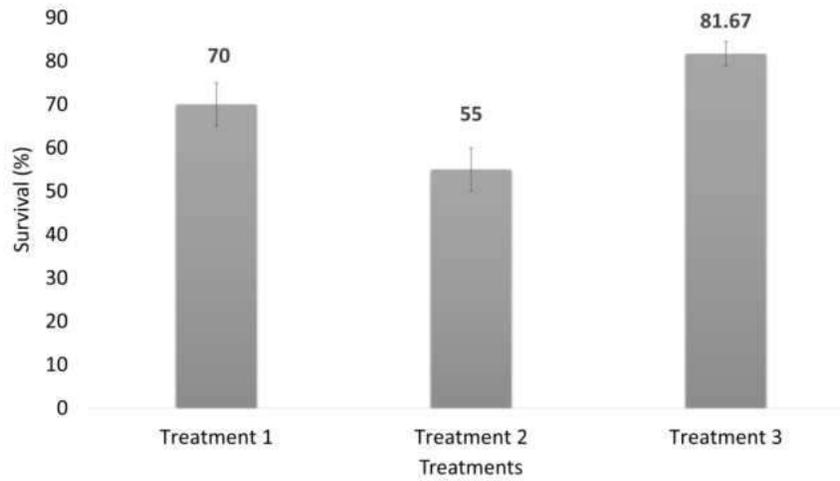


Figure 7. Effect of aeration on survival rate in soft-shell farming

Domestication, Breeding and Seed Production of Some Commercially Important Brackishwater Fishes

Researchers

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 Shawon Ahmmed, SO
 Md. Abu Naser, SO
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Objectives

- To enhance the survival rate of Chitra and Datina fish seed
- To domesticate the commercially important fishes in brackishwater environment
- To observe the food-feeding habit and reproductive biology of the fishes
- To develop induced breeding, seed production and nursery technique of the fishes

Achievements

Study-1: Identification of reproductive biology and peak breeding season of the targeted fishes using histology and monthly abundance of fry as well as the identification of targeted tank goby through DNA barcoding approach

Domestication and culture of five brackishwater fishes were being continued under controlled condition for brood development and gonadal maturation. Identification of reproductive biology and peak breeding seasons of each targeted fishes were performed for at least one year since the 1st data and gonad sample collection. Histology of gonad samples was performed through standard tissue histological process. Beside histology, monthly abundance of fry of the targeted fishes were also monitored in three different locations *viz.*, Shanta (Shibsa River), Baniakhali (Hodda River) and Burigoalini (Kholpetua River) for more accurate identification of the peak breeding seasons.

However, accurate species identification of the targeted tank goby was confirmed through DNA barcoding approach. The DNA extraction was performed by DNeasy Blood & Tissue Kit (Qiagen, Hilden, Germany). Then, the DNA amplifications were performed by mtCOI PCR marker. After that, the PCR product purification was done by QIAquickR Gel extraction kit. Sequencing was generated by bidirectional sequencing using Sanger sequencing method. Finally, the species identification was completed by checking the generated sequences using sequence analysis software (ABI) and assured by online BLAST search program.

Taposi (*P. paradiseus*): The development of oocytes of paradise threadfin can be divided into different developmental stages. Paired ovaries with mature oocytes were observed during the mature stage of ovary. Development of oocytes started from the month of December to April which is confirmed by the chronological presence of CNO, EPNO, LPNO, YVO, EYGO and LYGO (Figure 1) indicated the occurrence of spawning which was found in the month of July. Fully mature oocyte was found from the month of April to October indicated the spawning period of this species.

Identifying peak breeding season of Taposi fish

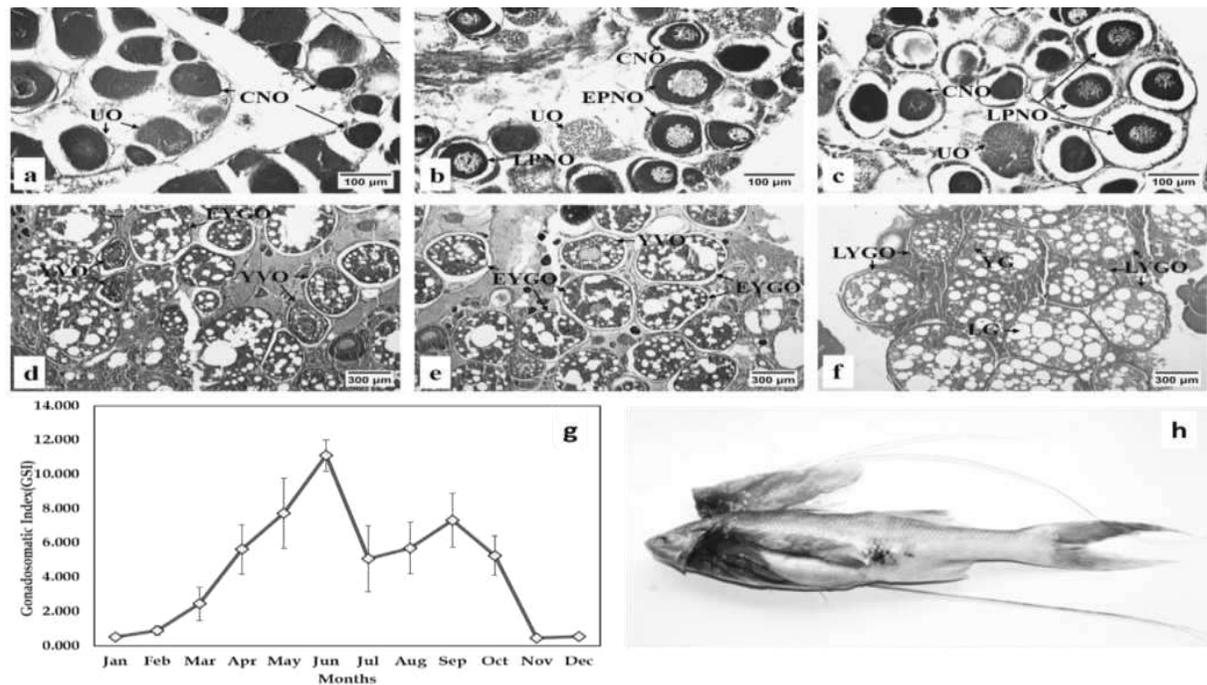


Figure 1: Micrographs showing Haematoxylin & Eosin stained ovary of *P. paradiseus* monthly (a) CNS= Chromatin Nucleolar Stage (b) EPNS= Early Perinucleolar stage (c) LPNS= Late Perinucleolar Stage (d) YVS= Yolk Vesicular Stage (e) EYGS= Early Yolk Granular Stage (f) LYGS= Late Yolk Granular Stage (g) GSI fitted graph (h) Dissected Taposi fish. [Note: a, b, c at 40x and d, e, f at 10x magnification, UO= Undeveloped oocyte; CNO= Chromatin nucleolar oocyte; EPNO= Early perinucleolar oocyte; LPNO= Late perinucleolar oocyte; YVO= Yolk vesicular oocyte; EYGO= Early yolk granular oocyte; LYGO= Late yolk granular oocyte; LG= Lipid Globule; YG= Yolk Granule.]

Whereas, the gonadosomatic index (GSI) of the species gave an idea about the seasonal progression of gonad development, sexual maturity and spawning season of a fish. The highest GSI value for the female was recorded in the month of June (11.10 ± 0.91), indicating the major/primary spawning season of this species. Thereafter, the GSI value sharply declined in July and then gradually rose to a second peak spawning season in the month of September (7.31 ± 3.57). The findings of this research indicated an extended spawning season from April to October with two peaks in June and September. The lowest GSI was recorded in the month of November (0.44 ± 0.08). After that the GSI value gradually increased from December to reach a maximum value in June. GSI value went a little down in July then gradually increased from August to give a second peak in September. With a gradual decrease in October, the GSI value drastically dropped in November and December (Figure 1).

Bhangon (*M. cephalus*): Histological identification of female gonad shows the stages having UO, CNO, EPNO, LPNO, EYVO, LYVO, EYGO and LYGO. The last stage (LYGO) indicated the full maturity of the female individuals. In case of *Mugil cephalus* both GSI and gonadal histological image showed that the month March is the peak spawning season for this species. In the month of April sometimes it shows to spawn. Another spawning season identified from August-October where September is the minor peak (Figure 2).

Identifying peak breeding season of Bhangon fish

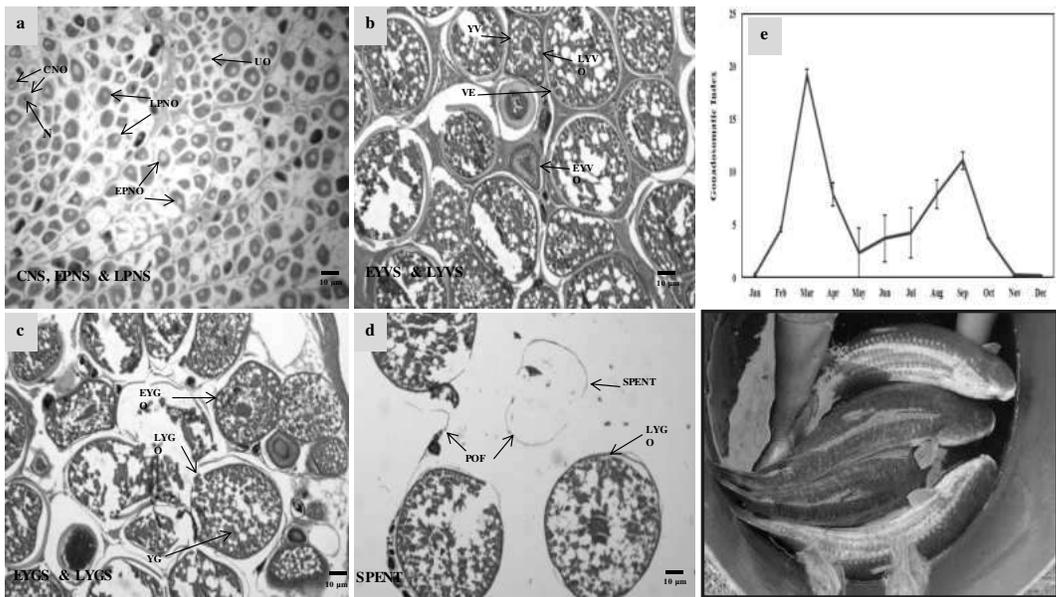


Figure 2. a. CNS (Chromatin nuclear stage), EPNS (Early perinuclear stage) and LPNS (Late perinuclear stage); b. EYVS (Early yolk vesicle stage) and LYVS (Late yolk vesicle stage); c. EYGS (Early yolk granular stage) and LYGS (Late yolk granular stage) d. SPENT. [Note: N= Nucleolei; YV= Yolk vesicle; YG= Yolk granule; VE= Vitelline envelope; POF= Post ovulatory follicle; UO= Undeveloped oocyte; CNO= Chromatin nuclear stage oocyte; EPNO= Early perinucleolar oocyte; LPNO= Late perinucleolar oocyte; EYVO= Early Yolk vesicle stage oocyte; LYVO= Late Yolk vesicle stage oocyte; EYGO= Early yolk granule stage oocyte; LYGO= Late yolk granule stage oocyte.]

Identifying peak breeding season of Kain Magur fish

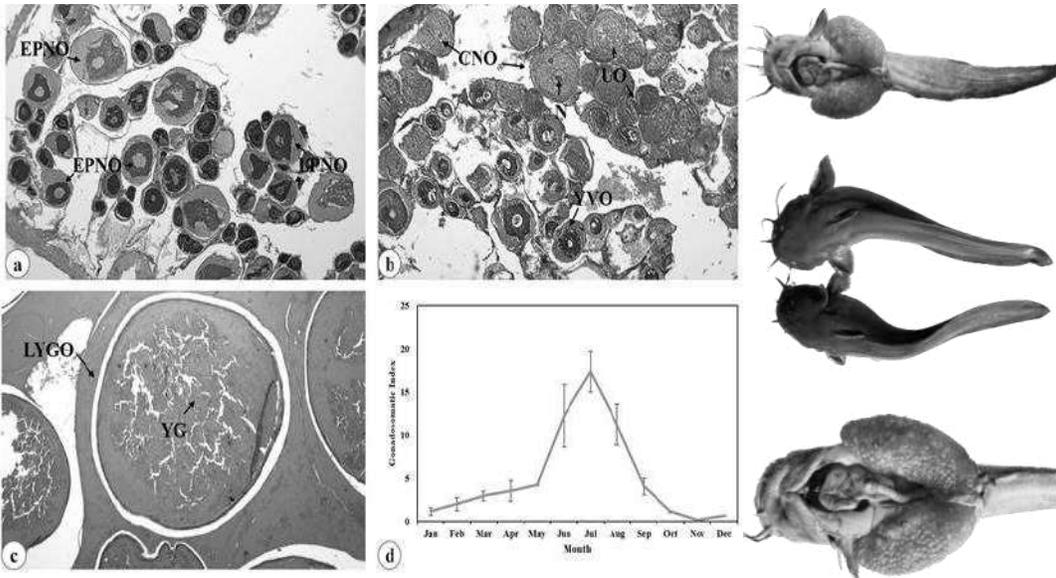


Figure 3. N= Nucleolei; YVO= Yolk vesicular Oocyte; YG= Yolk granule; UO= Undeveloped oocyte; CNO= Chromatin nucleolar oocyte; EPNO= Early perinucleolar oocyte; LPNO= Late perinucleolar oocyte; YVO= Yolk vesicular oocyte; LYGO= Late yolk granule stage oocyte.

Kain Magur (*Plotosus canius*): Graphical presentation of GSI value of *Plotosus canius* shows that this individual spawns mainly in the rainy season from June to August where in the month July is the peak spawning time. Histological slide shows that abundance of late yolk granular oocytes present from the month of June to August. Yolk granules are prominent inside the oocytes at onset of spawning period. Year-round histological observation of the developmental stages of oocytes is not fully completed yet (Figure 3) as because the single oocyte is too bigger to perform slides.

Royna (*Datnioides polota*): The *Datnioides polota* mainly spawns in the month of July. But it was seen to spawn from June to October. Year round GSI value shows peak spawning time in July and minor peak in October. During this spawning period histological observation shows that, LYGO contains dense yolk granules. Moreover, post ovulatory follicle indicated the egg releasing signs of this fish. All the oocyte development stages are not seen in the histological views yet (Figure 4).

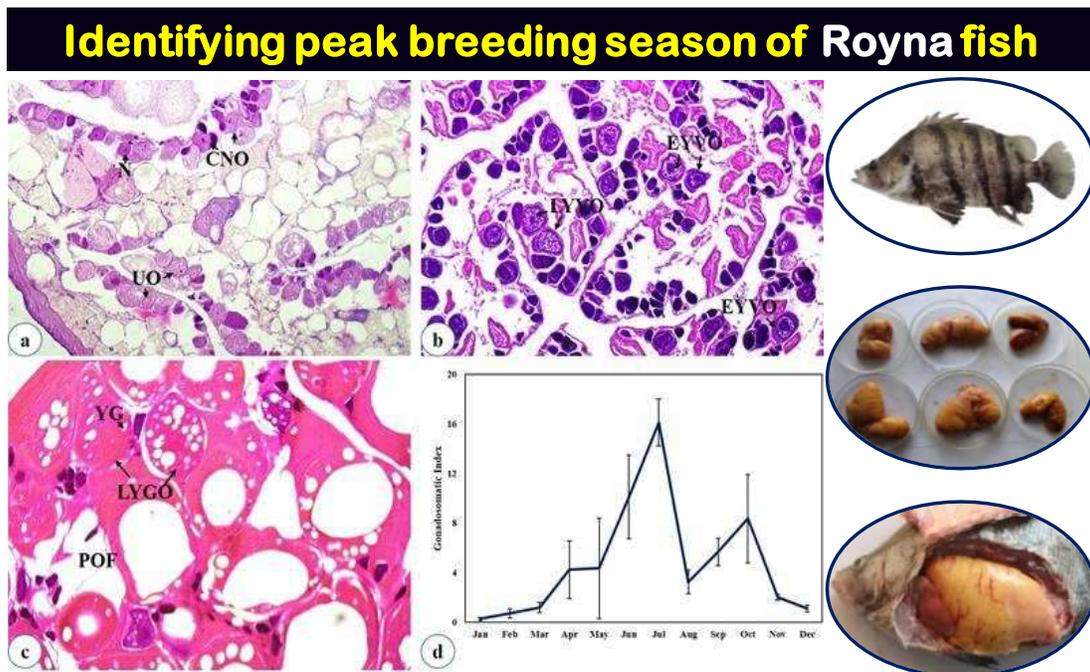


Figure 4. N= Nucleolei; YG= Yolk granule; POF= Post ovulatory follicle; UO= Undeveloped oocyte; CNO= Chromatin nucleolar oocyte; EYVO= Early Yolk vesicular oocyte; LYVO= Late Yolk vesicular oocyte; LYGO= Late yolk granular oocyte.

Bele (*G. giuris*): The gonadosomatic index (GSI) of the species gives an idea about the seasonal progression of gonad development, sexual maturity and spawning season of the fish. The highest GSI value for the female was recorded in the month of November (11.95 ± 4.17). Moreover, histological slide shows that abundance of late yolk granular oocytes present in the month from October to November indicating the peak spawning season of this species.

Thereafter, the GSI value sharply declined in January and then gradually rose from the month of August (4.23 ± 1.22). The findings of this research indicated an extended spawning season of Bele fish from August to December with a peak in November (Figure 5). The histological slides blur to make any sense therefore we were reanalyzing the histological samples to compare it with the other reproductive parameters. The findings of the histological slides are in line with the GSI graph.

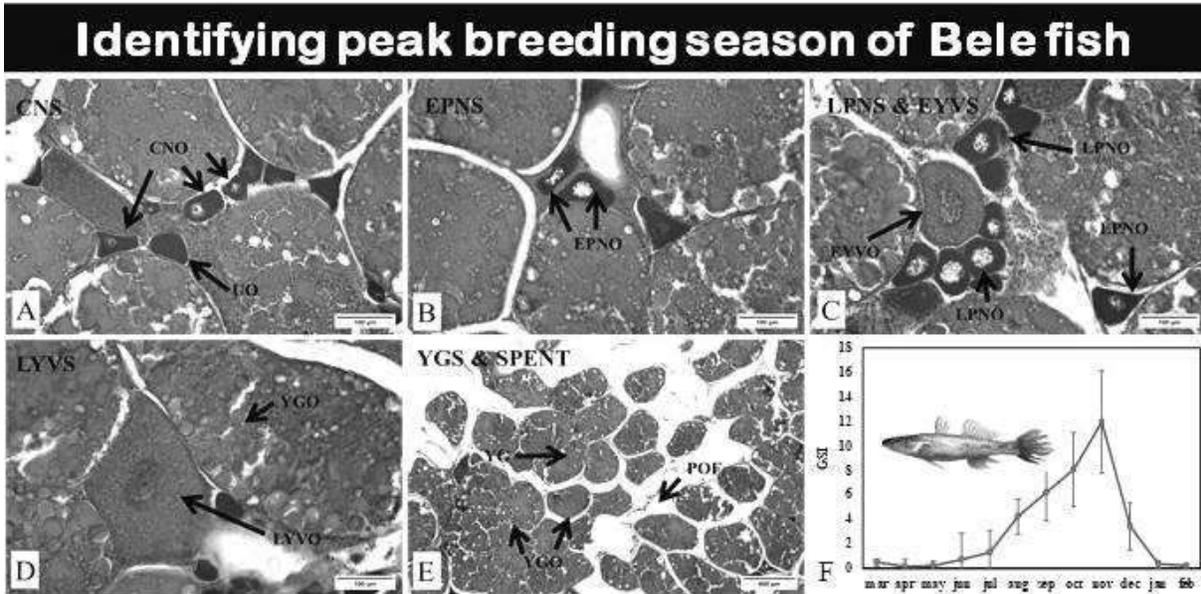


Figure 5. Graphical presentation of the monthly variation of GSI (Mean ± SD) and full gravid female of *G. giuris* in the south-western coastal region of Bangladesh

Besides histology, for more accurate identification of the peak breeding season, monthly abundance of fry in natural habitat were also monitored in three different locations viz., Shanta (Shibsa River), Baniakhali (Hodda River) and Burigoalini (Kholpetua River). We didn't found any fry during the study period expect some individuals during the respective peak breeding of each fishes.

However, species level accurate identification of the targeted tank goby was confirmed through DNA barcoding approach. The DNA extraction followed by DNA amplification, PCR product purification, sequencing and finally checking using sequence analysis software (ABI) and assured by online BLAST search program confirmed the species as *Glossogobius giuris* (Table 1).

Table 1. The result of BLAST analysis

Specimen Id	Gene bank (NCBI)				Inference
	Base pair	Total score	Similarity (%)	Reference	
Ab1	649	1192	99.85	MG923363.1	<i>Glossogobius giuris</i>

Study-2: Determiration of quality and doses of different hormones for breeding of *M. cephalus* (Bhangon) and *D. polota* (Royna)

To determine the quality and doses of different hormones for breeding of Royna fish, experiment was conducted with the following hormonal combinations (Table 2). However, no potential broods of Bhangon fish were found in the domestication pond. Therefore, the quality and doses of different hormones of Bhangon fish will be optimized when suitable broods are available. In addition, other three species (Taposi, Kain Magur and Bele) will also be considered for breeding as suitable broods are available in domestication pond or in the natural sources. The larvae will be reared with standard larvae rearing protocol. The breeding performance viz., latency period, fertilization, hatching and survival rate will be calculated as per the standard equations and compared among the treatments accordingly.

Table 2. Design of experiment to determine the quality and doses of different hormones for the breeding of Bhangon and Royna fish.

Treatments	Inducing agent	Hormone doses		
		E1 (♀: ♂)	E2 (♀: ♂)	E3 (♀: ♂)
T1	PG (mg/kg)	40:20	50:25	60:30
T2	LHRHa(μg/kg)	40:20	50:25	60:30
T3	S-GnRHa(μg/kg)	40:20	50:25	60:30
T4	0.9% NaCl	40:20	50:25	60:30

As we get some potential Royna brood fish in our domestication pond. Therefore, we conducted three breeding trials (E1, E2 and E3) to optimize the hormone and doses. The latency period stands between 36-46 hours among different experiments. Among all of the experiments, the significantly ($p < 0.05$) effective latency period was observed in T3 (37.5 ± 1.5 hrs) of E2. No fertilization took place in all the treatments of E1 (Table 3). In E2, a significantly higher ($p < 0.05$) fertilization rate was observed in T3 (93.5 ± 2.7 %) and the lowest performance was found in T2 (77.5 ± 1.9 %) and no fertilization took place in T1 and T4. Alike E2, the fertilization in E3 was observed only in T2 and T3, where in T3, the fertilization rate was highest (85.5 ± 3.3 %). Among all of the experiments, the highest fertilization rate was observed in T3 (93.5 ± 2.7 %) of E2. The fertilization rate of T3 is significantly higher ($p < 0.05$) in all experiments compared to T2. A curled movement of the embryos was observed within 16-18 hrs of spawning and the hatching took place within 22-24 hrs of fertilization. The calculated hatching rate was significantly higher ($p < 0.05$) in T3 compared to T2 in all the experiments as presented in Table 3. The highest hatching rate was observed in T2 (75.5 ± 4.5) with GnRHa hormonal injection at the rate of $50:25 \mu\text{g.kg}^{-1}$ body weight of female and male brood fish.

Table 3. Captive breeding in E1, E2 and E3 of *D. polota* (Rekha/Royna)

Treatments	Latency Period (hours)			Fertilization Rate (%)			Hatching Rate (%)		
	E1	E2	E3	E1	E2	E3	E1	E2	E3
T1	NR	NR	NR	NR	NR	NR	NR	NR	NR
T2	NR	41.5 ± 1.5^b	44.5 ± 1.5^c	NR	77.5 ± 1.9^c	68.5 ± 2.5^d	NR	47.8 ± 1.5^c	42.8 ± 2.3^d
T3	NR	37.5 ± 1.5^a	40.5 ± 1.0^b	NR	93.5 ± 2.7^a	85.5 ± 3.3^b	NR	75.5 ± 4.5^a	53.1 ± 1.8^b
T4	NR	NR	NR	NR	NR	NR	NR	NR	NR

Note: NR = No Response

If suitable brood fish of other targeted fishes are available in domestication ponds or in natural source, induced breeding trial will be conducted in the hatchery complex to determine the hormone and doses according to the study design.

Study-3: Effects of different salinity on breeding performance and larvae survival of *M. cephalus* (Bhangon) and *D. polota* (Royna)

To evaluate the effects of different salinity on breeding performance and larvae survival of Bhangon and Royna, experiment was conducted with four different salinity treatments, viz, T1 (24 ppt), T2 (27 ppt), T3 (30 ppt) and T4 (33 ppt) (Table 4). The larvae were reared with standard larvae rearing protocol. The

fertilization, hatching and survival rate were calculated as per the following equations and compared among the treatments accordingly.

$$\text{Fertilization rate (\%)} = \frac{\text{Number of fertilized eggs in sub - sample}}{\text{Total number of eggs observed in sub - sample}} \times 100$$

$$\text{Hatching rate (\%)} = \frac{\text{Number of hatchlings}}{\text{Total number of fertilized eggs}} \times 100$$

$$\text{Survival rate (\%)} = \frac{\text{Final population (Pt)}}{\text{Initial population (Po)}} \times 100$$

Table 4. Design of experiment to evaluate different salinity levels on breeding performance and larvae survival of Bhangon and Royna fish

Treatment	Salinity	Replications
T1	24	3
T2	27	3
T3	30	3
T4	33	3

Till reporting, three breeding trials were made to produce Royna larvae in the hatchery complex of Brackishwater Station. The highest fertilization rate was recorded as $93.5 \pm 2.7\%$ in T3 (30 ppt) which is significantly ($p < 0.05$) higher than T1 ($55.0 \pm 2.5\%$), T2 ($77.5 \pm 1.9\%$) and T4 ($68.5 \pm 2.5\%$). Similarly, the highest hatching rate was estimated as $80.5 \pm 4.5\%$ in T3 which is significantly ($p < 0.05$) higher than T1 ($35.5 \pm 2.5\%$), T2 ($53.1 \pm 1.8\%$), and T4 ($47.8 \pm 1.5\%$) (Table 5).

Table 5. Captive breeding of *D. polota* under different salinity

Treatments	Fertilization Rate (%)	Hatching Rate (%)	Survival Rate (%)
T1	55.0 ± 2.5^d	35.5 ± 2.5^d	0.0
T2	77.5 ± 1.9^b	53.1 ± 1.8^b	0.0
T3	93.5 ± 2.7^a	80.5 ± 4.5^a	0.0
T4	68.5 ± 2.5^c	47.8 ± 1.5^c	0.0

The water quality parameters and larval quality of the breeding tank was measured regularly. But unfortunately, the larvae survived only for 10 days. However, the experiment will be conducted for other fishes when suitable brood fish are available.

Study-4: Study of the embryonic and larval development of *M. cephalus* (Bhangon) and *D. polota* (Royna)

Immediately after ovulation, a small amount of milt with good motility was sprinkled over the released eggs for ensuring successful fertilization. Immediately after 10 minutes of incubation, only the buoyant eggs from the surface water were collected and shifted to the hatching tank (250 L fiber reinforced plastic tank) holding seawater (30 ppt salinity) for additional incubation. The fertilized eggs were found floating on the water surface. Microscopic investigation revealed that the fertilized eggs were translucent with an unbroken nucleus whereas the unfertilized eggs were opaque and broken nucleus. Embryonic and larval developmental stages of fertilized eggs were monitored continuously at every 20-30 minutes interval for ensuring every stages and documented under LEICA DM1000 LED microscope from zero hour post-fertilization (hpf) to larval stage.

Preliminary breeding success was achieved for Royna and Kain Magur fish. The larvae of Royna survived for 10 days (Figure 6) whereas the eggs of Kain Magur partially fertilized but stopped the progress after 12 hrs (Figure 7). However, complete success will be achieved in near future using the present experience as the hormone, hormonal dose and latency period has been optimized. The complete embryonic and larval development stages will be monitored in the upcoming breeding success.



Figure 6. Preliminary success on Royna breeding

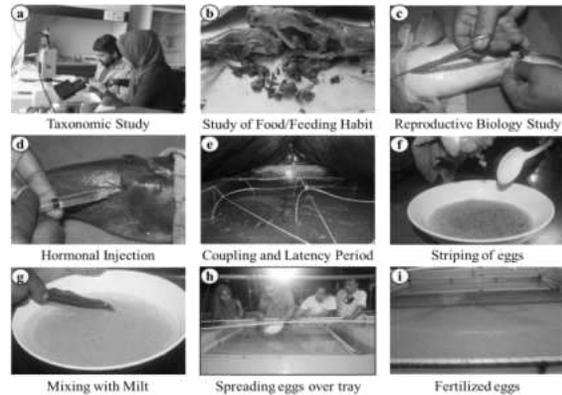


Figure 7. Preliminary success on Kain breeding

Application of Nanoparticles (NPs) as Feed Additives and Efficient Therapeutic Strategy for Shrimp Health Management

Researchers

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Objectives

- To explore antimicrobial capabilities of different multifunctional Nanoparticles (NPs) against infectious pathogens of shrimp.
- To develop an efficient feed additive for aqua feed industry.
- To assess the biocompatibility of using NPs.

Achievements

Experiment 1. Eco-friendly green synthesis of Nanoparticles (NPs) with different plant extract

Leaves of *A. ilicifolius* (English name: Holy mangrove; Local name: Hargoza) and *M. oleifera* (English name: Drumstick tree; Local name: Sajina). Different solvents (Ethanol, Acetone, Hexane, Ethyl acetate & n-butanol) with other necessary chemicals for extraction. Mueller hinton agar (MHA), thiosulfate citrate bile salts sucrose (TCBS) agar media, tryptic soy broth (TSB), blank antibiotic disc, antibiotic disc for antimicrobial test. Metallic silver salt ($\text{AgNO}_3 \geq 99.8\%$) were purchased from the company. The Nanoparticles synthesis was executed using two plant extract following the established biological methods.

Step-1. Preparation of plant extract

Collection and Authentication of Plant

Fresh Hargoza and Sajina plant leaves were collected from Dharatana riverbank and Chitoli and Boithpur villages, Bagerhat, Bangladesh, throughout the fiscal year 2022-23. Plant leaves were sent for identification and certification by Bangladesh National Herbarium, Dhaka, Bangladesh.

Extract preparation

The collected leaves were thoroughly cleaned and washed in running water followed by distilled water to remove any dust particle, and then shaded dried for consecutive 5 days. The dried leaves and stems were subjected separately to a mechanical grinder to prepare coarse powder. Large amount of coarse powder of leaves was sieved with 250-300 μm and stored at -20°C in separate air-tight containers and kept in a dry, cool, and dark place until used for the experiment. The crude extract was prepared by using six solvents e.g. water, acetone, methanol, ethanol, CHCl_3 and ethyl acetate following the established protocol. The extraction was done by maceration process using 30g of each dried leaf powder with 300 ml solvent was placed into the beaker and stirring for 12 hours using a magnetic stirrer at 50°C and 200 rpm. Later, Whatman filter paper No. 1 was used to filter the extracts, followed by concentrating the filtrates using a rotary evaporator at 45°C (pressure 57 mmHg). The remaining residue was dried using nitrogen gas and extract was stored -20°C until further use and analysis. The samples were kept unlidged for some days to

volatilize the residual solvents. Finally, the residues of different solvent extracts of leaves were collected separately, and the mass of each extract was calculated in percentage according to the following equation:

$$\text{Yield (\%)} = \frac{\text{mass of crude extract} \times 100}{\text{total mass of dry powder}}$$

Screening of the phytochemicals of *A. ilicifolius* and *M. oleifera* leaves extract

Freshly prepared extracts were subjected to preliminary phytochemical analysis to identify secondary metabolites like phenols, amino acid, saponins, terpenoids, alkaloids, glycosides, tannins, flavonoids, coumarin, quinone, anthocyanin and essential oils. Phytochemical tests using standard protocols were performed to construct the presence of bioactive compounds in different extracts of *A. ilicifolius* and *M. oleifera*.

Screening of different solvents extract with antimicrobial activity test (*In vitro*)

Pathogenic agents like *Vibrio parahaemolyticus* were brought from the stock which stored at -80°C of SRS Shrimp Health Management Laboratory. The antimicrobial activity of targeted leaf extract was assessed through Kirby Bauer disk diffusion method on the protocols specified in the CLSI guideline M100-S28 where the extract dose Inhibition zone diameter was considered for the determination of antimicrobial activity. Along with this, minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) were assessed simultaneously following the standard methods.

Investigation of *In vitro* antioxidant assay

The free radical scavenging properties of different extracts of *A. ilicifolius* and *M. oleifera* were determined against DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS [2,2'-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid)] (Arulkumar et al., 2018) assay following standard protocol. Trolox was used as reference standard. The antioxidant activity of extracts was calculated by using the following equation:

$$\text{Free radical scavenging activity (\%)} = \frac{\text{absorbance of control} - \text{absorbance of sample}}{\text{absorbance of control}} \times 100$$

The antioxidant value was expressed as IC₅₀, which is defined as the concentration in µg of the dry extract per ml that inhibits the formation of DPPH and ABTS radical by 50%. Each value was determined from the slope of the linear regression equation ($Y = mx + C$), obtained by plotting the Trolox standard curve. Total phenolic content (TPC), total flavonoid content (TFC) and total proanthocyanidin content (TPrC) by using the previously published standard protocol. Gallic acid and Catechin were the reference standards used for the above assay.

Step-2. Synthesis of Nanoparticles (NPs)

Green synthesis of AgNPs with *A. ilicifolius* and *M. oleifera* leaf extract

A complete and simplified protocol was standardized for the green synthesis of Nanoparticles using ethanolic extract of *A. ilicifolius* and *M. oleifera*, and AgNO₃ solution. With repetitive trial and error basis, concentration of AgNO₃, pH of extract and Extract: AgNO₃ ratio were fixed at 5mM, pH-10 and 1:2 respectively. The formation of Nanoparticle was accomplished following steps: (1) incubation at 60 °C for 6 hrs, (2) centrifugation at 10000 rpm for 15 minutes, (3) washing with sterile ddH₂O 2/3 times at 10000 rpm for 15 minutes & (4) drying at room temperature for 2 days. Synthesis of AgNPs were

confirmed by the changes of color and, a sharper and stronger peak of the UV-visible spectrum analysis and stored at -80 °C in airtight containers for further analysis and experiment.

Simple pyrolysis

It was performed with one-step pyrolysis (Heating in oven at 180 °C for 3 hours), sonication and centrifugation process.

Step-3 Characterization of (structural and chemical composition) of leaf extract coated composite AgNPs

The characterization of synthesized AgNPs was performed in Bangladesh Council of Scientific and Industrial Research, Dhaka and Jashore University of Science and Technology, Jashore, Bangladesh.

Absorption spectrum analysis

During the biological synthesis of AgNPs, 200 µL of reaction mixture was withdrawn and monitored using UV-VIS spectrophotometer with a wavelength ranging from 300-800 nm.

Checking of morphology, elemental composition, purity, and crystallinity

These phenomena were assessed using scanning electron microscopy (SEM), energy dispersive X-ray (EDX) and X-ray diffraction (XRD) spectroscopy.

Identification of functional group

The functional group of synthesized AgNPs was identified by FTIR (Fourier transform-infrared) equipment.

Profiling of size distribution

It will be performed using dynamic light scattering (DLS) machine.

Thermal analysis

Thermal analysis of AgNPs will be measured by using TGA at a heating rate of 10°C/min under a nitrogen atmosphere.

Experiment 2. Exploring *In vitro* antimicrobial efficacy (AME) of composite Nanoparticles (AgNPs)

Pathogenic agents like *Vibrio parahaemolyticus*, *Pseudoalteromonas ostreae* and *Shewanella khirikhana* were brought from the stock stored at -80°C of shrimp disease and health management laboratory. The antimicrobial activity, minimum inhibitory concentration (MIC), minimum bactericidal concentration (MBC) and IC₅₀ of targeted NPs will be assessed through disk diffusion and agar dilution method. Inhibition zone diameter, OD value and total plate count will be considered for the determination of AME and MIC, MBC and IC₅₀.

Experiment-1. Eco-friendly green synthesis of Nanoparticles (NPs) with different plant extract Extraction Yield

Acanthus ilicifolius and *Moringa oleifera* leaf extracts using six different solvents were used to determine the extraction yield. Of the six solvents (water, acetone, methanol, ethanol, CHCl₃ & ethyl acetate) water gave highest extraction yield for both plants e.g. Hargoza (15.8%) and Sajina (14.9%) while the 2nd and 3rd highest yield was produced by methanol and ethanol.

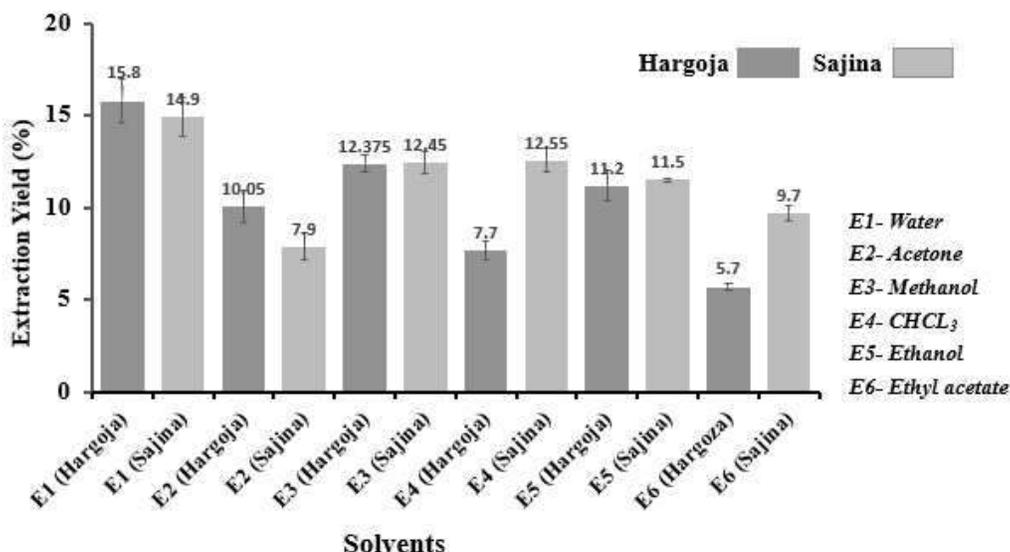


Figure 1. Extraction yield of *A. ilicifolius* and *M. oleifera* crude extracts using various solvents.

Phytochemical screening of *A. ilicifolius* and *M. oleifera* crude extracts

The preliminary phytochemical screening using 11 phytochemical tests revealed that *A. ilicifolius* contained about 8 classes of bioactive compounds (BC) with ethanol, acetone and methanolic extract whereas *M. oleifera* with acetone and methanolic extract showed the existence of almost 10 and 9 BCs respectively.

Table 1. Phytochemical screening of *A. ilicifolius* and *M. oleifera* crude extracts

Phytochemicals	Test name	<i>M. oleifera</i> (Sajina)					<i>A. ilicifolius</i> (Hargoza)				
		E1	E2	E3	E4	E5	E1	E2	E3	E4	E5
Alkaloids	Alkaloids	√	√	X	X	X	√	√	X	X	X
Amino acids	Xanthoprotein	√	√	X	X	√	X	X	X	√	√
Phenols	FeCl ₃ test	√	√	√	√	√	√	√	√	√	√
Flavonoids	Alkaline reagent	√	√	√	√	X	√	√	√	√	X
Tannins	FeCl ₃	√	X	X	√	X	√	√	X	√	X
Saponins	Foam test	√	√	X	√	X	√	√	X	√	X
Terpenoids	Salkowskis	√	√	X	√	X	√	√	X	√	√
Phlobatanins	1% HCl acid	X	X	X	X	X	X	X	X	X	X
Quinones	HCl acid	√	√	X	X	X	X	√	√	X	X
Coumarin	NaOH	√	√	√	√	X	√	√	√	√	X
Anthocyanin	Sulfuric acid	√	√	X	√	X	√	√	√	√	√

Antioxidant test

M. oleifera and *A. ilicifolius* extracts were used for different antioxidant tests like DPPH free radical scavenging activity, ABTS free radical scavenging activity, Ferric Reducing Antioxidant Power (FRAP), Total Phenolic Content Assay (TPC), Total Flavonoid Content Assay (TFC), CUPRAC Assay, TPrC Assay and H₂O₂ scavenging assay.

Total phenolic contents (TPC)

The total phenolic contents (TPC) (30.75 mg GAE/g dry powder) in *M. oleifera* were found significantly higher in acetone extract (3mg/ml) as compared to other solvent extract. But in *A. ilicifolius* total phenolic contents (TPC) (25.95 mg GAE/g dry powder) were found significantly higher in ethyl acetate extract as compared to other solvent extract (Figure 2).

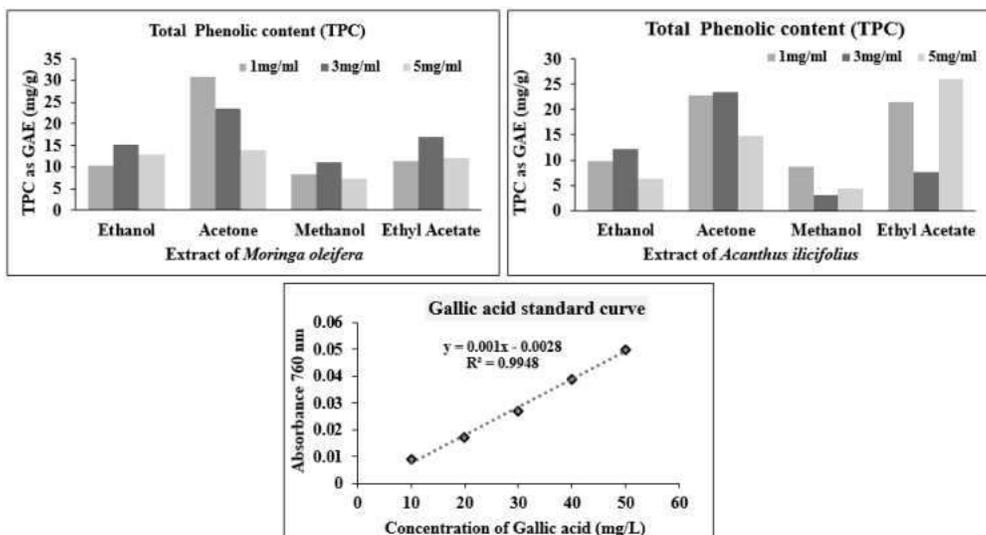


Figure 2 TPC in *M. oleifera* and *A. ilicifolius* extracts comparing with gallic acid

Total flavonoid contents (TFC)

Total flavonoid contents (TFC) (14.16 mg catechin/g dry powder) in *A. ilicifolius* were found significantly higher in acetone extract (1mg/ml) as compared to other solvent extract. But in *M. oleifera* total flavonoid contents (TPC) (7.66 mg catechin/g dry powder) were found significantly higher in methanol extract (1mg/ml) as compared to other solvent extract (Figure 3).

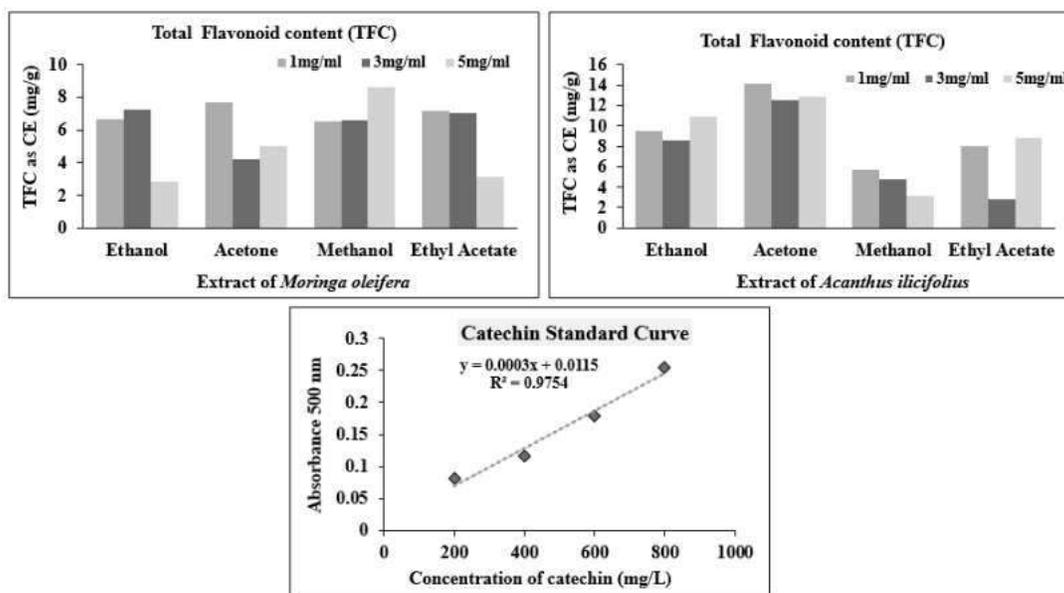


Figure 3 TFC in *A. ilicifolius* and *M. oleifera* extracts comparing with catechin

DPPH Free Radical Scavenging Assay

In this process, nitrogen-free radical in the DPPH is readily scavenged by the antioxidant compounds, and the purple color of DPPH solution is cleared by the antioxidants. The findings show that the antioxidant activity of crude *A. ilicifolius* in ethanolic extracts (88%, $IC_{50}= 0.61\pm 0.11$) and *M. oleifera* extracts increases dramatically as the concentration of these extract increases comparable to extracts with phenolic and flavonoid content. Compared to the positive control (i.e., Trolox, $IC_{50}=0.034 \text{ mg mL}^{-1}$), the IC_{50} values of all crude extracts showed lower DPPH radical scavenging effects (Figure 4).

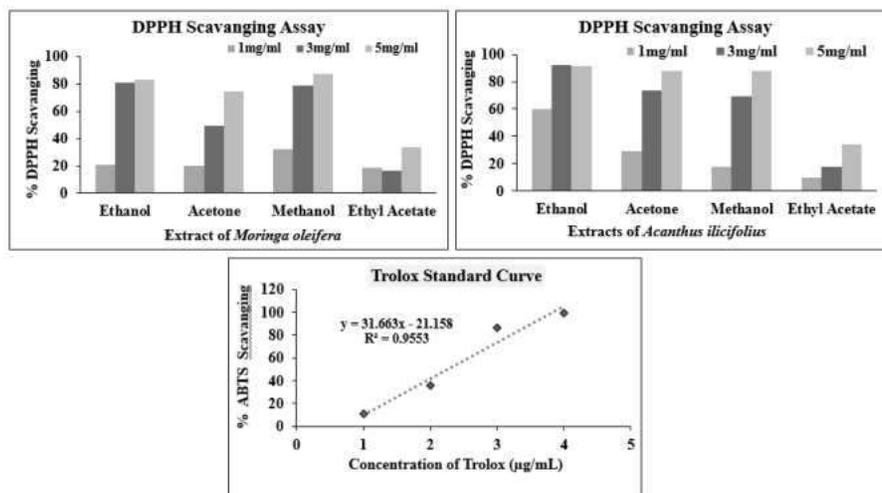


Figure 4. DPPH assay in *A. ilicifolius* and *M. oleifera* extracts based on trolox standard

ABTS (2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) Free Radical Scavenging Assay

ABTS chromophore between ABTS and hydrogen donating oxidizing agent, in this case, potassium persulfate. Among the methanolic extracts, *A. ilicifolius* recorded significantly higher ABTS free radical scavenging activity (66.78%, $IC_{50}=10.09\pm 0.0185 \text{ mg mL}^{-1}$) followed by *M. oleifera* (66.09%, $IC_{50} = 4.25\pm 0.008 \text{ mg mL}^{-1}$) (Figure 5). As shown in Table 4, the IC_{50} values exhibited the order (methanol>acetone>ethanol>ethyl acetate), comparable to extracts with phenolic and flavonoid content. Compared to the positive control (i.e., Trolox standard, $IC_{50}=0.11 \text{ mg mL}^{-1}$), the IC_{50} values of all crude extracts showed lower ABTS radical scavenging effects.

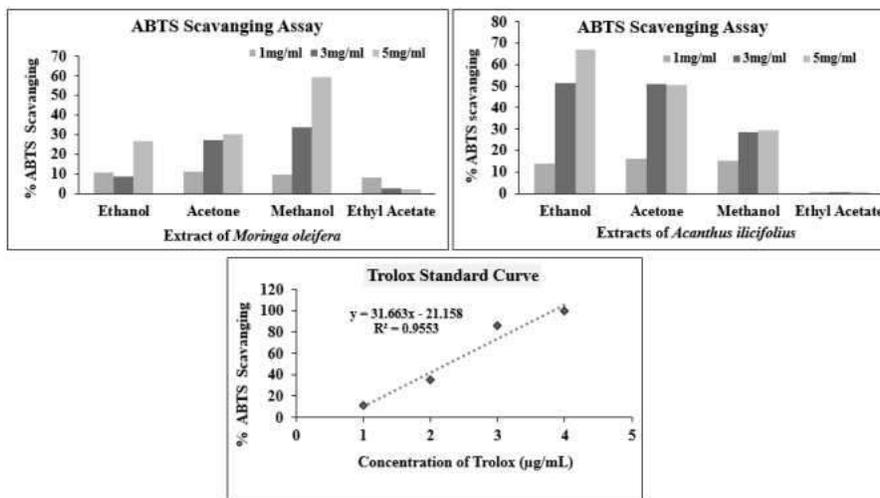


Figure 5. ABTS assay in *A. ilicifolius* and *M. oleifera* extracts comparing with trolox

Total procyanidin content (TPrC)

Total procyanidin content (TPrC) higher in Acetone extract (11.46 mg Catechin /g dry powder) in case of Hargoza but in Sajina higher value was found in methanol extract (6.5 mg Catechin /g dry powder) (Figure 6).

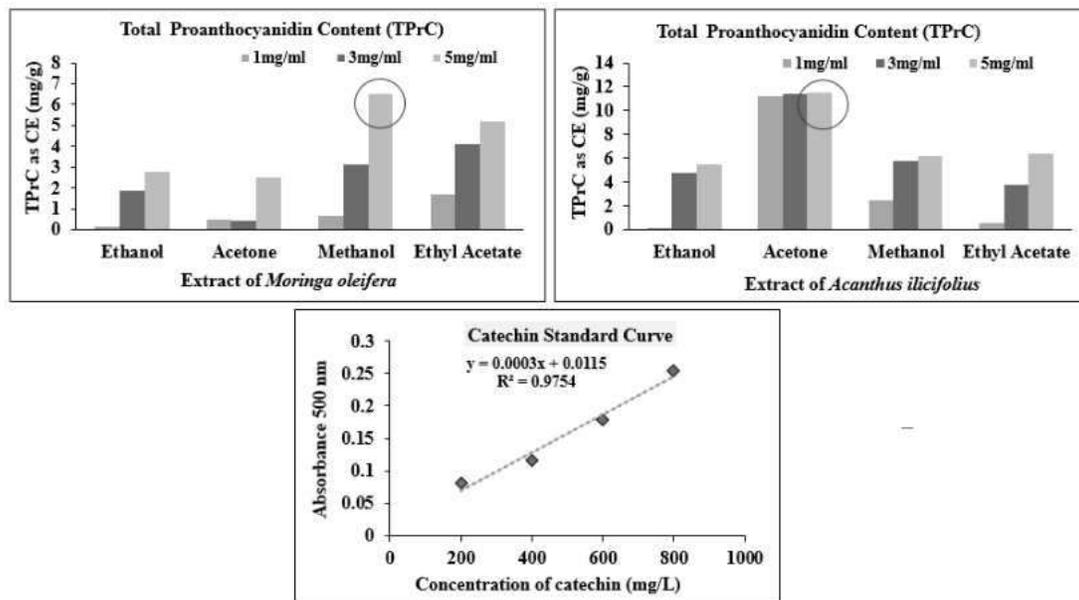


Figure 6 TPrC in *A. ilicifolius* and *M. oleifera* extracts comparing with catechin

Table 2. IC₅₀ values of *M. oleifera* DPPH assay

Assay	IC ₅₀ (mgmL ⁻¹ values of different crude extracts of <i>M. oleifera</i>)				
	Trolox	Ethanol	Methanol	Acetone	Ethyl acetate
DPPH assay	0.03±0.001	2.36±0.10	1.92±0.09	3.27±0.12	9.98±0.13

Table 3 IC₅₀ values of *M. oleifera* ABTS assay

Assay	IC ₅₀ (mgmL ⁻¹ values of different crude extracts of <i>M. oleifera</i>)				
	Trolox	Ethanol	Methanol	Acetone	Ethyl acetate
ABTS assay	0.11±0.0009	11.34±0.37	4.25±0.008	9.08±0.34	19.77±0.68

Table 4 IC₅₀ values of *A. ilicifolius* ABTS assay

Assay	IC ₅₀ (mgmL ⁻¹ values of different crude extracts of <i>A. ilicifolius</i>)				
	Trolox	Ethanol	Methanol	Acetone	Ethyl acetate
ABTS assay	0.11±0.005	3.44±0.16	10.29±0.185	5.92±1.11	711.71±0.14

Table 5 IC₅₀ values of *A. ilicifolius* DPPH assay

Assay	IC ₅₀ (mgmL ⁻¹ values of different crude extracts of <i>A. ilicifolius</i>)				
	Trolox	Ethanol	Methanol	Acetone	Ethyl acetate
DPPH assay	0.03±0.002	0.61±0.11	2.61±0.083	2.29±0.22	7.54±0.27

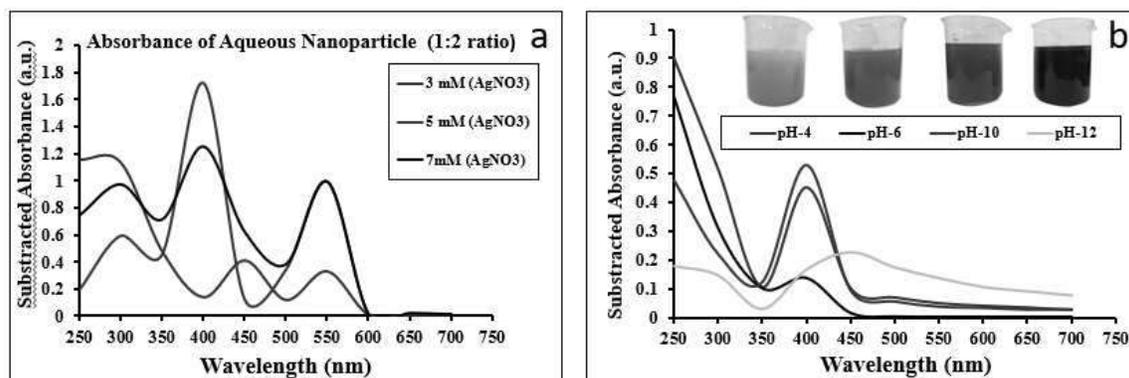


Figure 7. Optimization of (a) AgNO₃ concentration and (b) pH of extract in synthesis of NPs

Optimization of AgNO₃ concentration and pH of extract in synthesis of NPs

With repetitive trial and error basis, concentration of AgNO₃, pH of extract and Extract: AgNO₃ ratio were fixed at 5mM, pH-10 and 1:2 respectively (Figure 7-a and 7-b) considering the highest peak (OD value) between 300-500 nm. After 6 hours, the synthesis solution of silver nanoparticles using pH variations from *A. ilicifolius* leaves extract showed various colors. The colors formed at pH 4 were yellowish, light brown at pH 6 and dark brown at pH 10 and pH 12 are (Figure 7 b). This color is the characteristic from the surface plasmon resonance of AgNPs. The UV-Vis spectra were subtracted to show the equalize baseline between treatments (Figure 7 b). The difference in the value of λ_{max} and the number of λ_{max} can indicate differences related to the size and shape of AgNPs. The AgNPs absorbance value increases with the increasing of pH, except pH 12, where at pH 10 there is a high absorption value, and there were 3 peaks that indicate different sizes of AgNPs. A higher absorption value can also indicate a higher number of nanoparticles. Synthesis of AgNPs were confirmed by the changes of color and, a sharper and stronger peak of the UV-visible spectrum at 400 nm for both Hargoza and Sajina (Figure 8). The formation of Nanoparticles was accomplished following steps: (1) incubation at 60 °C for 6 hours (2) centrifugation at 10000 rpm for 10 minutes, (3) washing with sterile ddH₂O 2/3 times at 10000 rpm for 15 minutes & (4) drying at room temperature for 2 days (Figure 9).

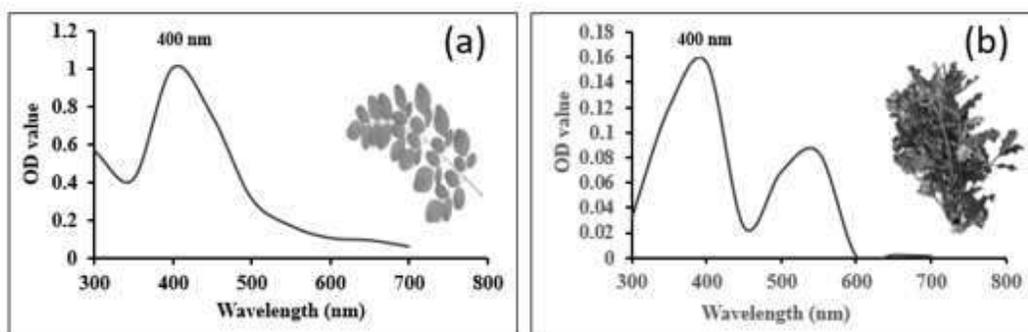


Figure 8 UV-vis absorption spectrum of AgNPs synthesized by (a) *M. oleifera* (b) *A. ilicifolius*

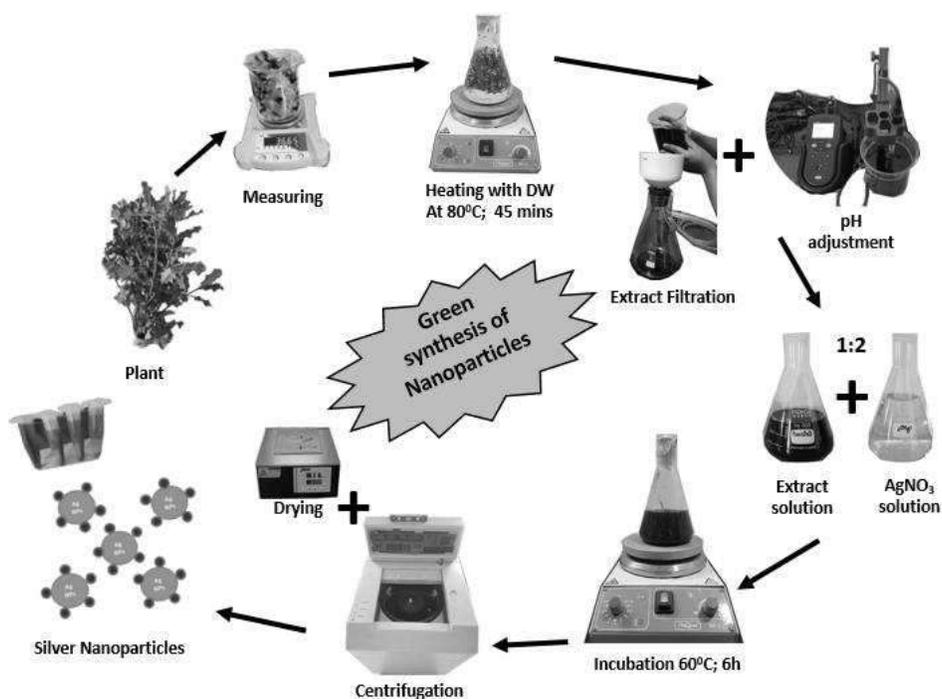


Figure 9. Work flow of the Silver Nanoparticle (AgNPs) formation

Characterization of (structural and chemical composition) of *A. ilicifolius* and *M. oleifera* leaf extract coated composite AgNPs

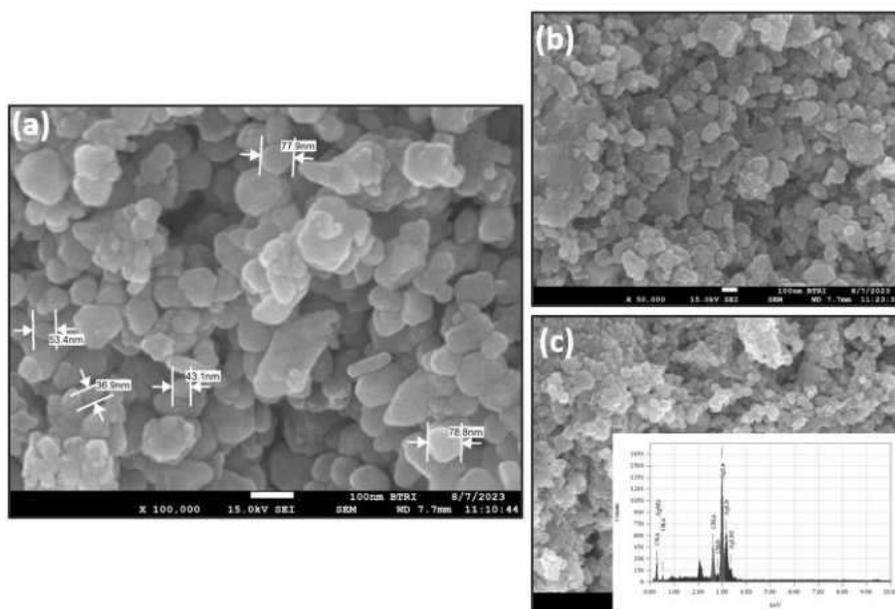


Figure 10 SEM with EDX image of *A. ilicifolius* extract mediated AgNPs.

Nanoparticles usually referred as particles with a size up to 100 nm. In the present study, results showed in figure 10 (a-b), the average particle size was 36.9 nm to 78.8 nm which confirmed the formation of nanoparticles and their shape was clear spherical with no agglomeration. The result of EDX analysis (Figure 10-c), revealed the detection of strong signals for silver and nitrate ions. The signal at 3.0 strongly

suggested that corresponding binding energies of AgLa was the element of the NPs. The elemental composition as demonstrated from EDX spectra revealed strong signal for silver. Additionally, C, Cl and Oxygen also detected. Carbon signal might have resulted from the grid, oxides during sample preparation and Cl might have been a phytochemical moiety responsible for capping Nanoparticle as shown in inset Figures 10 (b) and(c).

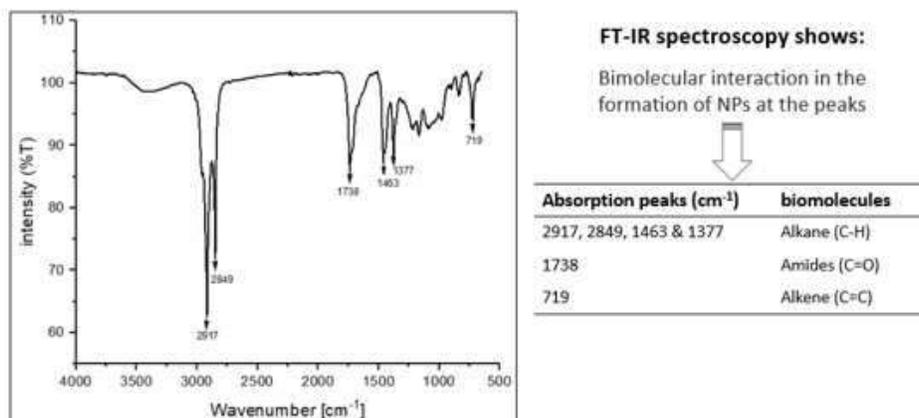


Figure 11. FTIR spectrum of *A. ilicifolius* plant extract mediated AgNPs.

The *A. ilicifolius* plant extract mediated AgNPs (Figure 11) showed distinct absorption peaks in the FTIR analysis at 2917 cm⁻¹ and 2849 cm⁻¹ which response for the alkane (C-H stretch), 1738 cm⁻¹ for esters group (C=O stretch), 1463 cm⁻¹ and 1377 cm⁻¹ for alkane group (C-H stretch) and 719 cm⁻¹ for alkene (C=C). FTIR spectroscopy revealed that the main functional group components of the *A. ilicifolius* plant extract mediated AgNPs were esters, amines, alkane and alkene, phenol, and flavonoid.

Experiment-2. Exploring *In vitro* antimicrobial efficacy (AME) of composite Nanoparticles (AgNPs)

The antimicrobial activity of *A. ilicifolius* and *M. oleifera* extract mediated AgNPs is presented in Figure 12 a-b and 13. *A. ilicifolius* at 500-1000 mg/ml and *M. oleifera* at 450 mg/ml extract mediated AgNPs showed significant inhibition zone against *V. parahaemolyticus* (15 mm) followed by *Pseudoalteromonas ostreae* (13 mm) and *Shewanella khirikhana* (12mm) (Figure 13). It can be noted that the difference in susceptibility pattern toward AgNPs exposed to Gram-positive and Gram-negative strains relies on their cell wall make up.

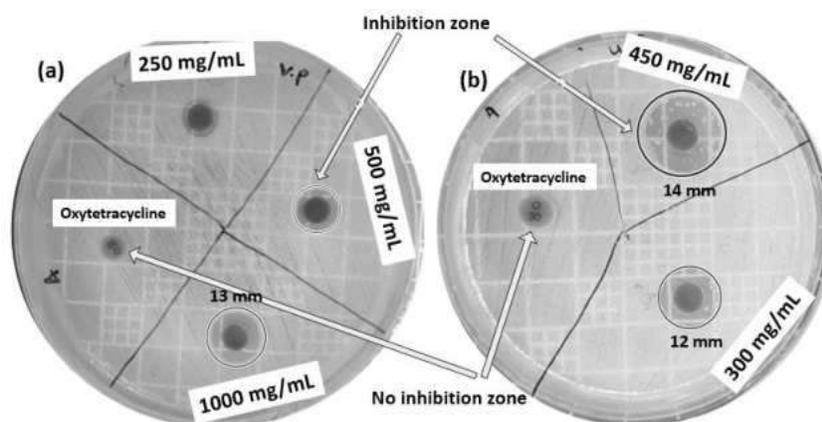


Figure 12. Antimicrobial Activity Assay of (a) Hargoza and (b) Sajina extract mediated AgNPs against *V. parahaemolyticus*

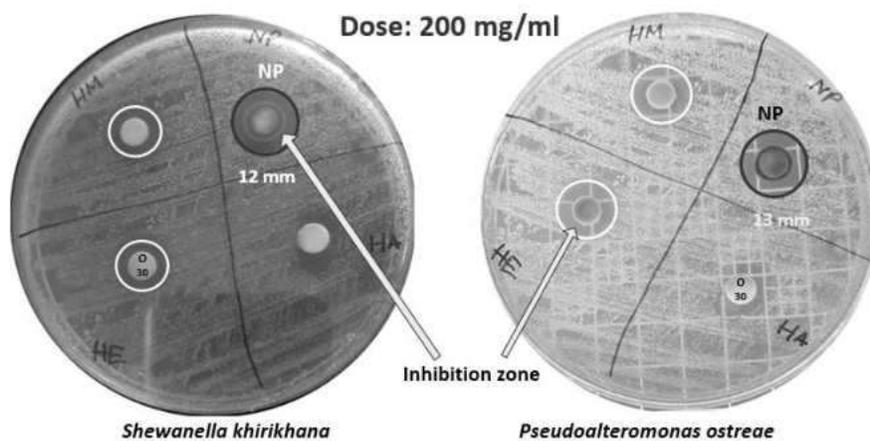


Figure 13. Antimicrobial activity of *Acanthus ilicifolius* extract mediated AgNPs against *Shewanella khirikhana* and *Pseudoalteromonas ostreae*

Effect of *Najas sp.* on Physicochemical Parameters of Soil, Water and Immunogenic Properties in Shrimp (*P. monodon*) Farming

Researchers

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Objectives

- To assess the primary productivity and soil, water quality of pond.
- Comparative study on microbial community and shrimp health status.
- To assess the bioactivity of *Najas sp.*

Achievements

Based on last year's best results, 20% of the pond space in the treatment ponds were planted with *Najas sp.* Control pond was maintained with traditional culture practices and applying 50% commercial feed (T₁) and applying no feed (T₂) according to control set as treatments.

Table 1. Experimental Design

Treatment	Feeding	<i>Najas sp.</i> plantation in pond	Replications
Control pond	Normal feeding (Without plantation)	20% of water area (Based on previous year finding)	3
T ₁	50% feeding		
T ₂	No feeding		

Experiment-1. Effect of different feeding ratio in Shrimp (*P. monodon*) farming with *Najas sp.*

The ponds were made ready by drying, liming (quick lime: dolomite 2:1) @ 250 kg/ha of soil, and then filling with tidal water to a depth of 1m. Chlorine was added to the water @ 20 ppm to disinfect it and eliminate any microorganisms. Inorganic fertilizer Urea and TSP were applied @ 25 and 30 kg/ha, respectively, to hasten the development of the water's color and the growth of plankton. After producing enough plankton, the necessary quantity of PCR-tested PL was stocked to the experimental ponds. 20% of the water area in treatment ponds was planted with *Najas sp.* Normal feeding rates were followed by usual practice in the control pond, however in T₂ no feed was given, and in T₁ 50% less feed was given than in control.



Plate 1: Preparation of ponds



Plate 2: Feeding in culture ponds

The water of the ponds was treated with 15 ppm dolomite on monthly basis and fertilized with inorganic fertilizer whenever necessary. Zeolite @ 4 ppm was applied to the ponds in 3rd month of culture. Feeding behavior and well-being of shrimp were checked twice daily by setting check tray. After 120 days of culture, shrimps were harvested by complete dewatering and the ponds were prepared again for next as usual following all the previous interventions.

Study-1. Assess the primary productivity, soil and water quality of ponds

Water quality analysis

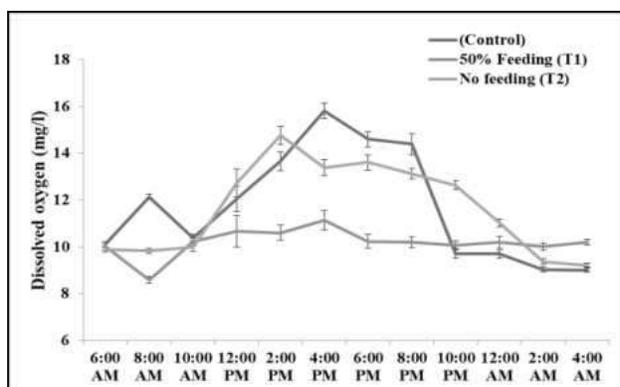
The water quality variables viz., temperature, depth, transparency, salinity, pH and total alkalinity, dissolved oxygen were monitored at 15 days interval following standard methods. The recorded average water quality variables are shown in Table 2. In water quality, alkalinity has shown larger difference in treatment ponds than control.

Physico-chemical parameter

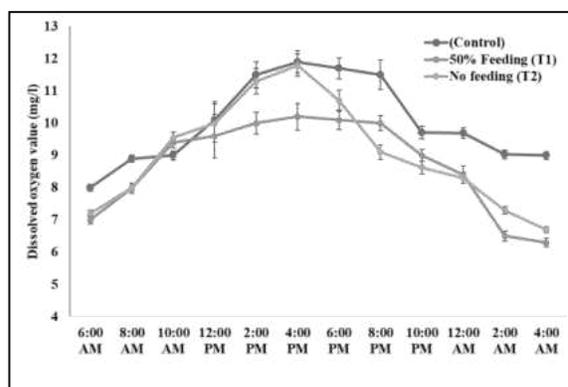
Table 2. Water quality parameters in different culture ponds

Physicochemical Parameter of water	Control	T ₁ (50% feeding)	T ₂ (No feeding)
Temperature (°C)	30.28±1.36	30.36± 0.48	30.14± 0.19
pH	8.1± 0.58	8.37± 0.64	8.49± 0.31
Salinity (ppt)	8±1.88	8.1± 1.25	9± 1.4
Alkalinity (mg/l)	115.5±55.05	96.5±12.75	90.5±23.34
Ammonia (mg/l)	0.03±0.01	0.035±0.01	0.025±0.01
Dissolved Oxygen (mg/l)	7.78± 2.54	8.54± 2.13	9.25± 0.91
Conductivity (mS/cm)	7.89± 1.47	6.58± 1.03	6.558± 1.18
Total Dissolved Solids (g/l)	3.96± 0.78	3.34± 0.53	3.39± 0.65

DO fluctuation at 24h



DO fluctuation in summer day



DO fluctuation in rainy day

Figure 1. DO fluctuation for 24h in different environmental conditions

Minerals\ micronutrient

Minerals of water were analyzed in the laboratory of SRDI, Khulna.

Table 3. Nutritional changes of water of the culture ponds in different treatments

Sampling Time	Treatment	P	K	S	Z	Ca	Mg	Cu	Fe	Mn
Before culture	Control	0.35	0.157	1.42	0.003	2.69	0.72	<0.1	0.03	0.16
Mid-Culture		0.28	0.202	1.32	0.016	2.83	2.96	<0.01	<0.01	<0.01
Before culture	50% Feeding	0.34	0.135	1.18	0.012	2.62	0.68	<0.1	<0.1	<0.01
Mid-Culture		0.43	0.169	1.06	0.005	2.75	2.54	<0.01	<0.01	<0.01
Before culture	No feeding	0.43	0.136	1.12	0.0002	2.22	0.73	<0.1	<0.1	<0.01
Mid-Culture		0.38	0.167	1.3	0.002	2.62	2.25	<0.01	<0.01	<0.01

P = Phosphorus, K = Potassium, S = Sulfur, Z = Zink, Ca = Calcium, Mg = Magnesium, Cu = Copper, Fe = Iron, Mn= Manganese

Soil quality analysis

Minerals of Soil (till date) was analyzed in the laboratory of SRDI, Khulna.

Table 4. Soil quality parameters in different culture ponds

Sampling Time	Treat ment	OM	Total N	P	K	S	Z	B	Ca	Mg	Cu	Fe	Mn
Before culture	Control	0.8	0.05	21.35	0.85	198.3	2.61	1.175	56.35	7.36	9.14	117.95	82.84
Mid-Culture		1.27	0.07	11.58	0.93	53.55	1.63	1.39	29.86	6.96	9.94	68.42	46.76
Before culture	50% Feeding	1.35	0.08	6.39	0.7	56.35	0.34	1.3	25.22	7.25	9.38	28.35	32.35
Mid-Culture		1.55	0.09	13.98	0.95	108.7	1.45	1.13	47.86	7.16	9.28	89.00	60.29
Before culture	No feeding	1.69	0.098	9.25	0.86	39.11	0.37	1.05	45.48	7.93	6.07	22.86	48.3
Mid-Culture		0.35	0.02	5.58	0.83	51.39	45.4	1.15	31.64	6.56	7.31	20.74	51.01

OM = Organic matter, N = Nitrogen, P = Phosphorus, K = Potassium, S = Sulfur, Z = Zink, B = Boron, Ca = Calcium, Mg = Magnesium, Cu = Copper, Fe = Iron, Mn = Manganese

Plankton analysis

Phytoplankton was found at very low in culture ponds and zooplankton is lower in *Najas* sp. containing ponds than control pond.

Table 5. Plankton concentrations in different treatments

Ponds	Phytoplankton (cells/L)	Phytoplankton Species	Zooplankton (cells/L)	Zooplankton Species
T ₁	1±0.5 × 10 ³	Anabaena, Lyngbya	6±0.5× 10 ³	Nauplius, Helidiaptomus, Diaptomus, Cyclops, Moina
T ₂	1±0.5 × 10 ³		5±0.5 × 10 ³	
Control pond	3±0.5 × 10 ³		9±0.5 × 10 ³	

Study-2. Comparative study on microbial community, shrimp growth performance and health status

Comparative analysis of microbial community

Vibrio bacterial load in control pond was found higher than *Najas sp.* containing pond after two months of culture. This result shows *Najas sp.* has the ability to defiance against *vibrio*

Growth performance of shrimp

The growth performance in 50% feeding with *Najas* was higher than control and T₂ (No feeding). The production scenario implies that, production rate has been increased manifolds than the traditional culture practice. Indeed, further study is needed to validate the present findings before planning for extension to the farmers.

Weight gain

The average weight of shrimp was 21.78 ± 3.2, 32.5 ± 2.6 and 13.60 ± 2.9g in control, T₁ and T₂ pond respectively, after 105 days culture period.

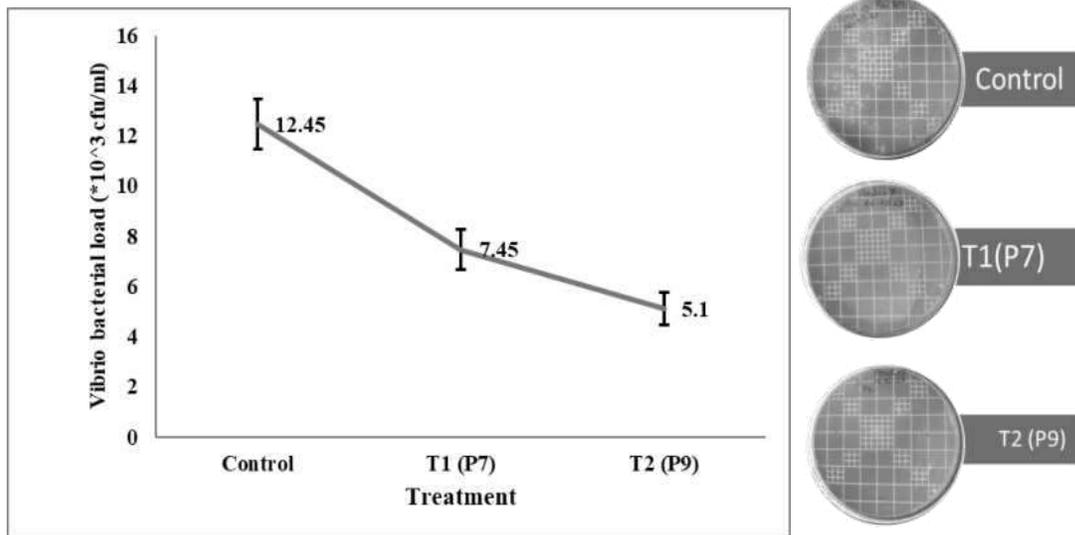


Figure 2. *Vibrio* bacterial load in different treatments



Plate 3. Length (cm) and weight (g) data collection of shrimp fortnightly

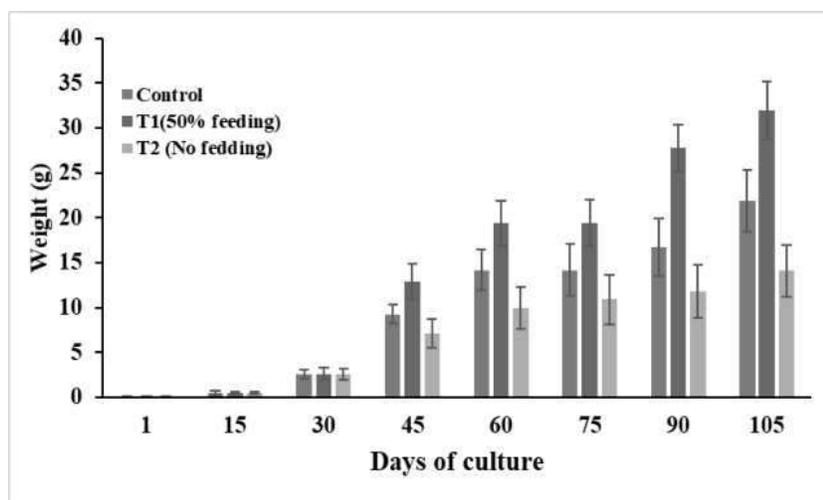


Figure 3. Shrimp weight in different treatments.

Length gain

The average length of shrimp was 13.48 ± 1.9 , 16.37 ± 1.3 and 11.2 ± 1.7 cm in control, T₁ and T₂ pond respectively, after 105 days culture period.

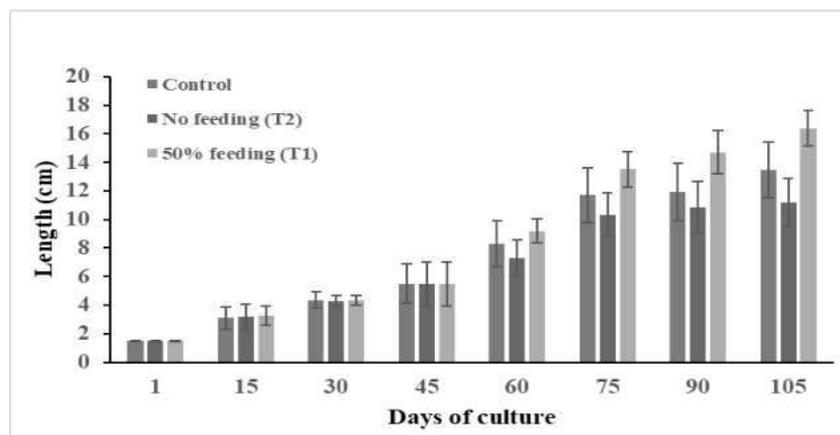


Figure 4. Shrimp length gain in different treatments

Health status

Efficacy of *Najas sp.* extract on immune parameters of shrimp using *In vivo* assay

In vivo Antiviral (WSSV) Activities

To outset challenge experiment, one treatment and one control group of juvenile tiger shrimp (≈ 6.0 g) each having 3 replications with 10 individuals was transferred in to the 40 L glass aquarium containing UV treated water. After 3 days acclimatization, the treatment group was fed with different concentration of *Najas sp.* extract coated diet at 5% BW twice daily for 21 days while control group were provided extract free shrimp diet. After 21 days of feeding trial, experimental animals from both groups were subjected to WSSV challenge by immersion method with moderate aeration.

All parameters were maintained same in both groups during the entire challenge period. Removal of wastes and 30% water change were done daily. Test animals was monitored for 96 hours post infection

(h.p.i) and checked daily for mortalities. Dead shrimp was removed, counted for survival, and subjected to polymerase chain reaction (PCR) analysis to confirm presence of WSSV. Specific primer set for WSSV was used, electrophoresis of PCR products revealed heavy bands in shrimp infected with WSSV. Three concentrations of MeOH extract were used (1g/Kg, 3g/Kg and 5g/Kg) in feed. After 21 days of feeding, immune parameters were examined.



Plate 4: Challenge trial experiment to assess the effect of *Najas* sp. extract on shrimp health

Total Hemocyte Count (THC)

Highest Total Hemocyte Count (THC) was found in T₁ (1g/Kg). That was more than 6 times higher (51.8x 10⁵ cells/ml) than control. High amount of THC indicates higher immunity.

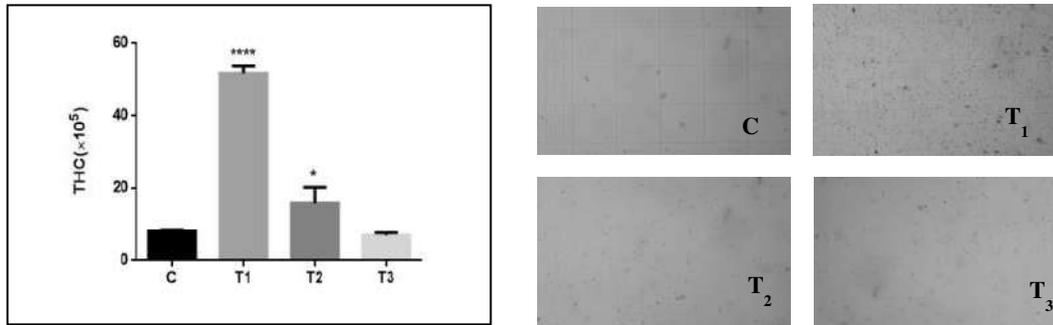


Figure 5. Total Hemocyte Count (THC)

Hemocyte Clotting Time (HCT) and Superoxide Dismutase (SOD)

HCT was found lower in T₁, which indicate immunity was higher in T₁ than other treatments. For SOD T₁ also showed better result than other treatments

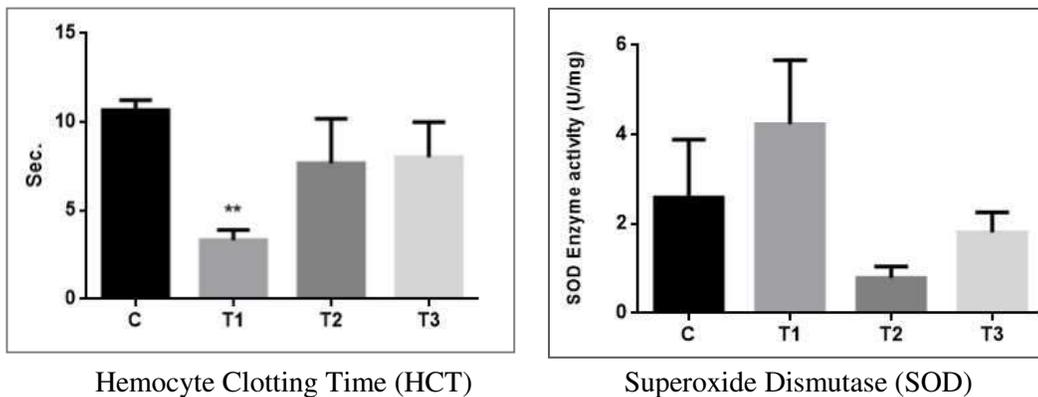


Figure 6. Immune parameter of *Penaeus monodon* in feed trial

Lethal Dose (LD 50) and Survival functions analysis

1 g/kg of MeOH extract was used in feed for challenge trial. LD50 of control was 48 hpi (hours post infection), where treatment showed 78 hpi. (1.5 times higher survival than the control pond).

The survival function analysis revealed that the probability of cumulative survival in the treatment group was 100% within the first 30 hrs of the challenge test with WSSV. Two consecutive little falls of cumulative survival happened between 30-40 hrs, which then continued ($\geq 90\%$) over 80 hrs, until a sudden fall just below 80% survival of *P. monodon* challenged larvae. On the other hand, animals without treatment with *Najas*'s extract after WSSV infection might start to die from the 15th h in the challenge test experiment, and with a continuous mortality towards the end of the challenge test. Three sharp falls after 65 hrs reduced the survival from 80% to < 40% at the end of 90 hrs.

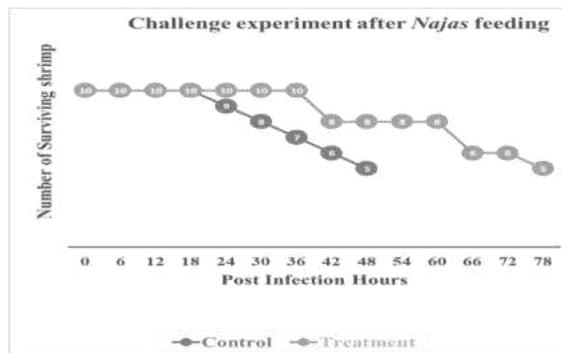


Figure 7. LD50 counting after feeding MeOH extract of *Najas* sp. in challenge trial

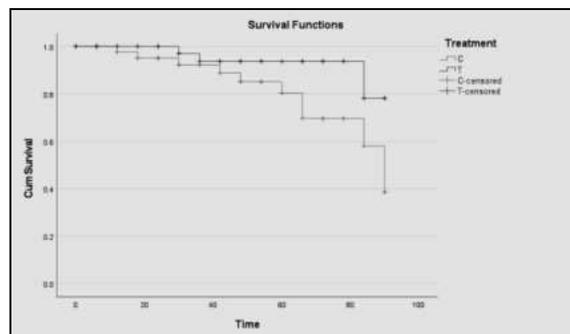


Figure 8. Survival functions analysis of MeOH extract of *Najas* sp. used in feed trial

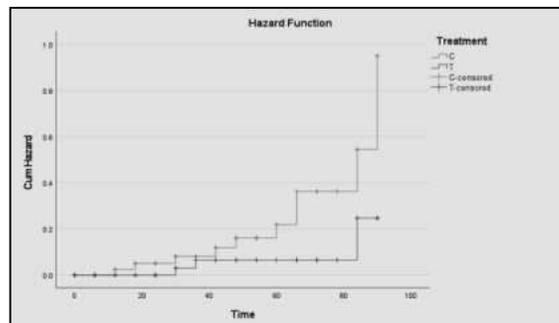


Figure 9. Hazard functions analysis of *Najas* sp MeOH extract used in feed trial

The probability of hazard function in the treatment group was less than 10% after 40 hrs of the experiment and continued up till the 85th h of the challenge test, with a sudden fall increased the hazard

for over 20% mortality, which indicated a probability of high protection against WSSV post infection. On the other hand, the cumulative hazard in the control group started at 15th h, gradually decreased the survival up till 65thhrs, sharp mortality occurred with a higher hazard without *Najas* extract treatment.

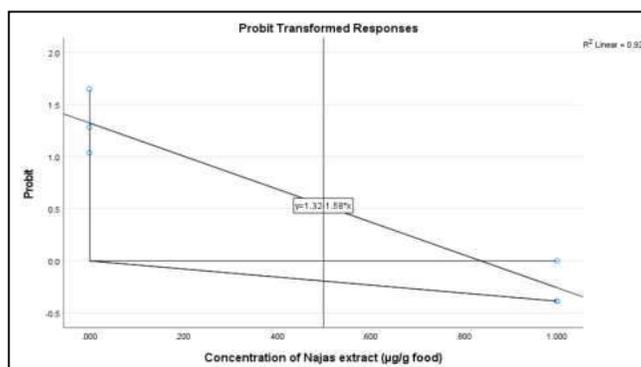


Figure 10. Percent mortality and probit mortality of *Penaeus monodon* juveniles fed with *Najas sp.* extract supplemented diet against WSSV infection.

The probit regression analysis indicated that probit values were higher within the control groups, and 50% of the mortality happened much quickly in the control group than that of the treatment group. Probit analysis indicated that 50% mortality of *P. monodon* juveniles can be happened within the 72hrs experimental period when the concentration of *Najas* extract in food is $\leq 0.5 \mu\text{g/g}$, which started to reduce the mortality at higher concentrations, which can give a complete protection at the concentration $\geq 1 \mu\text{g/g}$.

Study-3. Bioactive compound and micronutrient analysis of *Najas sp.*

After collection of *Najas sp.* from pond it dried in sun . Dried *Najas sp.* was grinded by a mechanical blender and sieved with a 335 mm mesh size sieve and the powder passed through the sieve and collected to store at -80°C until needed for further analysis. The *Najas sp.* Samples were extracted using various conventional organic solvents such as ethanol, hexane, acetone, and water as a polar solvent mixture. Exactly, 50g of *Najas sp.* powder was placed in 500 mL beaker followed by 300 mL solvent and the extraction was performed at 50°C on a hot plate under constant stirring (200 rpm) for 12 h. Then, the extract with solvent was separated from the residue using filtration. Finally, the extract was separated from the solvent using a rotary vacuum evaporator at 65°C . The extract was kept at 4°C until needed for further analysis.

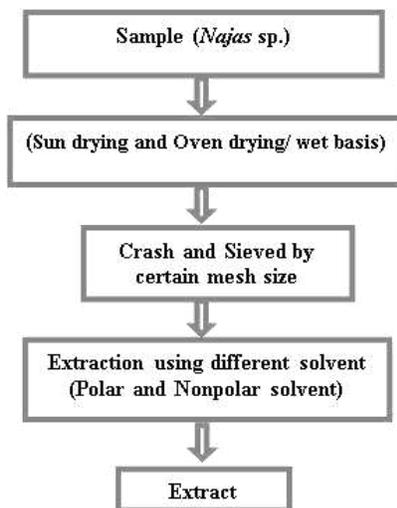


Figure 11. Flow diagram of extract preparation

Bioactive compounds analysis by GC-MS

The GC-MS analysis of bioactive compounds from the different solvent extracts of *Najas* sp. was done using GC-MS. One microliter of the prepared 1% of the extracts diluted with respective solvents was injected in a splitless mode. Relative quantity of the chemical compounds present in each of the extracts of *Najas* sp. was expressed as percentage based on peak area produced in the chromatogram. Three solvent (Methanol, Acetone and Hexane) extract of *Najas* sp. were analyzed by GC-MS among seven solvent extracts on the basis of higher antioxidant and antimicrobial test. In Acetone crude extract, 15 bioactive compounds were found; among these Oleic Acid (C₁₈H₃₄O₂) was dominant (30%), in hexane extract Lauric Acid was found higher (17.7%). On the other hand, in methanol extract Petroselinic acid was highest (37%).

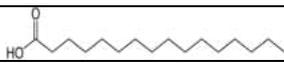
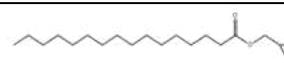
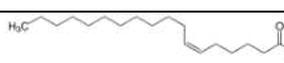
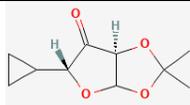
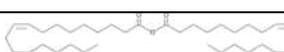
Table 6. Bioactive compounds in Acetone crude Extract of *Najas* sp.

SN	Chemical compounds	Systematic name (molecular formula)	Retention Time (min)	Area %	Molecular structure
01	Caprylic Acid	Octanoic acid (C ₈ H ₁₆ O ₂)	11.49	2.20	
02	Capric Acid	N-Decanoic Acid (C ₁₀ H ₂₀ O ₂)	16.43	0.92	
03	Lauric Acid	Dodecanoic Acid (C ₁₂ H ₂₄ O ₂)	21.19	8.26	
04	Delta-decalactone	2H-Pyran-2-one, Tetrahydro-6-Pentyl (C ₁₀ H ₁₈ O ₂)	21.93	3.95	
05	Myristic Acid	Tetradecanoic acid (C ₁₄ H ₂₈ O ₂)	25.36	4.41	
06	Delta-Tetradecalactone	2H-Pyran-2-one, Tetrahydro-6-Nonyl (C ₁₄ H ₂₆ O ₂)	26.38	1.61	
07	Methyl isotridecanoate	Methyl 11-Methyl-Dodecanoate (C ₁₄ H ₂₈ O ₂)	28.06	0.44	
08	Palmitic Acid	N-Hexadecanoic Acid (C ₁₆ H ₃₂ O ₂)	29.32	16.03	
09	13-Octadecenoic Acid, Methyl Ester	Methyl (E)-octadec-13-enoate (C ₁₉ H ₃₆ O ₂)	31.62	0.91	
10	Oleic Acid	9-Octadecanoic Acid (C ₁₈ H ₃₄ O ₂)	32.91	30.59	
11	Glycidal Palmitate	Oxiran-2-ylmethyl hexadecanoate (C ₁₉ H ₃₆ O ₃)	35.64	7.82	
12	Isocitronellene	1,6-Octadiene, 5,7-Dimethyl-(R) (C ₁₀ H ₁₈)	36.66	2.08	
13	Octanoic acid	1,3-Dioctanoic acid (C ₁₉ H ₃₆ O ₅)	37.46	1.58	
14	Butyl oleate	Butyl 9-Octadecanoate or 9-18:1 (C ₂₂ H ₄₂ O ₂)	38.36	0.62	
15	Glycidal Oleate	Oxiran-2-ylmethyl (Z)-octadec-9-enoate (C ₂₁ H ₃₈ O ₃)	39.45	9.30	

Table 7. Bioactive compounds in Hexane crude Extract of *Najas* sp.

SN	Chemical compounds	Systematic name (Molecular formula)	Retention Time (min)	Area %	Molecular structure
01	Caprylic Acid	Octanoic acid (C ₈ H ₁₆ O ₂)	11.678	3.78	
02	Capric Acid	N-Decanoic Acid (C ₁₀ H ₂₀ O ₂)	16.597	2.164	
03	4-butylthiazole	4-Butyl-1,3-Thiazole (C ₇ H ₁₁ NS)	17.066	1.724	
04	Methyl 3-oxo-2-propylheptanoate	Heptanoic Acid, 3-Oxo-2-Propyl-,Methyl Ester (C ₁₁ H ₂₀ O ₃)	20.229	0.349	
05	Lauric Acid	Dodecanoic Acid (C ₁₂ H ₂₄ O ₂)	21.388	17.575	
06	Delta-decalactone	2H-Pyran-2-one, Tetrahydro-6-Pentyl (C ₁₀ H ₁₈ O ₂)	21.958	6.579	
07	Myristic Acid	Tetradecanoic acid (C ₁₄ H ₂₈ O ₂)	25.517	9.957	
08	Palmitic Acid	N-Hexadecanoic Acid (C ₁₆ H ₃₂ O ₂)	29.424	10.649	
09	N-Propyle 11-Octadecenote	N-Propyle 11-Octadecenote (C ₂₁ H ₄₀ O ₂)	32.98	11.154	
10	Glycidal Palmitate	Oxiran-2-ylmethyl hexadecanoate (C ₁₉ H ₃₆ O ₃)	35.704	7.628	
11	Lauron	12-Tricosanone (C ₂₃ H ₄₆ O)	37.57	1.289	
12	Glycidal Oleate	Oxiran-2-ylmethyl (Z)-octadec-9-enoate (C ₂₁ H ₃₈ O ₃)	39.54	7.16	

Table 8. Bioactive compounds in Methanol crude Extract of *Najas* sp.

SN	Chemical compounds	Systematic name (molecular formula)	Retention Time (min)	Area %	Molecular structure
01	Cyclomethicone 6	Cyclohexasiloxane, Dodecamethyl (C ₁₂ H ₃₆ O ₆ Si ₆)	11.25	0.086	
02	Cyclooctasiloxane, Hexadecamethyl	Cyclooctasiloxane, Hexadecamethyl (C ₁₆ H ₄₈ O ₈ Si ₈)	18.95	0.134	
03	Lauric Acid	Dodecanoic Acid (C ₁₂ H ₂₄ O ₂)	21.12	2.059	
04	Octadecamethyl-cyclononasiloxane	Cyclononasiloxane, Octadecamethyl- (C ₁₈ H ₅₄ O ₉ Si ₉)	22.213	0.315	
05	Myristic Acid	Tetradecanoic acid (C ₁₄ H ₂₈ O ₂)	25.92	4.341	
06	Tetradecanoic acid, 10,13-Dimethyl-Methyl Ester	Tetradecanoic acid, 10,13-Dimethyl-Methyl Ester (C ₁₇ H ₃₄ O ₂)	28.329	0.4931	
07	Palmitic Acid	N-Hexadecanoic Acid (C ₁₆ H ₃₂ O ₂)	30.335	29.91	
08	13-Octadecenoic Acid, Methyl Ester	Methyl (E)-octadec-13-enoate (C ₁₉ H ₃₆ O ₂)	31.945	1.693	
09	Glycidal Palmitate	Oxiran-2-ylmethyl hexadecanoate (C ₁₉ H ₃₆ O ₃)	36.057	12.612	
10	Petroselinic acid	6-Octadecanoic Acid (C ₁₈ H ₃₄ O ₂)	33.928	37.098	
11	Camphoric acid	D-Ribo-Tetrofuranose,4-C-Cyclopropyl-1,2-O-Isopropylidene-Alpha (C ₁₀ H ₁₆ O ₄)	35.24	2.27	
12	Oleic Anhydride	Oleic Anhydride (C ₃₆ H ₆₆ O ₃)	38.83	3.19	

FTIR analysis of various extracts of *Najas* sp.

FTIR analysis of *Najas* sp. acetone extract exhibited distinctive absorption peaks at 3364.95 cm⁻¹ assigned for normal polymeric hydroxyl (-OH) stretch, 2950 cm⁻¹ and 2850 cm⁻¹ assigned for aliphatic (Methyl, Methlene) group, 1978.62 cm⁻¹ corresponds to aromatic ring, 1648.19cm⁻¹ represent the presence of alkenes group C=C, 1700 cm⁻¹ for carbonyl groups. According to FTIR spectroscopy, the acetone extract included the major functional group components were carboxylic acid, aromatic hydrocarbon, halogens, phenol, and flavonoid.

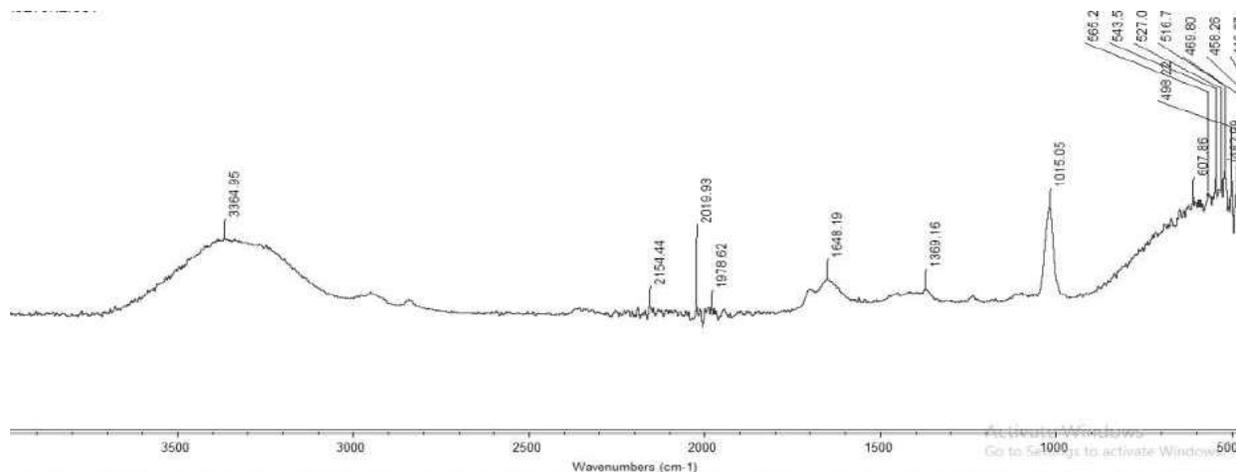


Figure 12. FTIR spectrum of *Najas* sp. acetone extract

The *Najas* sp. methanol extract showed distinct absorption peaks in the FTIR analysis at 3335.91 cm⁻¹ which response for the normal polymeric hydroxyl (-OH) stretch, 2942.68 cm⁻¹ and 2832.40 cm⁻¹ for saturated aliphatic (C-H stretch) group, 2186.51 cm⁻¹ for alkynes group (C≡C medial alkyne), 2107.72 cm⁻¹ for alkyne group (C≡C terminal alkyne), 2019.52 cm⁻¹ corresponds to aromatic ring, 2008.76 cm⁻¹ for common inorganic ions, 1942.96 cm⁻¹ for carbonyl compound, 1652.70 cm⁻¹ represent the presence of alkene group C=C. FTIR spectroscopy revealed that the main functional group components of the methanol extract were carboxylic acid, aromatic hydrocarbon, halogens, phenol, and flavonoid.

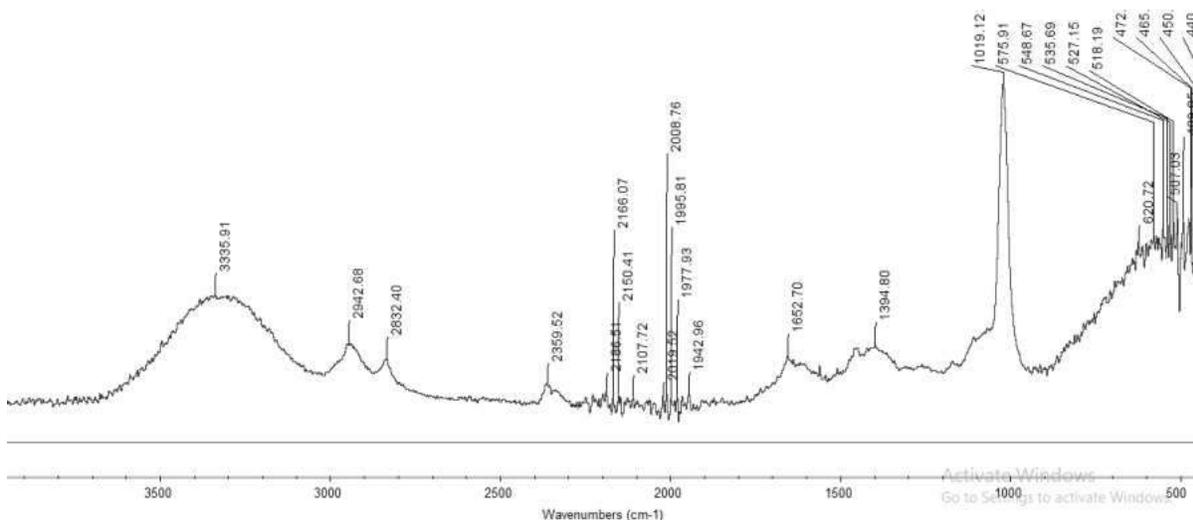


Figure 13. FTIR spectrum of *Najas* sp. methanol extract

In the FTIR examination, the *Najas* sp. Hexane extract produced distinct absorption peaks at 2921.92 cm⁻¹ and 2852.24 cm⁻¹ for saturated aliphatic (C-H stretch) group, 2161.99 cm⁻¹ for alkyne group (C≡C medial alkyne), and 1739.54 cm⁻¹ to indicate the existence of carbonyl compound, at 1457.39 cm⁻¹ for carbonate ion and 722.07 cm⁻¹ for aromatic ring. FTIR spectroscopy showed that the primary functional group constituents of the methanol extract were aromatic hydrocarbon, halogens, phenol, and flavonoid.

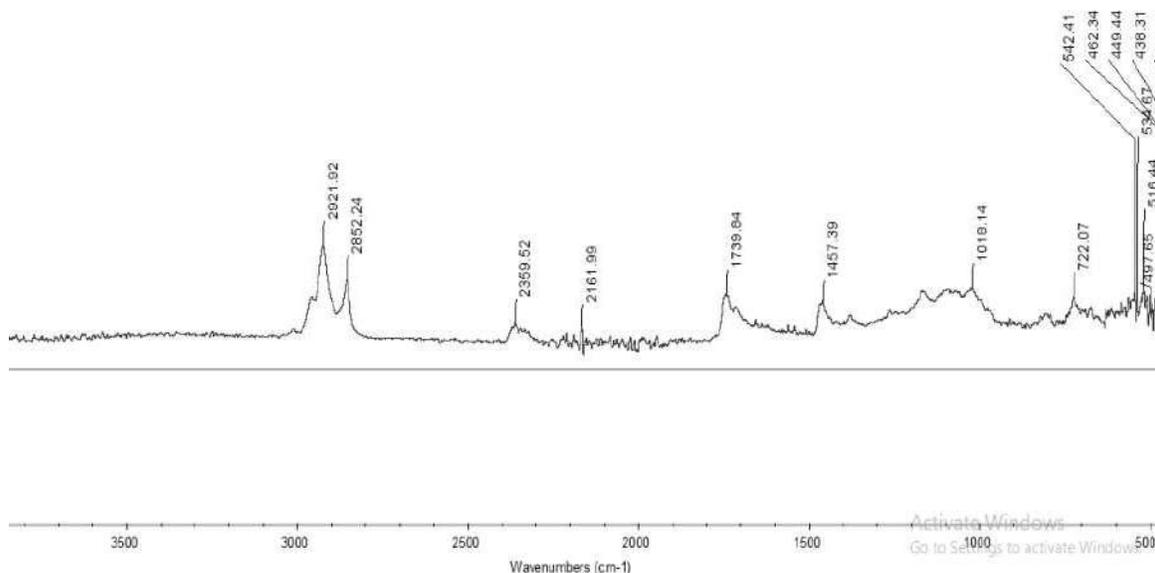


Figure 14. FTIR spectrum of *Najas* sp. Hexane extract

Amino Acid Analysis

Table 9: Amino acid profile of *Najas* sp.

Sl no	Amino Acid	Amount (mg/g)
1	Aspartic acid	16.549
2	Threonine	5.414
3	Serine	7.403
4	Glutamic acid	13.863
5	Glycine	8.124
6	Alanine	7.826
7	Cystine	1.447
8	Valine	3.767
9	Methionine	1.833
10	Isoleucine	1.834
11	Leucine	7.211
12	Tyrosine	4.245
13	Phenylalanine	3.305
14	Histidine	4.510
15	Lysine	5.123
16	Arginine	5.027
17	Proline	4.111

Bioactivity test of *Najas* sp.

Antioxidant test

Najas sp extract was used for different antioxidant test like DPPH free radical scavenging activity, ABTS free radical scavenging activity, Ferric Reducing Antioxidant Power (FRAP), Total Phenolic Content Assay (TPC), Total Flavonoid Content Assay (TFC), CUPric Reducing Antioxidant Capacity Assay (CUPRAC), Total procyanidin content Assay (TPrC) and Hydrogen peroxide scavenging assay (H₂O₂)

Total phenolic contents (TPC)

The total phenolic contents (TPC) (16.425 mg GAE/g dry powder) were found significantly higher in Acetone extract as compared to other solvent extract.

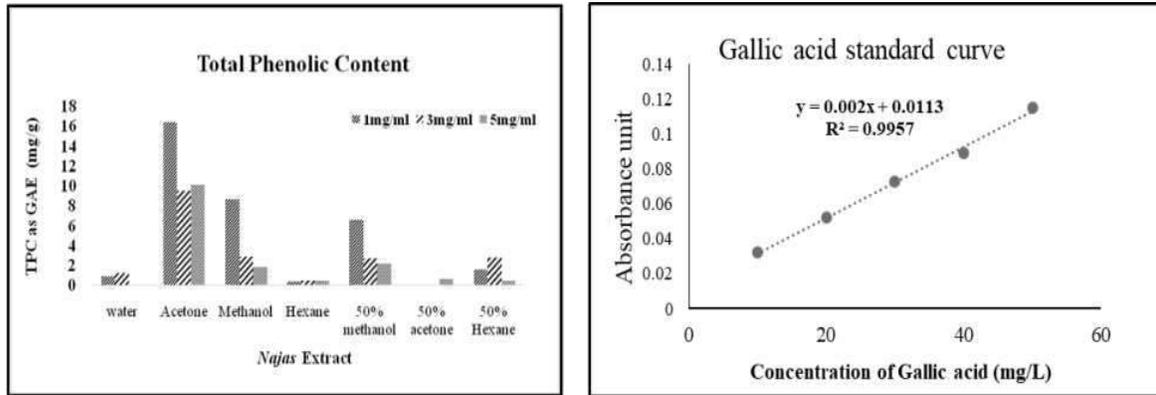


Figure 15. Total phenolic content (TPC) of *Najas sp*

Total flavonoid contents (TFC)

Total flavonoid contents (TFC) of *Najas sp.* (10.2 mg Cathechin /g dry powder) were also found significantly higher in Acetone extract as compared to other solvent extract.

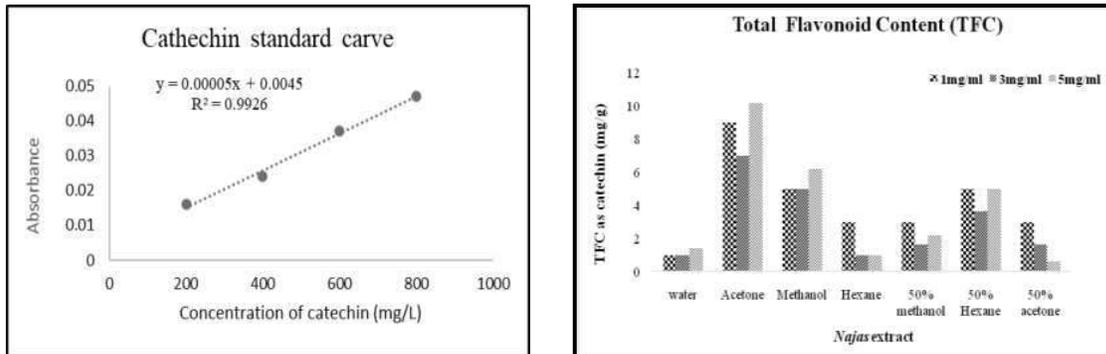


Figure 16. Total flavonoid content (TFC) of *Najas sp*

DPPH Free Radical Scavenging Assay:

For DPPH scavenging best result showed in 50% acetone extract (35.7±1.625%).

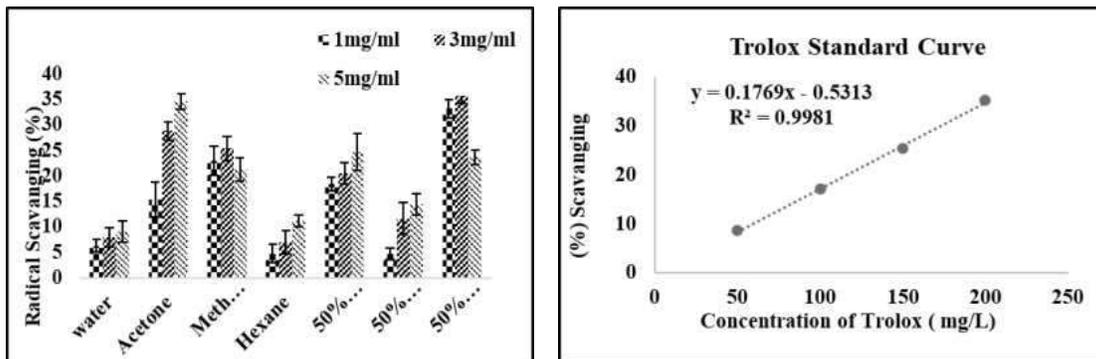


Figure 17. DPPH free radical scavenging activity of *Najas sp*

ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) Free Radical Scavenging Assay

On the other hand, ABTS scavenging best result showed in methanol extract (97.41±2.25%).

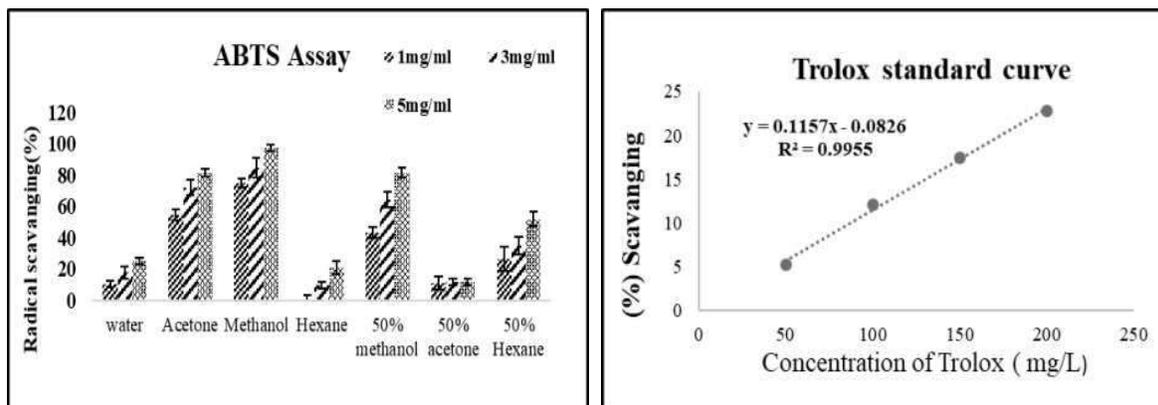


Figure 18. ABTS free radical scavenging activity of *Najas sp*

Ferric Reducing Antioxidant Power Assay (FRAP)

FRAP was found higher in both Acetone and Methanol (78 mg GAE/ g dry powder).

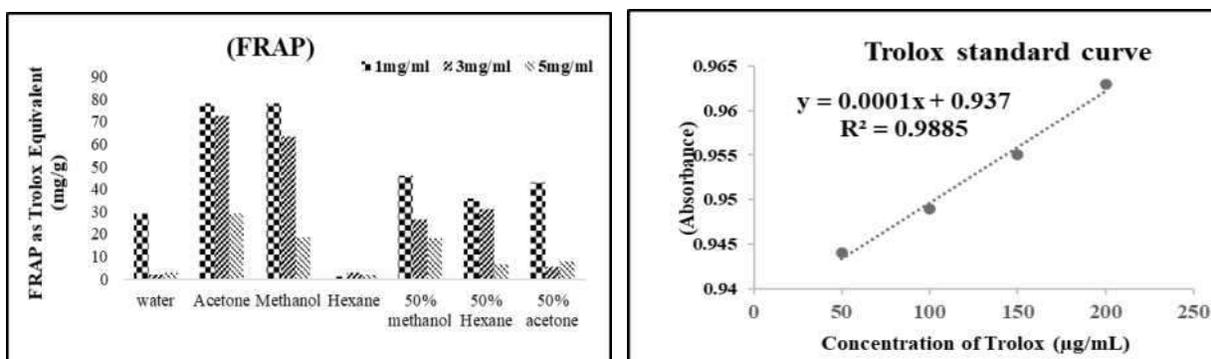


Figure19. Ferric Reducing Antioxidant Power (FRAP) of *Najas sp*

CUPric Reducing Antioxidant Capacity Assay (CUPRAC)

Same as FRAP, CUPRAC also found higher in Acetone (361.63 mg Trolox / g dry powder) and Methanol (327.25 mg Trolox / g dry powder).

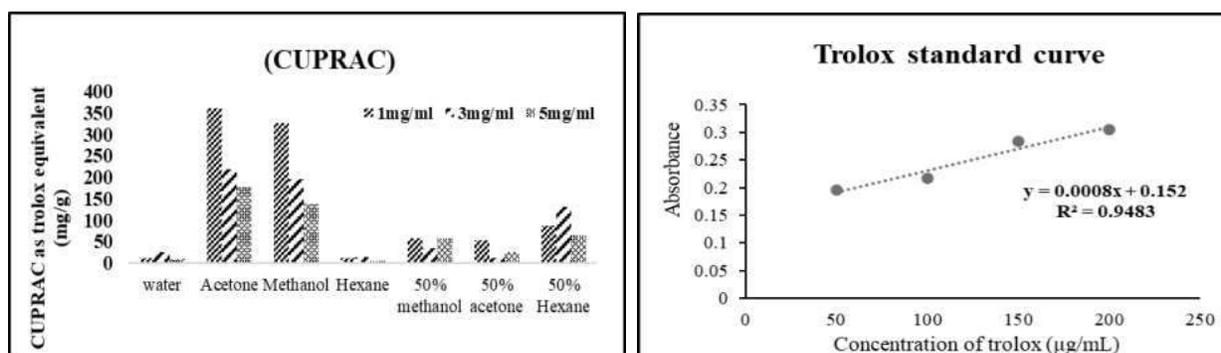


Figure 20. Reducing antioxidant capacity (CUPRAC) of *Najas sp*

Total procyanidin content (TPrC)

Total procyanidin content (TPrC) higher in Acetone extract (160 mg Cathecin /g dry powder).

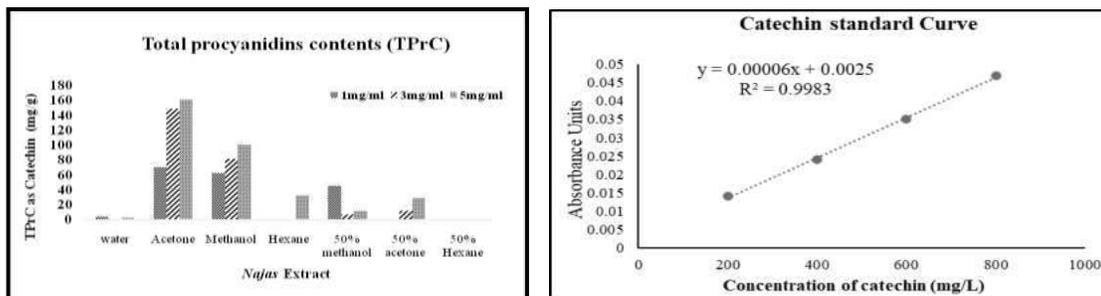


Figure 21. Total procyanidin content (TPrC) of *Najas sp*

Hydrogen peroxide (H₂O₂) scavenging assay:

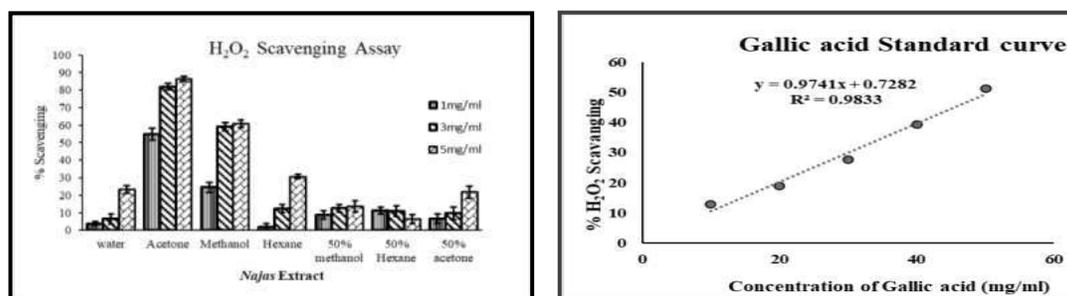


Figure 22. Hydrogen peroxide scavenging (H₂O₂) of *Najas sp*

Correlation between different antioxidant

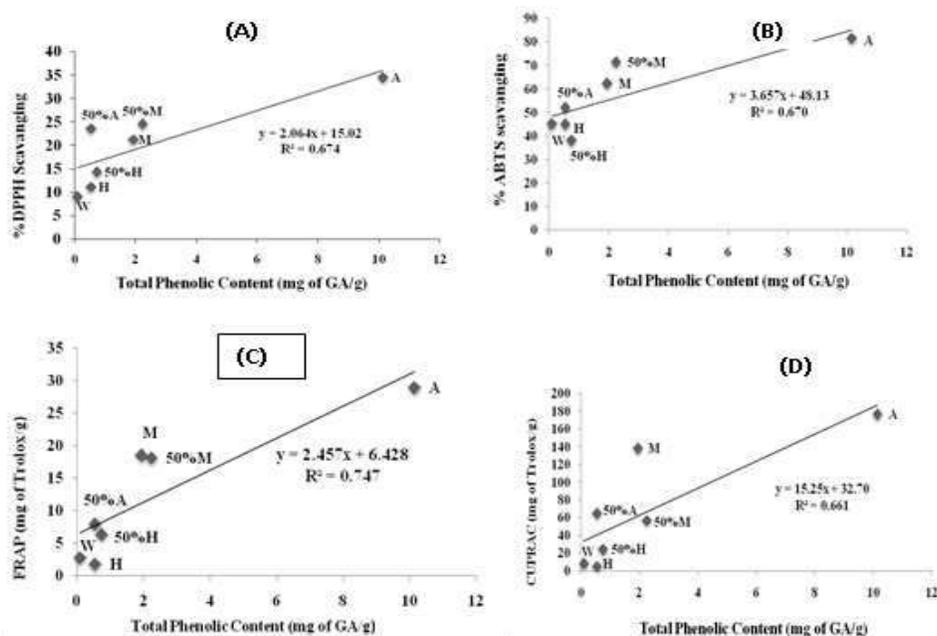


Figure 23. Scatter plot diagrams showing the correlation of total phenolic content (mg of GA/g) vis-à-vis (A) DPPH (n = 7; R² = 0.674), (B) ABTS (n = 7, R² = 0.670), (C) FRAP (n = 7, R² = 0.747), (D) CUPRAC (n = 7, R² = 0.661),

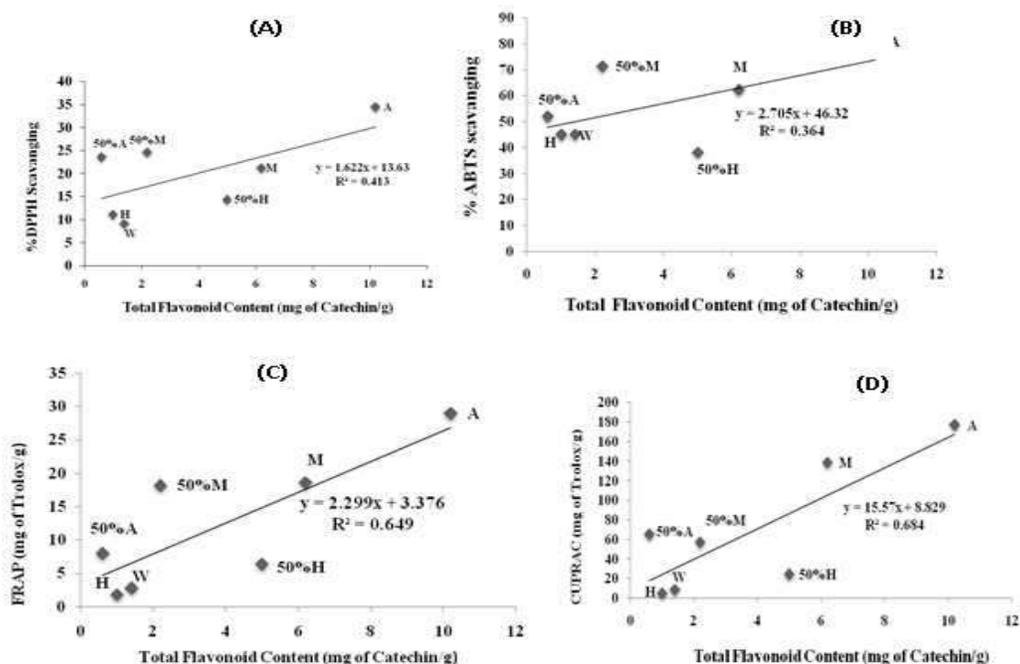


Figure 24. Scatter plot diagrams showing the correlation of total flavonoid content (mg of Catechin/g) vis-à-vis (A) DPPH (n = 7; $R^2 = 0.413$), (B) ABTS (n = 7, $R^2 = 0.364$), (C) FRAP (n = 7, $R^2 = 0.649$), (D) CUPRAC (n = 7, $R^2 = 0.684$),

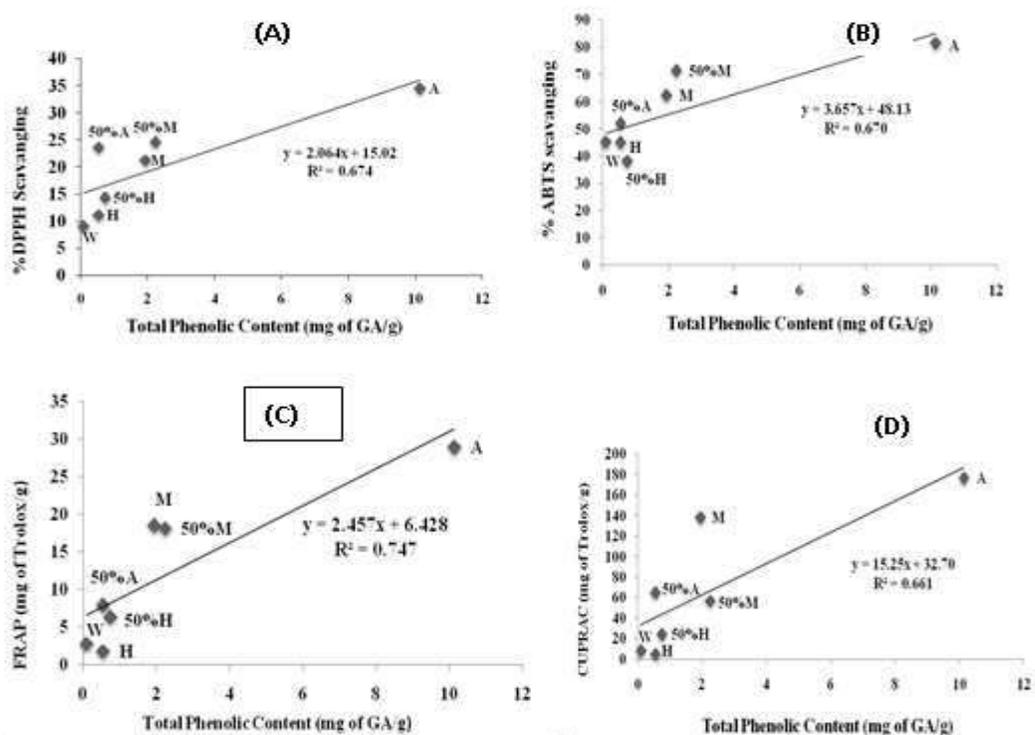


Figure 25. Scatter plot diagrams showing the correlation of total Proanthocyanidin content (mg of Catechin/g) vis-à-vis (A) DPPH (n = 7; $R^2 = 0.571$), (B) ABTS (n = 7, $R^2 = 0.464$), (C) FRAP (n = 7, $R^2 = 0.643$), (D) CUPRAC (n = 7, $R^2 = 0.867$),

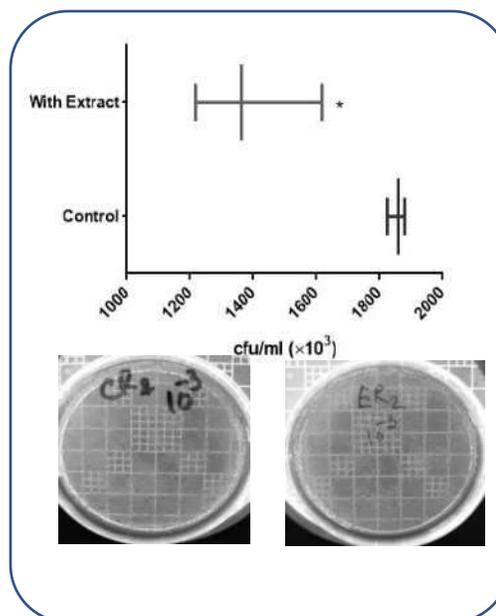
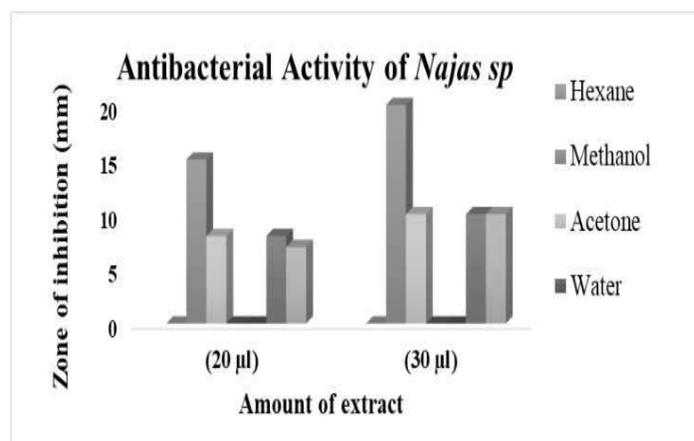
Table 10. IC₅₀ of different crude extract of *Najas* sp

Assay	IC ₅₀ (mg mL ⁻¹ values of different crude extracts)							
	Trolox	Water	Methanol	Acetone	Hexane	50% Methanol	50% Acetone	50% Hexane
DPPH assay	0.25±0.008	61.77±0.41	11.34±0.11	7.98±1.66	29.58±3.61	21.45±3.64	13.50±2.37	19.52±1.93

Assay	IC ₅₀ (mg mL ⁻¹ values of different crude extracts)							
	Trolox	Water	Methanol	Acetone	Hexane	50% Methanol	50% Acetone	50% Hexane
ABTS assay	0.01±0.004	11.81±0.21	0.57±0.01	0.07±0.03	8.47±2.31	1.61±0.20	4.87±1.08	15.79±0.65

11.1.3.5 Antimicrobial test using *In vitro* assay

Seven extract of *Najas* sp. were used to determine antibacterial activities against *Vibrio parahaemolyticus*. Only MeOH and Acetone extract showed antibacterial activities. Highest inhibition zone was observed in MeOH extract MeOH extract showed 1.5 times higher inhibition against *V. parahaemolyticus*

**Figure 26.** Antibacterial activities of *Najas* sp.

Prophylactic and Nutritional Properties of Algal Supplements as Larval Molting Promoter and Immune Modulator in Shrimp and Prawn Aquaculture

Researchers

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Md. Ariful Islam, SSO
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Objectives

- To develop pathogen checklist for prawn hatchery
- To infer prophylactic activity of different natural sources
- To develop improved larvae rearing technique using enriched artemia, higher nutrient rich compounds and probiotics
- To develop medicated feed for shrimp and prawn culture

Achievements

Study-1 Investigation of causative agents for larval mortality of prawn

Under this experiment, Samples were collected from the Kocha river, Pirojpur of Bangladesh in fresh condition during breeding season and were transported to Shrimp Health Management Laboratory, SRS, Bagerhat. Prawn pleopods from each prawn were finely chopped and then 20~30 mg was used for the DNA and RNA extraction for PCR-based diagnosis of OIE-listed and non-listed pathogens. Along with the brood, all probable source of pathogen viz., artemia, brine, fresh water, ingredients of egg custard, etc. were screened for pathogens.

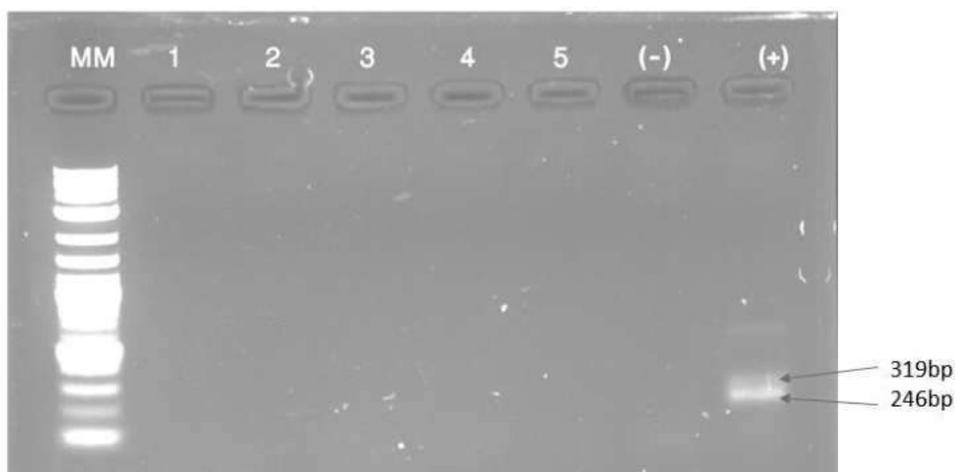


Figure 1. PCR assay for MrGV. UV illumination of PCR product after gel electrophoresis; MM: molecular marker, Lane 1~3: brood from Kocha river, Lane 4: Larvae from control tank of hatchery (with no microalgae), Lane 5: Larvae from treatment tank (with algae), Lane (-): Negative Control, Lane (+): Positive Control

Study-2: Screening of prophylactic activity of different natural sources

Seaweed collection

Hypnea sp, *Ulva* sp and *Gracilaria* sp were collected from the intertidal zones of a rocky shore in Saint Martin’s Island. The seaweed was carefully harvested using scissors and placed in sterile containers. Each sample was labeled with the species name, collection date, and location. To avoid cross-contamination, the containers were rinsed with distilled water and dried before each sample was collected. The collected seaweed samples were transported to the laboratory on ice and immediately stored in a -20°C freezer until further processing.

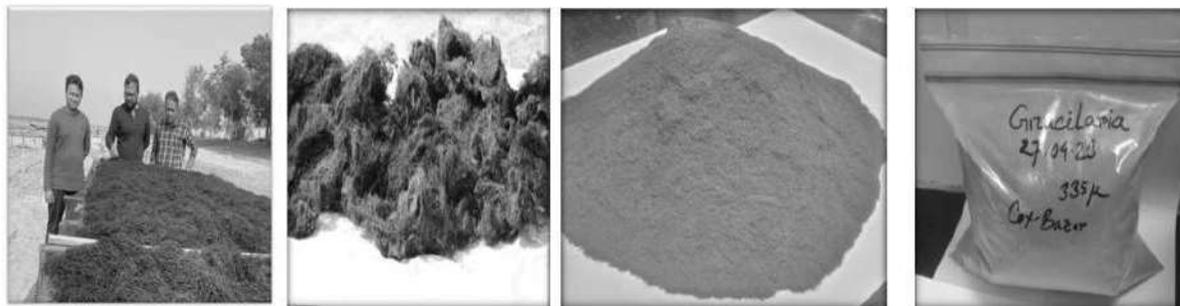


Figure 2. Seaweed collection, drying and processing

Extraction Yield

The extraction yield refers to the percentage of the total weight of extracted compounds in relation to the initial weight of the seaweed sample. The seaweeds were extracted using three solvents (Acetone, methanol and ethanol). In case of *Hypnea* sp, the highest yield extraction (4.075%) was found in Acetone extraction and lowest (0.8%) was found in ethanol extraction. On the other hand, methanol extraction produced highest yield (22.95%) for *Ulva* sp and lowest (2.55%) was found in ethanol extraction (Figure 3). Similarly, in the case of *Gracilaria* sp the highest yield extraction (11.68%) was observed in Acetone extraction and lowest (3.4%) found in ethanol extraction.

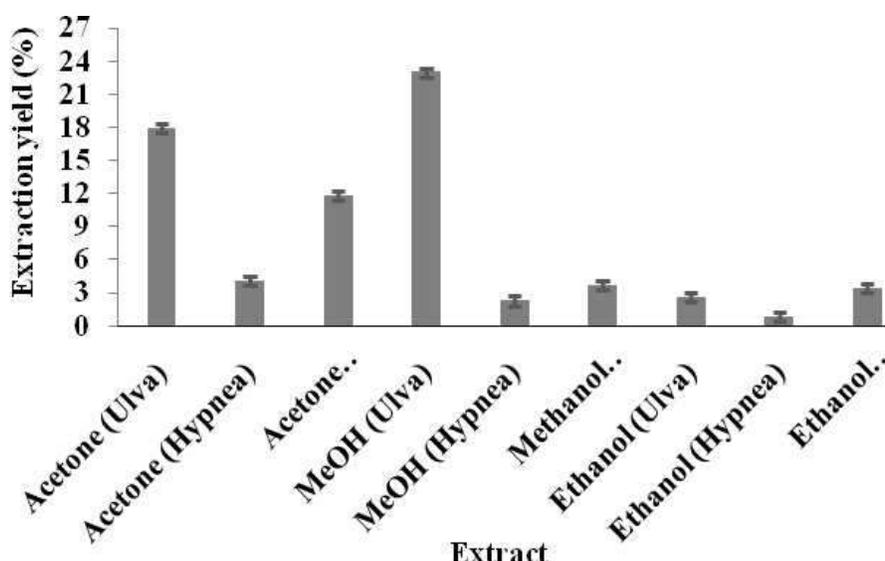


Figure 3 Extraction yield of different seaweed extract

Phytochemical Screening and Bioactivity test of seaweed

Phytochemical Screening

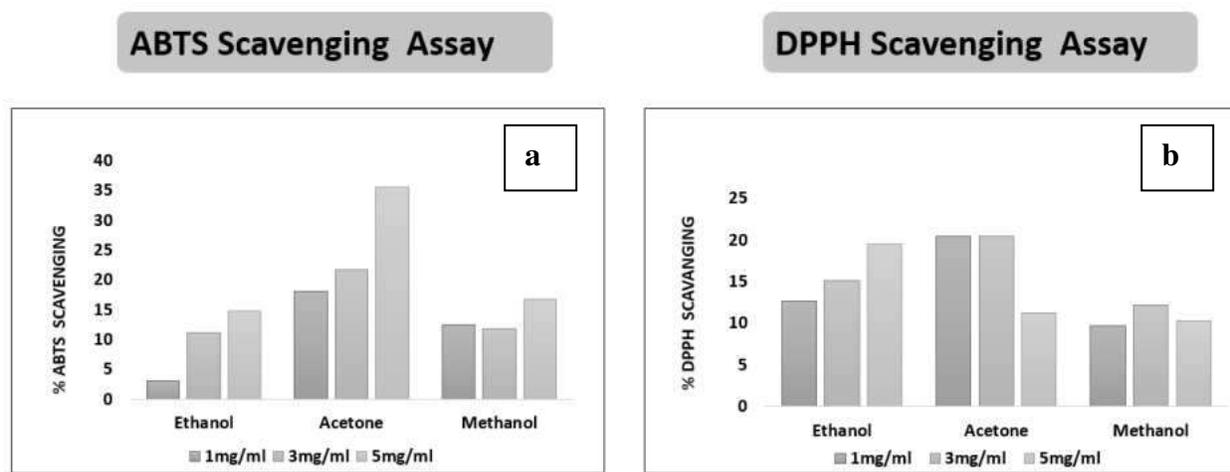
Phytochemical screening was performed for two seaweed species, and a total of 11 screening tests were carried out. These tests were conducted to determine the presence or absence of various phytochemical compounds in the seaweed samples. The results of these screening tests (Table-1) provide valuable information about the chemical composition of the seaweed species, and can be used to identify potential medicinal or nutritional properties.

Table 1. Results of phytochemical analysis of *Hypnea* sp, *Ulva* sp and *Gracilaria* sp plant extract

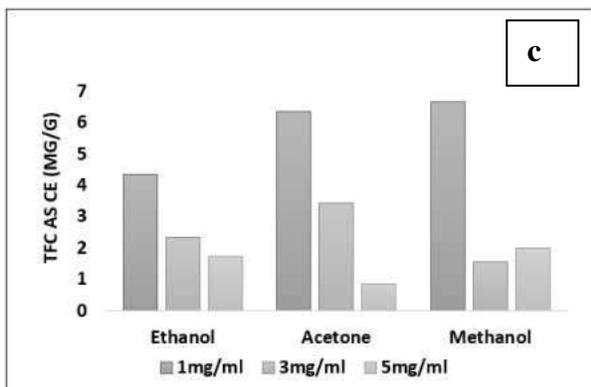
Sl. No.	Phytochemicals	Test Names	Methanol			Acetone			Ethanol		
			<i>Hypnea</i> sp	<i>Ulva</i> sp	<i>Gracilaria</i> sp	<i>Hypnea</i> sp	<i>Ulva</i> sp	<i>Gracilaria</i> sp	<i>Hypnea</i> sp	<i>Ulva</i> sp	<i>Gracilaria</i> sp
1.	Alkaloids	Alkaloids	+	+	+	+	+	+	-	-	+
2.	Amino Acid	Xanthoprotein	+	-	-	+	-	-	-	-	-
3.	Phenol	FeCl ₃ test	+	+	+	+	+	+	+	+	+
4.	Flavonoids	Alkaline reagent	+	+	+	+	+	+	+	+	+
5.	Tannins	FeCl ₃ test	-	+	+	+	+	+	-	-	+
6.	Saponin	Foam test	+	-	+	+	+	-	-	-	+
7.	Terpenoids	Salkowskis test	+	+	+	+	+	+	-	-	+
8.	Phlobatanins	1% HCl acid test	-	-	-	-	-	-	-	-	-
9	Quinones	Hydrochloric acid	+	+	+	+	-	+	-	+	+
10	Coumarin	NaOH test	+	+	+	+	+	+	+	+	+
11	Anthocyanins	Sulfuric acid	+	+	+	+	+	+	-	+	+

Antioxidant test

To determine the antioxidant activity; several assay such as ABTS (2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid)) assay, DPPH (2,2-diphenyl-1-picrylhydrazyl) assay, Total Flavonoid Content (TPC), Total proanthocyanidin (TPrC) test were performed.



Total Flavonoid Content (TFC)



Total Proanthocyanidin Content

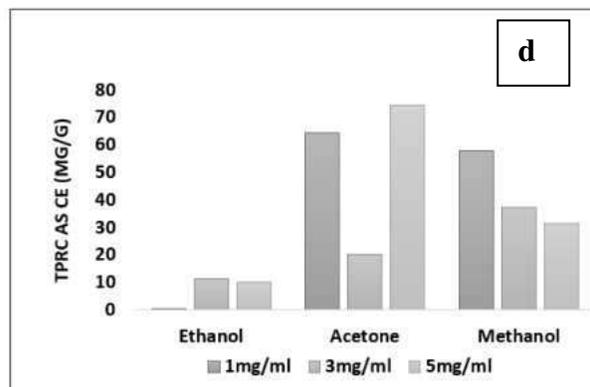
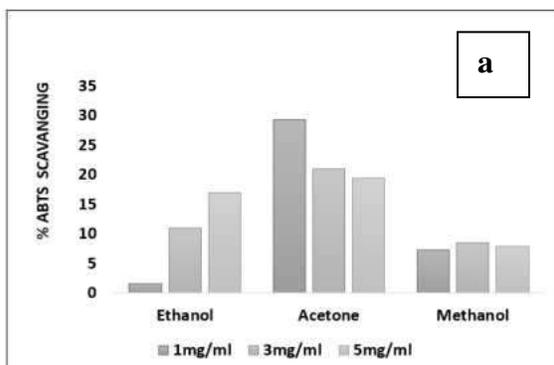
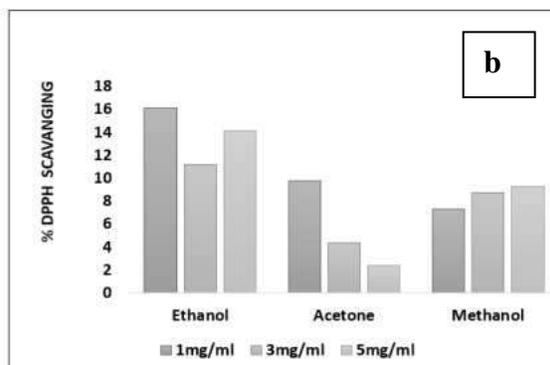


Figure 4. Different antioxidant activity in *Hypnea* sp where (a) ABTS; (b) DPPH; (c) TFC and (d) TPrC assay

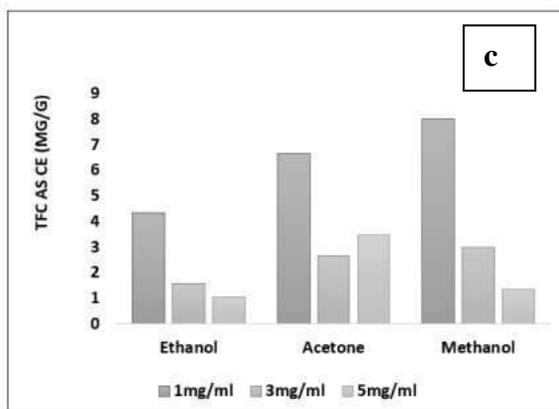
ABTS Scavenging Assay



DPPH Scavenging Assay



Total Flavonoid Content (TFC)



Total proanthocyanidin Content

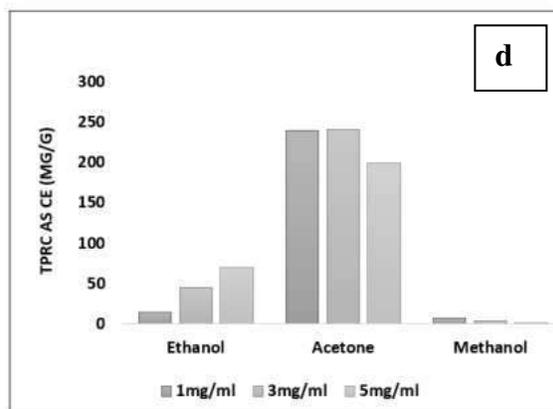


Figure 5. Different antioxidant activity in *Ulva* sp where (a) ABTS; (b) DPPH; (c) TFC and (d) TPrC assay

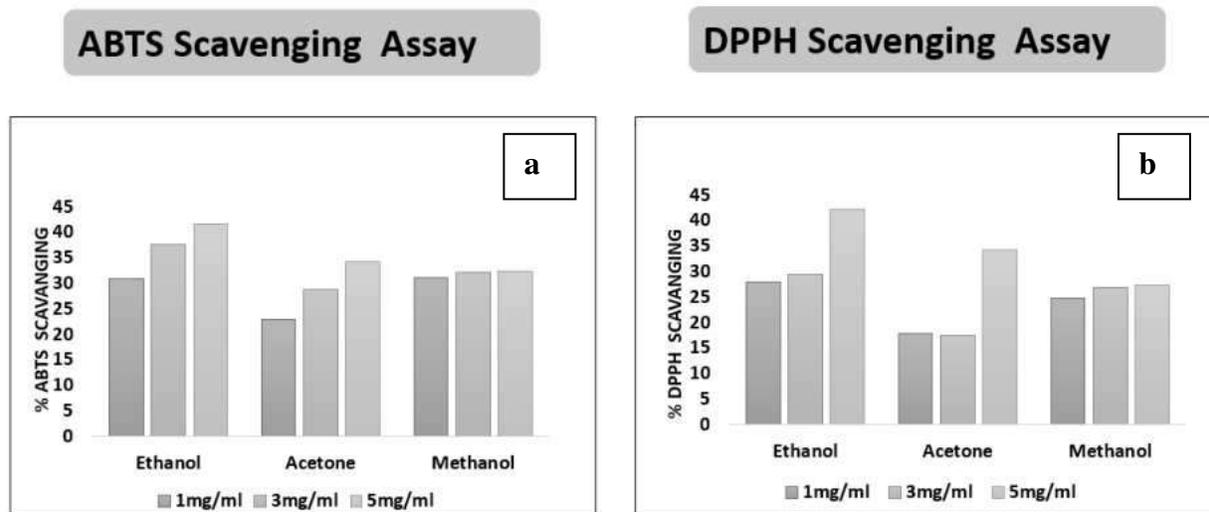


Figure 6. Different antioxidant activity in *Gracilaria* sp where (a) ABTS; (b) DPPH

In 5 mg/ml concentration, DPPH scavenging of *Hypnea* sp showed best result in ethanol extract (19.51%) ; on the other hand ABTS scavenging showed best result in acetone extract (35.62%). Total flavonoid contents (TFC) of *Hypnea* sp. (2 mg Cathecin /g dry powder) were found higher in methanol extract as compared to other solvent extract. Total procyanidin content (TPrC) higher in Acetone extract (74 mg Cathecin /g dry powder) (Figure 4). In case of *Ulva* sp, DPPH scavenging showed best result in ethanol extract (14.14%); on the other hand, ABTS scavenging showed best result in acetone extract (19.49%). Total flavonoid contents (TFC) of *Ulva* sp. (3.46 mg Cathecin /g dry powder) were found higher in acetone extract as compared to other solvent extract. Total procyanidin content (TPrC) higher in acetone extract (199 mg Cathecin /g dry powder) (Figure 5). Similarly, *Gracilaria* sp, DPPH scavenging showed best result in ethanol extract (42.28%); on the other hand, ABTS scavenging showed best result in acetone extract (41.66%) (Figure 6).

Antibacterial activity

The potentiality of *Hypnea* sp, *Ulva* sp and *Gracilaria* sp as sources of antibacterial agents against *Vibrio parahaemolyticus* was evaluated. Three seaweed extracts viz. methanol, ethanol and acetone were initially screened for antibacterial activity against *V. parahaemolyticus* by the disc diffusion method.

Table 2. Results of antibacterial activity of seaweed extracts

Seaweed Species	Inhibition Capacity Against <i>Vibrio Parahaemolyticus</i>		
	Methanol extract	Ethanol extract	Acetone extract
<i>Hypnea</i> sp	-	-	-
<i>Ulva</i> sp	+	+	+
<i>Gracilaria</i> sp	+	+	+

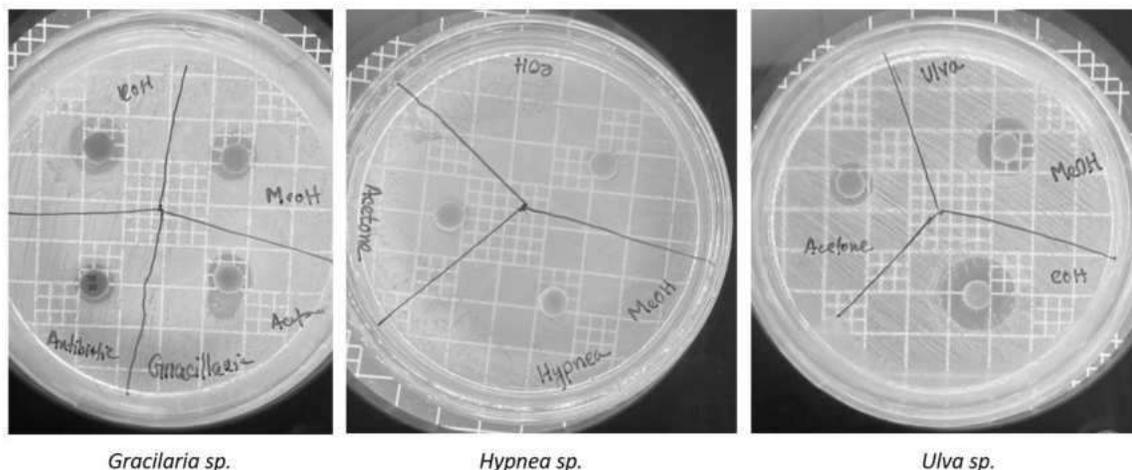


Figure 7. Antibacterial activity of seaweed extracts

The preliminary test was conducted using a suitable assay, which demonstrated clear zones of inhibition around the discs impregnated with all the extracts of *Ulva sp* and *Gracilaria sp* indicating the presence of active compounds with antibacterial properties.

Experiment-1 Assessment of larval molting efficacy using different plants & seaweeds

Treatments	Sources of the natural Extract	Dose of microalgae (Black algae powder + spirulina powder)	Stocking Density
T ₁	<i>Hypnea sp</i>	(2+2) 4 ppm	2000 larvae/litter
T ₂	<i>Gracilaria sp</i>		
T ₃	<i>Ulva sp</i>		
T ₄	Hargoza		
C	Black algae		

To make wet-lab experiment, Four treatment and one control group of prawn larvae (stage-3:72%, Stage-4:27%, Stage-5: 1%) with 2000 individuals were transferred in to the each 300 L fiber glass tank containing UV treated water. Different sea weed and plant extracts (*Hypnea sp*, *Ulva sp*, *Gracilaria sp*, Hargoza, Black algae) + spirulina powder was provided at a dose of 4.0 ppm with 4 and 6 times per day in the fiberglass tank of T₁, T₂, T₃, T₄ and C respectively. Fecal material, unused feed, molted shells, etc. were siphoned out prior to feeding. Hygienic condition was maintained in every step and extreme care were taken. Continuous aeration was provided for sufficient oxygen supply. After 15 days of larvae rearing in wet lab, all larvae were collected and progression rate of metamorphosis in different larval development stage and enzymatic activity (amylase, protease, and lipase enzyme activity) were recorded and analyzed for comparison.

Stage Variation and Molting Rate

Among all treatments, T₄ (Hargoza) showed higher stage variation (stage-6: 10%, stage-7: 30%, stage-8:40% and stage-9:20% than other treatments (Figure 8). Lower stage variation was found in T₂ (*Gracilaria sp*) contains (stage-5: 50%, stage-6: 20%, stage-8:20% and stage-9:10% (Figure 8). So, Hargoza could increase progression rate of metamorphosis in different larval development stage in prawn.

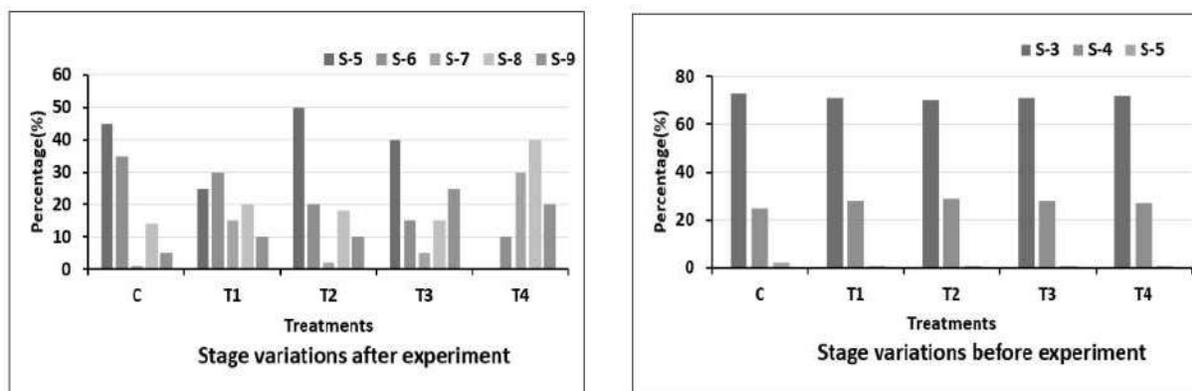


Figure 8. Stage variation in different larval development stage of prawn under 15 days of rearing in wet lab

Digestive Enzyme Activities

Amylase activity

Amylase activity was assayed by starch hydrolysis method of Bernfeld in which the increase in reducing power of buffered starch solutions was measured. The specific activity of amylase was calculated as milligrams of maltose liberated per gram of protein per hour (mg/g/h). The reaction mixture consisted of 0.125 ml of 2% (w/v) starch solution, 0.125 ml of 0.1 M citrate phosphate buffer (pH 7.5) and 0.5 ml enzyme source. The reaction was incubated at 37 °C for 1 hour, and the absorbance was measured at 600 nm against a blank. For the blank, the enzyme source was added just after the incubation period. Maltose solution was used as standard (Bhavan et al., 2010).

Protease activity

The protease activity was estimated by using the casein-hydrolysis method by the method of Furne *et al.* (2005). Casein was used as substrate. The reaction mixture contained casein at 1% (w/v) (0.25 ml), 0.25ml of 0.1M glycine –NaOH buffer (pH 10) and 0.1ml supernatant (enzyme source). The mixture was incubated for 1 h at 37°C. The reaction was stopped by addition of 0.6 ml 8% (w/v) trichloro-acetic acid solution; kept for 1 h at 2°C; centrifuged at 1800 g for 10 min and the absorbance of supernatant was measured at 280 nm against blank.

Lipase activity

The lipase activity was determined by the evaluation of the degradation of triacylglycerol's, diacylglycerols, and monoacylglycerols to free fatty acids, following the method of Bier (1955). 1 litre of Polyvinyl alcohol was prepared. A solution of 1% polyvinyl alcohol and 5ml of 0.1 N HCl was heated to 75°C- 85°C. Then they were cooled and filtered. The solution was adjusted to 8.0 with 0.1 N NaOH. Virgin olive oil was added to an aliquot of this solution for obtaining 0.1 M substrate concentration. This mixture was emulsified for 5 min. A mixture of 1 mL of emulsified solution, 0.5 mL of enzyme source and 0.5 mL of phosphate-citrate buffer was incubated for 4 hours at 37°C. To stop the reaction and break the emulsion, 3 mL of 1:1 ethanol-acetone was added. To the reaction mixture, phenolphthalein in ethanol 1% (w/v) was added titrated against 0.01 N NaOH. For the blanks, the same procedure was followed and boiled enzyme was used. Porcine type 2 Lipase was used as standard.

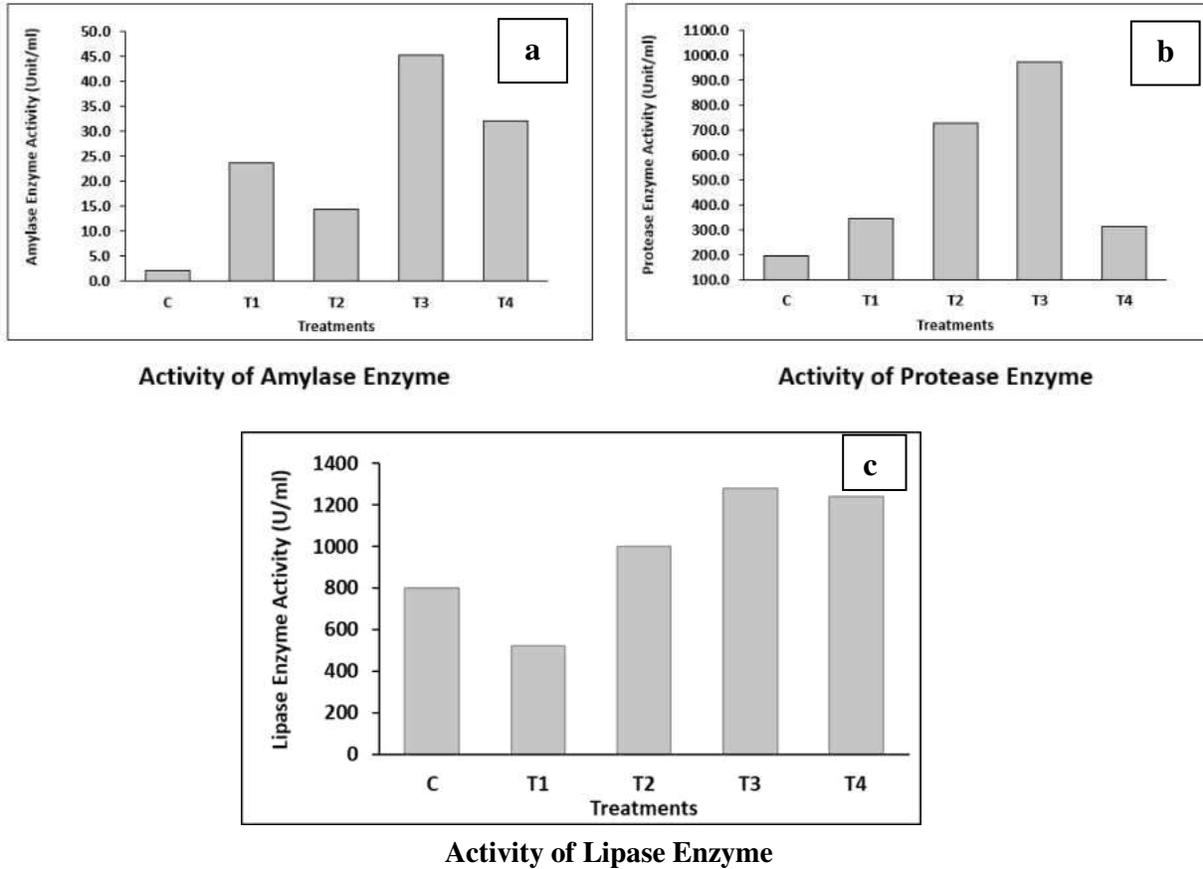


Figure 9 Digestive Enzyme Activity Assay a) Amylase b) Protease C) Lipase in the larvae reared in wet lab

Among all treatments, T₃ (*Ulva* sp) showed higher protease, amylase and lipase enzyme activities than other treatments(Figure 9). So, *Ulva* sp could increase protease, amylase and lipase enzyme activity in shrimp.

Refinement of existing organic shrimp (*Penaeus monodon*) farming using eco-friendly management protocol in southwest region of Bangladesh

Researchers

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Md. Iqramul Haque, SO

Objectives

- To assess the present status of organic shrimp (*Penaeus monodon*) farming compare to standard protocol
- To mitigate the gaps of existing culture practices according to the standard protocols

Achievements

Study. Optimization of stocking density of organic shrimp (*P. monodon*) in station ponds.

Experimental design

Three ponds in Shrimp Research Station were used considering the following experimental design:

Treatments	Stocking density (individual/m ²)	Feed	Culture period (days)	Replications
T ₁	5	Formulated organic feed	120	3
T ₂	7			
T ₃	9			

Pond preparation

Pond preparation and pre-stocking management

After being drained out and re-excavated to clear away the polluted layer of bottom mud, all of the chosen ponds were entirely exposed to the sun for 5-10 days to get rid of other unpleasant gases. Ponds were prepared by repairing embankments and clearing weeds of various kinds. To maintain post-larval shrimp in rearing ponds for a short period of time (10-15 days), approximately 10% of the area of each treatment was surrounded by nylon mesh secured with a bamboo frame. The surrounding pond area was biosecurity walled off with blue net to keep out virus-carrying organisms. Prior to the study, ponds were given a 250 kg/ha agricultural lime (CaCO₃) treatment based on the pH of the soil. Small mesh filter nets were used to fill the ponds with tidal water till a depth of 1.0 m and the water was disinfected and cleared of all animal lives using chlorine at a concentration of 20 ppm. Organic fertilizers such as fermented mixtures of molasses, rice bran, and yeast were administered to the ponds in a 40:25:0.12 kg/ha ratio. After applying molasses for two to three days, 60 kg of liquid mustard oil cake was applied. The water's color changed to green after 4-5 days of fertilization.

Source of post-larvae and pond stocking

Solely organic tiger shrimp, *P. monodon* (specific pathogen free; SPF) post-larvae (PL-12) were collected from organic hatchery of Cox-bazar. Shrimp post-larvae were transported in plastic bags and upon arrival at the farm, slowly acclimated to the pond conditions for 1 h. After proper acclimation, the PL were released directly into the ponds according to the experimental design.



Figure 1. Pond preparation and stocking of shrimp PL to the experimental ponds

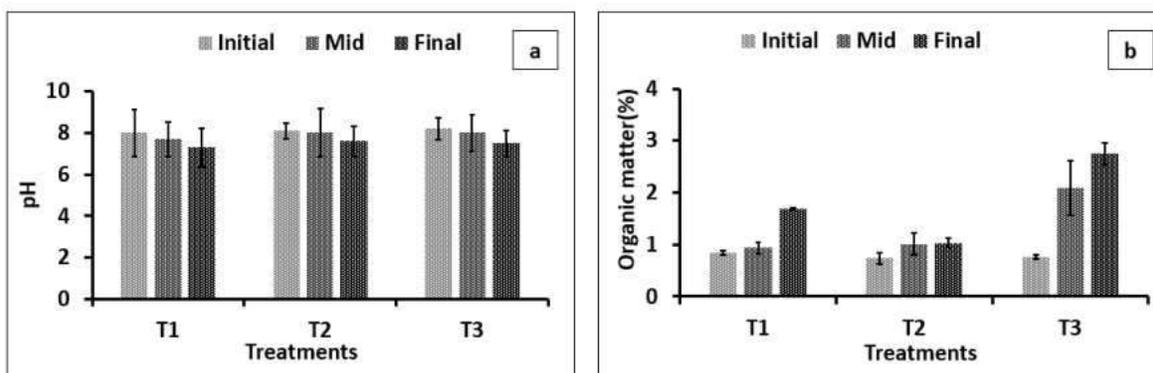
Physicochemical characteristics of soil of organic shrimp ponds

Physicochemical characteristics (salinity, pH, organic carbon, total nitrogen, phosphorus, and potassium) of soil of experimental ponds were analyzed in the laboratory of SRDI, Khulna throughout the culture period. Soil profile indicated that initially the soil was moderate in pH, but pH level in the final sample reduced in all the treatments than the initial. The presence of nutrient (Nitrogen and phosphorus) and organic matter in soil were very low in the initial sample, but nutrients were increased with the increasing of culture duration and with the increment of stocking densities.

Water quality management and measurements

Water quality parameters such as water temperature, pH, Dissolved oxygen (DO), Salinity, Alkalinity and Ammonia were measured regularly at 7 days interval throughout the experimental period. All the parameters were found almost suitable in all treatments in every sampling date without showing considerable differences (Table 2)

As illustrated in figure 3a, temperature of the experimental ponds varied from 37.94 to 28.84 °C with slight fluctuation during the culture period. Highest temperature was recorded in the 3rd and 5th weeks of the culture period which was due to the fluctuations of seasonal variations in sunlight exposure and length of the day. Dissolved oxygen (DO) levels in all treatments were always >5.0 mg/L and ranged between 6.19-10.67 mg/L (Figure 3b).



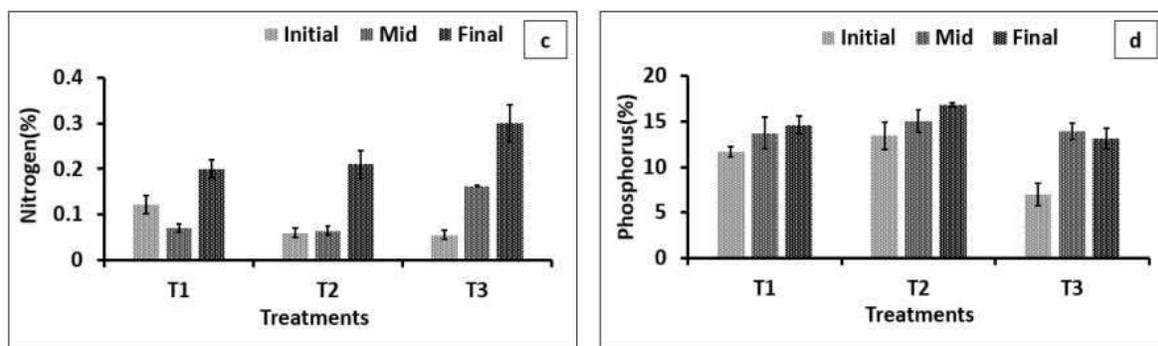
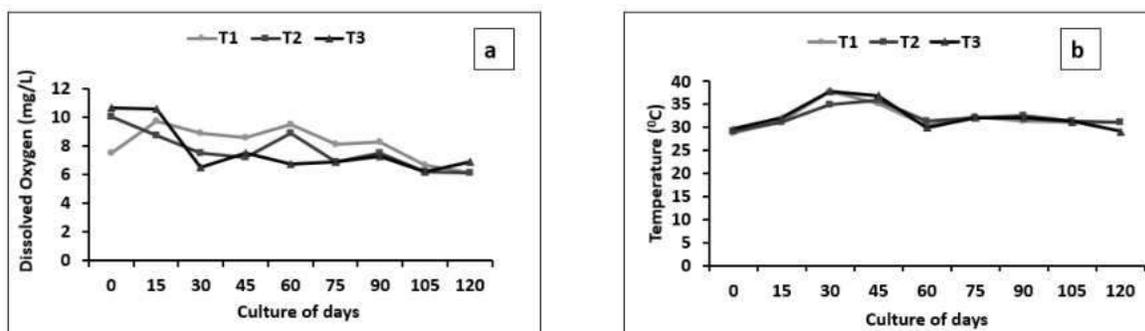


Figure 2. Soil characteristics of organic shrimp ponds a) pH b) Organic matter (%) c) Nitrogen (%) d) Phosphorus (%) under different treatments

Table 2. Water Quality Parameters of organic shrimp ponds

Pond	DO (mg/L) (Mean ± SD)	Temperature (°C) (Mean ± SD)	pH (Mean ± SD)	Salinity (ppt) (Mean ± SD)	Alkalinity (mg/L) (Mean ± SD)	Ammonia (mg/L) (Mean ± SD)
T ₁	8.86±1.54	33.60±0.66	7.86± 0.65	7.30±3.11	136.30±35.05	0.13±0.05
T ₂	8.49± 1.36	32.41± 1.85	7.66± 0.58	7.18± 2.52	143.33±23.12	0.13±0.04
T ₃	8.31±2.14	33.81±1.62	7.46± 0.74	7.70±2.46	145.33±8.86	0.17±0.05
Recommended range	≥ 5	28-32	7.0 – 8.3	5-30	≥ 100	≤ 0.1

Lazur (2007) mentioned that the optimum range of dissolved oxygen for shrimp and prawn is >4 ppm which is very similar to the finding of the present study. The pH value of all experimental ponds water ranged between 6.47-8.81 (Figure 3c). The salinity level in different experimental ponds varied within 3.42 to 11.85 ppt (Figure 3d). Transparency is the most crucial factor for shrimp culture ranged between 14 to 33cm in all experimental ponds. Meanwhile, that of total alkalinity ranged between 132-190 mg/L (Figure 3f). However, all the monitored water quality variables were within acceptable ranges and favorable for the growth, survival and culture of organic shrimp in earthen ponds.



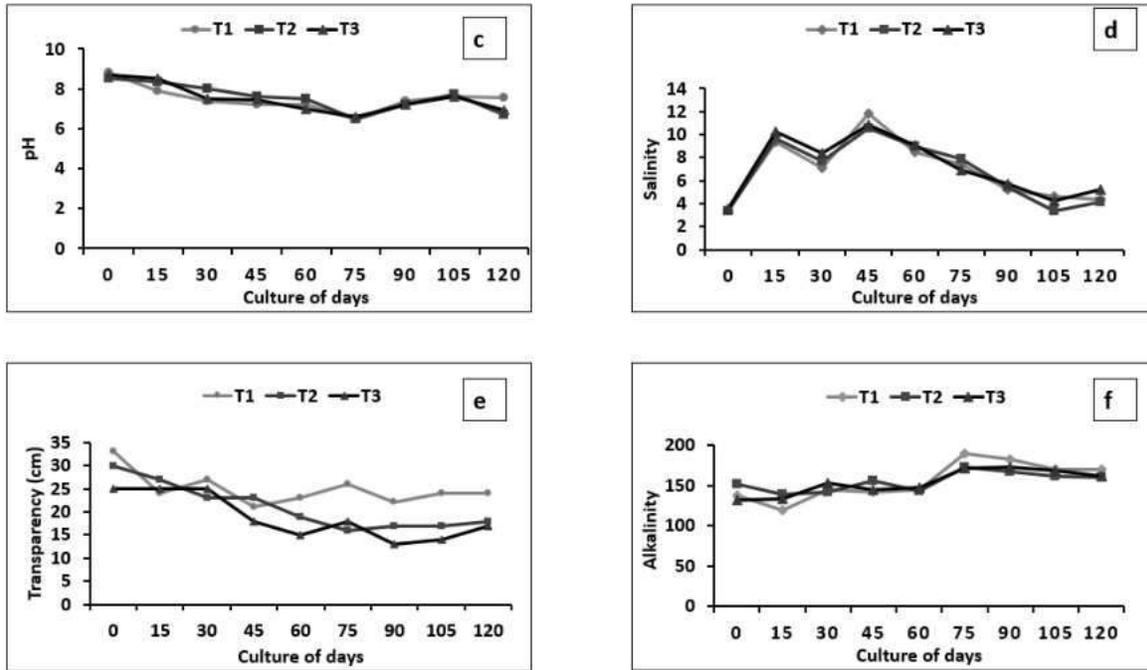


Figure 3. Water quality parameters of different treatments in fortnightly basis a. Temperature; b. Dissolved Oxygen c. pH; d. Salinity; e. Transparency; f. Total Alkalinity

Qualitative and Quantative Plankton analysis

Several Phytoplankton and Zooplankton groups experimental ponds were found dominated in T₂ compared to others. Among the zooplankton groups, Euglenophyceae, Rotifers, Copepods, Crustaceans and Phytoplankton groups Bacillariophyceae, Cyanophyceae, Chlorophyceae were available in T₂ and higher quantities of zooplankton in T₂ compared to other treatments were recorded which might be due to availability of nutrients and favorable water quality parameters. Lowest Phytoplankton counts were found in T₃ (5.52×10³ cells/L) and highest in T₂ (10×10³ cells/L). Similarly, lowest Zooplankton counts were found in T₃(1.2×10³ cells/L) and highest in T₂(3.8×10³ cells/L).

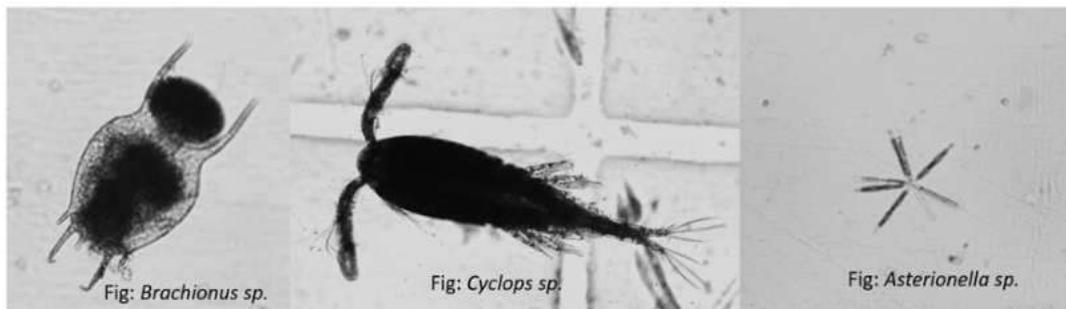


Figure 4. Isolated plankton species during the experimental period

Chlorophyll-a measurement

Chlorophyll-a was calculated following the equation as below,
 Chlorophyll-a (µg/l) = v/(Vxd) x [11.60(E665-E750) -1.31(E645-E750) - 0.14(E630-E750)]

Where, v = vol. of extract (ml)

V = vol. of water sample (l)

d = Path length of the cuvette (cm)

Chlorophyll- a was found higher in T₂ than the other ponds similarly with phytoplankton and zooplankton abundance.

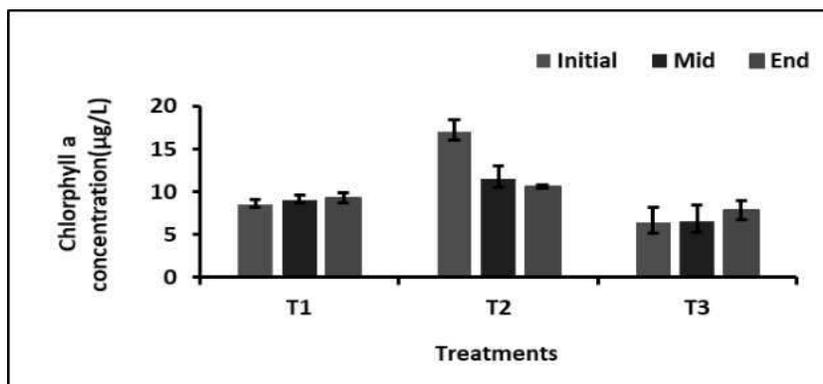


Figure 5. Chlorophyll-a concentration in experimental ponds

Microbial load count

Bacterial load in bottom sediment was found low at initial sample and decreased to almost zero after application of liming, but increased further with the increase in culture duration. The concentration of bacterial load was higher in the end sample and it was highest in higher stocking density at the end of culture period. However, intensification of stocking density of shrimp might lead excessive influx of uneaten feed, faeces and molted shell on to the bottom sediment, which may have increased the bacterial load and activity onto the sediment-water interface.

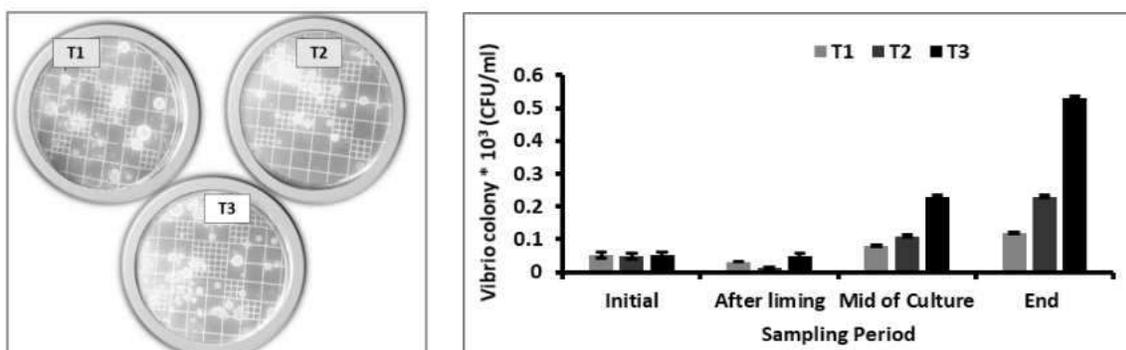


Figure 6. Microbial load count in the bottom soil of experimental ponds

Feeds and feeding

An organic feed was formulated following the formulation chart given in project proposal which proximate analysis is given below:

Table 3: Proximate composition of Formulated organic feed

Parameter	Calculated value (%)
Protein	33.0
Lipid	3.5
Moisture	8
Ash	12.0
Fiber	8.5



Figure 7. Preparation of organic feed

Shrimps were fed twice daily with formulated organic feed @ 3-5% body weight. To increase natural productivity of pond water a mixture of organic ingredients viz. molasses, yeast and rice bran @ 40 kg/ha; 120 g/ha; 25kg/ha were applied.

Growth Performance of Organic Shrimp

After 120 days of culture, all shrimps were harvested and production was estimated. Higher growth was observed in T₁ in comparison to others after 120 days culture period, in T₁, T₂ and T₃ were 28.73±0.45, 23.95±0.52 and 21.32±1.02g respectively. Compare to other treatments, T₁ shows good result. After 120 days of culture average length in T₁, T₂ and T₃ 16.23± 1.04, 13.68±0.52 and 11.52±1.23 cm respectively.

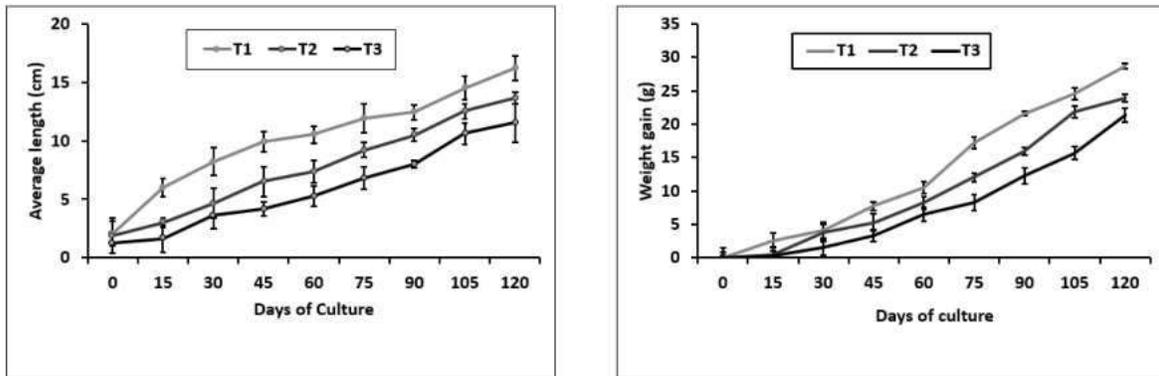


Figure 8. Growth Performance of Organic shrimp

In this year (2022-23), the remarkable achievement was that no disease outbreaks occurred among the experimental ponds. After 120 days of culture it was found that highest body weight gain was achieved under the T₁ having stocking density 5ind./m². It indicated its superiority over other treatments having high stocking density. Validatization through repetition of this formulated feed needed to be tested to maximize the profit level before extension to farmer’s field.

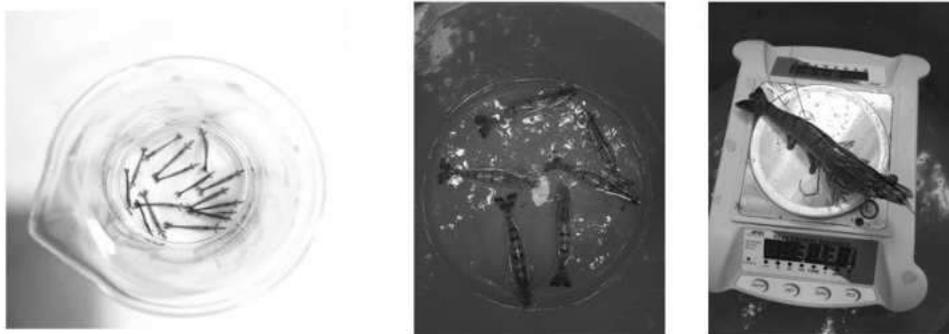


Figure 9. Organic shrimp after 4 months rearing

Biochemical analysis of bottom soil of ghers in relation to shrimp production

Researchers

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Md. Iqramul Haque, SO
Md. Arifuzzaman, SO

Objectives

- To assess the biochemical parameters of shrimp ghers bottom sediment
- To determine the residual concentration of biochemicals in shrimp and their toxicological risk
- To estimate the nutrient budget of shrimp ghers
- To evaluate the energy budget of the shrimp ghers in relation to their production

Achievements

Experiment-1. Assessment of the biochemical parameters of bottom sediment

Study-1 Exploration of farming techniques and management features

Shrimp culture techniques were evaluated from the degree of management applied throughout the production cycle from the initial stage of pond preparation to the harvesting of shrimp. Farm records had been used to quantify the manure and fertilizers, supplemental feeds, and shrimp harvests and to have information on the management practices applied and inputs used. Per hectare, shrimp yields were calculated from the final biomass obtained in each pond. The farmers were interviewed for detailed information on the generalized scenario of management regimens in those selected shrimp ghers as gher size, gher dikes, design and layout, water control, water exchange, depth, source of fry, stocking density, rearing period, crops/yr, feed used, aeration system, cumulative mortality, survival rates, lime and fertilizers used, production. Biomass of other shrimp species as well as the finfish species were also recorded and added to the total production. Gross yield was expressed as production in kg/ha/cycle.

Status of Farmers

Maximum farmers in Bagerhat had experience above 10 years but 50% farmers had 1 to 5 years' experience in Khulna district. On the other hand, most of farmers had experience above 5 years to 10 years in Satkhira district (Figure 1).

Pre-stocking Activities

Most of the farms had no periphery canal in Bagerhat but periphery canal availability high in Satkhira region (Figure 2). In Bagerhat, maximum gher size was above 100 to 150 decimals and maximum gher size was above 50 to 100 decimals in Khulna whereas in Satkhira maximum gher size was less than 50 decimals of the field survey (Figure 2). Most of the gher's average water depth in the study area was less than or equal to 3 feet (Figure 3). All the ghers of Khulna and Bagerhat region used river water for shrimp cultivation but most of the ghers used river water and ground water as water source in Satkhira (Figure 3).

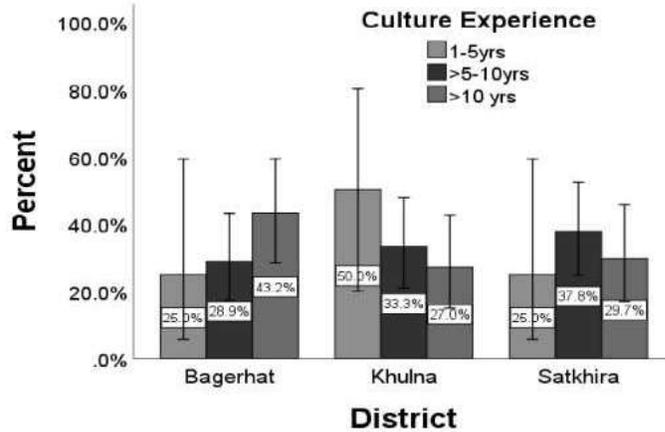


Figure 1. Culture experience of farmers of the study area

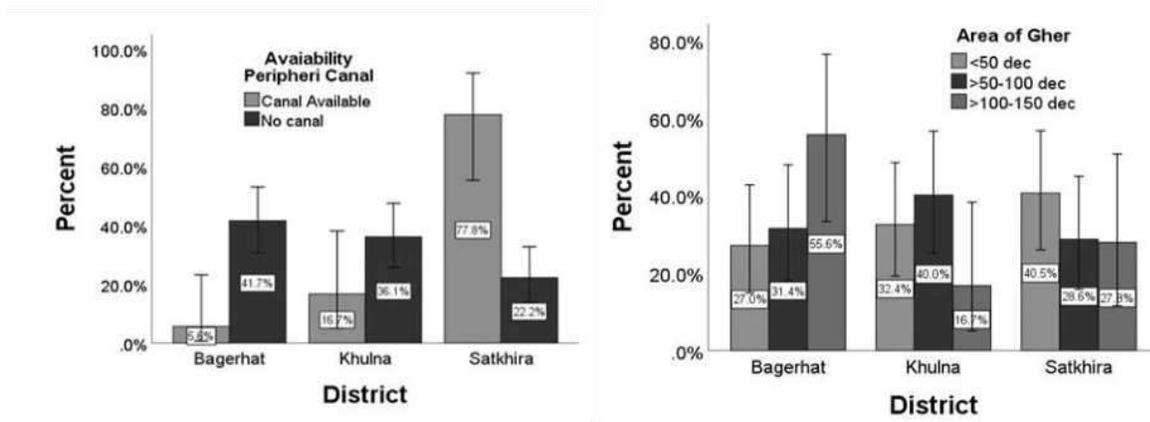


Figure 2. Periphery canal availability and Gher area of the study area

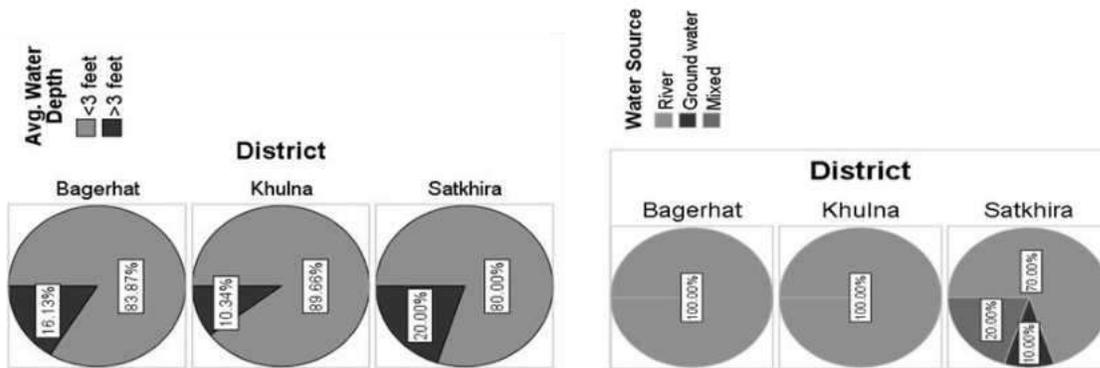


Figure 3. Average water depth and source of water Ghers of the study area

All the ghers of the study area exchanged water for 1 time/month, but 6.67% farmers in Satkhira region exchanged water in gher for 2 times/month. Most of the gher followed above 5 steps for gher preparation method in Bagerhat and Khulna regions, but 50% in satkhira region (Figure 4). In Bagerhat all shrimp cultivators used inorganic fertilizer (Urea, TSP, DAP etc.) and in Khulna all farmers used organic fertilizer but organic and inorganic both fertilizers were used in Satkhira equally (Figure 4).

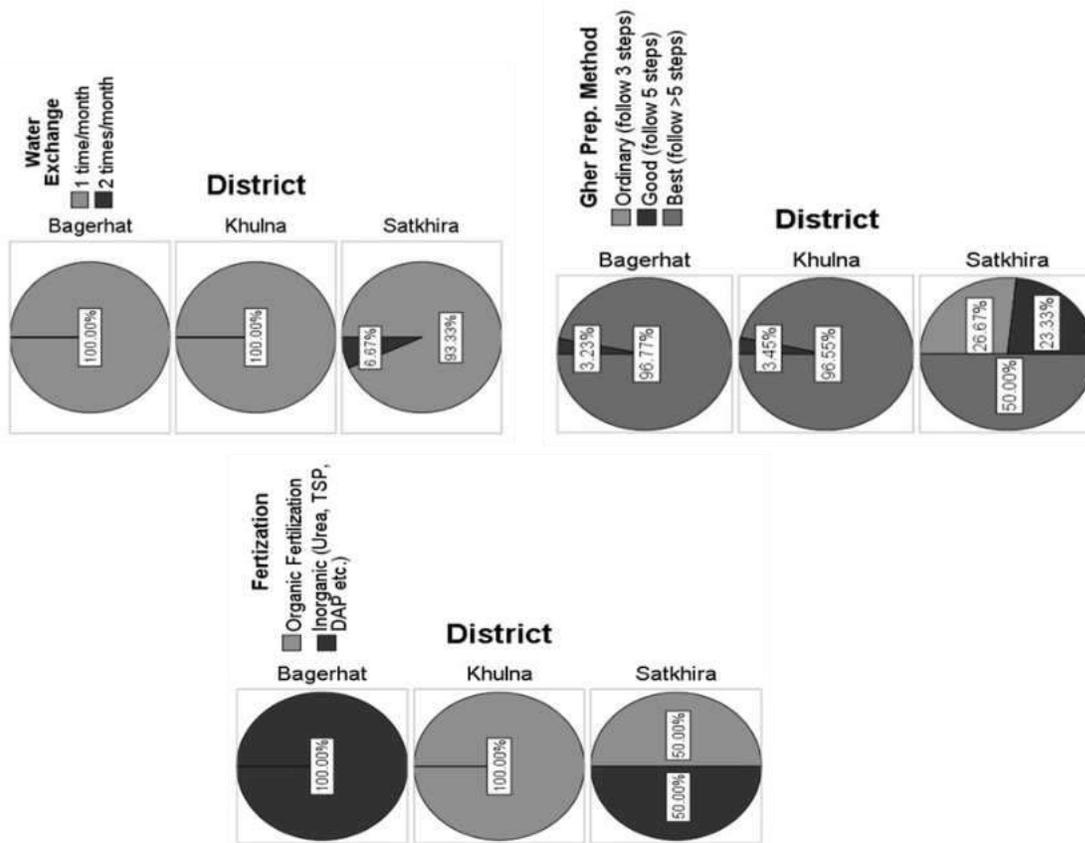


Figure 4. Overview of water exchange, gher preparation method and fertilization uses

During Stocking Activities

From the study, it was found that 100% gher's of Bagerhat cultured galda, bagda and white fishes in same gher at the same time but in Khulna and Satkhira regions monoculture of shrimp was found (Figure 5). Maximum farmers in Bagerhat district stocked hatchery produced SPF PL in their gher (Figure 5).

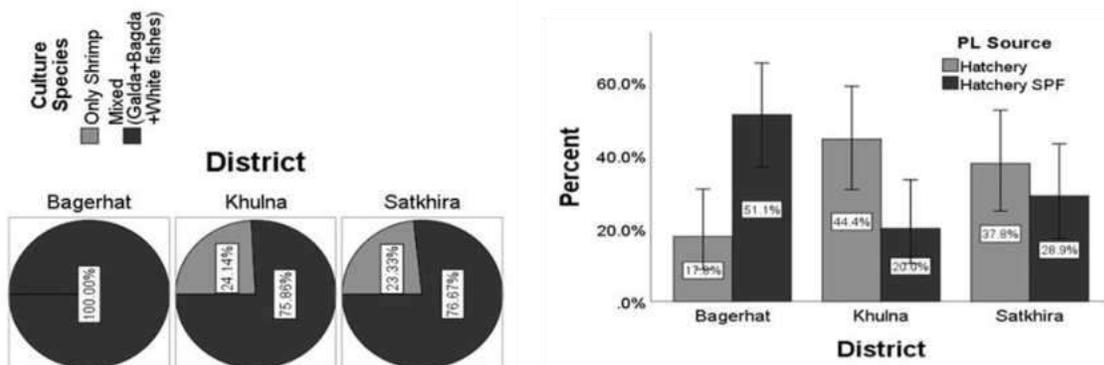


Figure 5. Overview of culture species and PL source

Most of the farmers in Bagerhat had stocked PL in gher above 150 to 200 pieces/decimal and above 100 to 150 pieces/decimal in Khulna but in Satkhira PL had stocked @ 100 or less than 100 pieces per decimal (Figure 6). The farmers of Bagerhat district stocked PL in their gher more than 2 times compared to other districts (Figure 6).

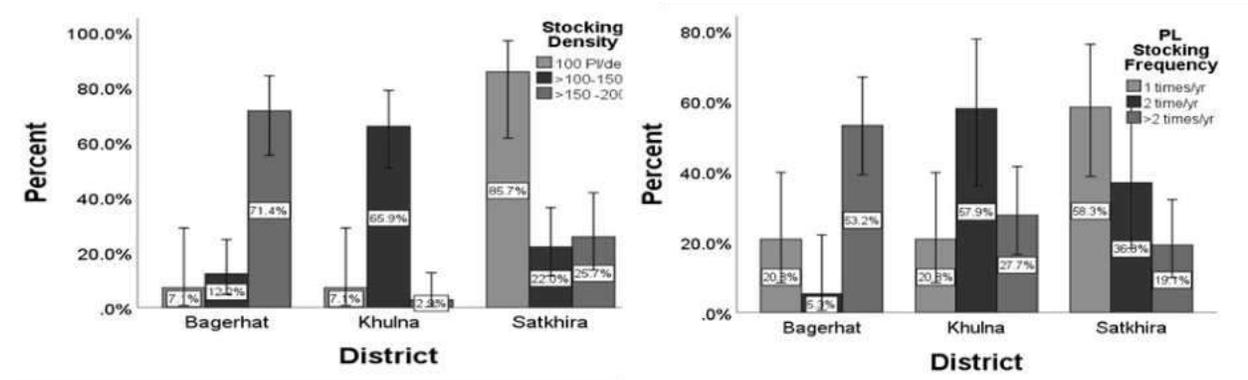


Figure 6. Stacking density and PL stocking frequency of shrimp

Post-stocking Measurements

Maximum farms in Khulna and Satkhira regions used formulated feed instead of commercial feeds but in Bagerhat used more commercial feed than formulated one (Figure 7). Amount of feed used in the most of the gher of studied area was less than 5% of the body weight but 16.13% gher was used feed at 10% or above 10% of body weight in Bagerhat (Figure 7). Maximum farmers applied feed 1 to 2 times per day in the studied area but some gher of Satkhira and Khulna applied feed 3 to 4 times per day (Figure 8). Water quality parameters were monitored regularly in all the gher of Bagerhat but in Satkhira maximum farms did not check water quality parameters (Figure 8). The culture period of the most of the gher in the studied area was maintained above 8 months but in Satkhira and Bagerhat culture duration of some gher was above 6 to 8 months (Figure 10). Survival rate in maximum farms of Bagerhat and Khulna district was 60 to 70% but in Satkhira survival rate was above 70 to 80% of maximum farms. Some farms of Bagerhat and Satkhira had shown survival rate above 80% (Figure 10).

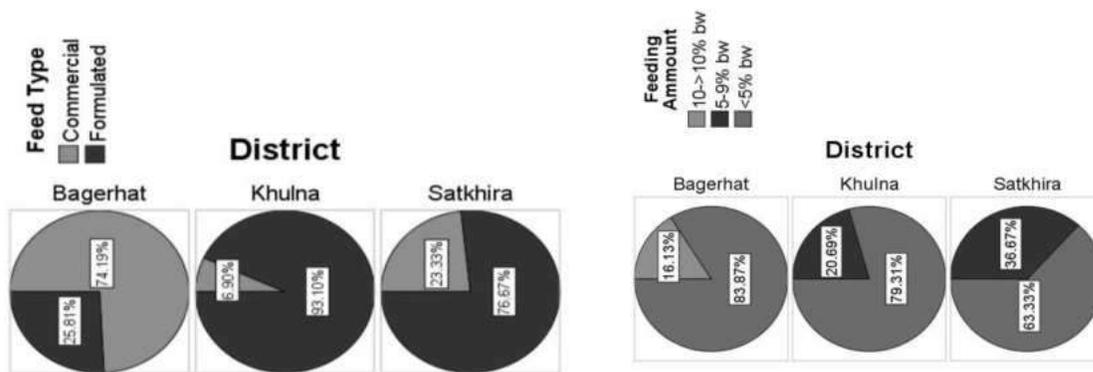


Figure 7. Overview of using feed type and feeding amount in gher

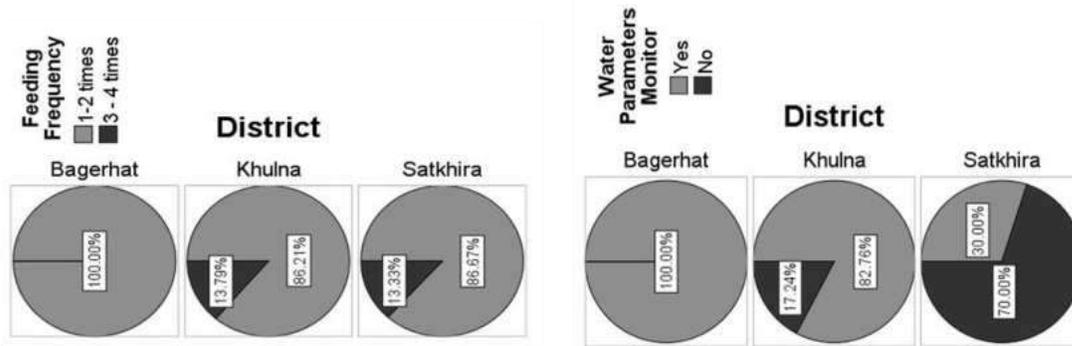


Figure 8. Feeding frequency and water parameter monitoring status

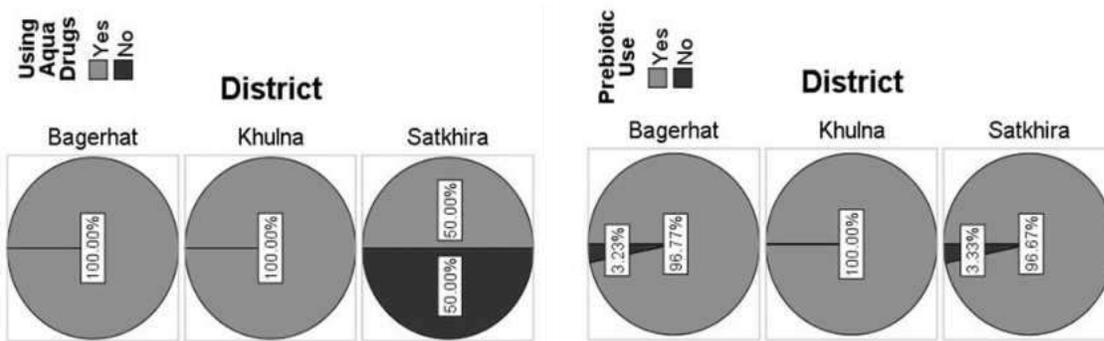


Figure 9. Aqua drugs and prebiotic used status in gher

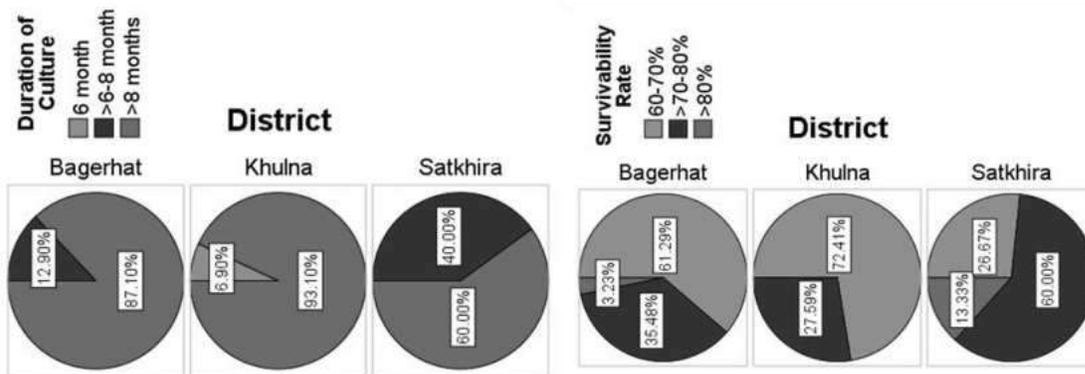


Figure 10. Culture duration and survivability shrimp in the study area

Study-2. Assessment of the chemical parameters of bottom sediment

Monitoring of the chemical features of gher’s bottom sediment

During the monitoring of chemical composition of gher’s bottom sediment, the major components were sulfur, iron, manganese, calcium and organic matters which concentrations were 5 times higher in the sediment from cluster gher in contrast with the non-cluster gher (Figure 11).

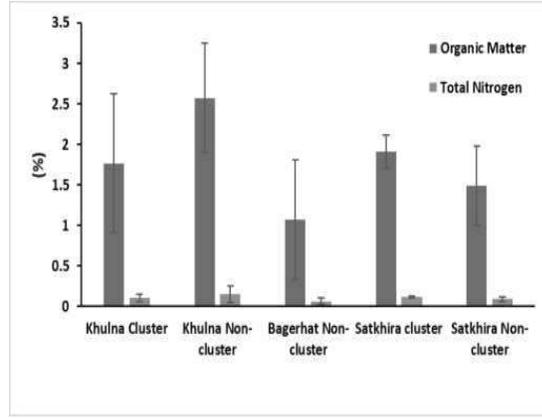
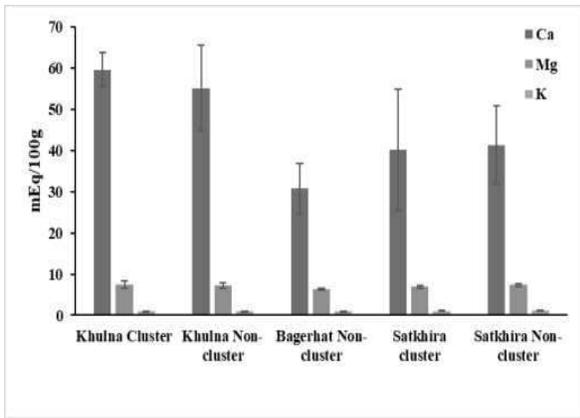
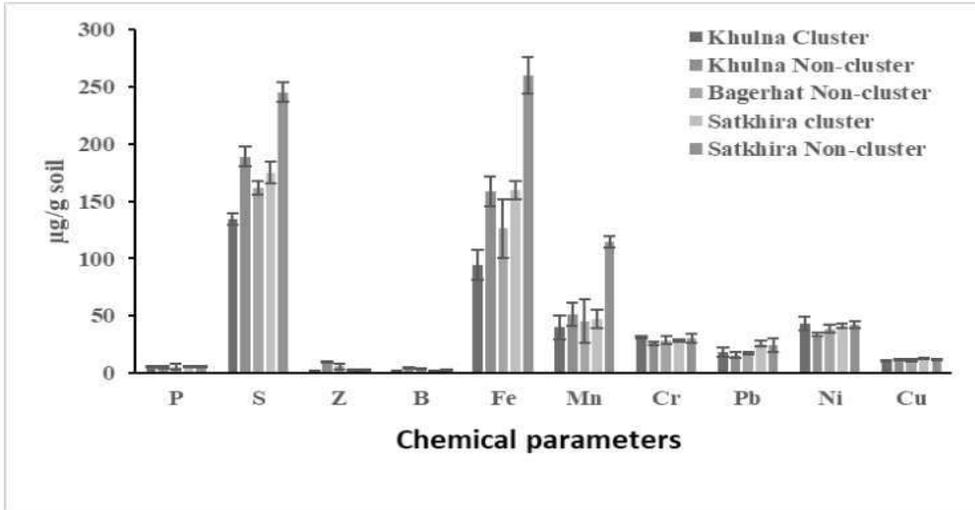
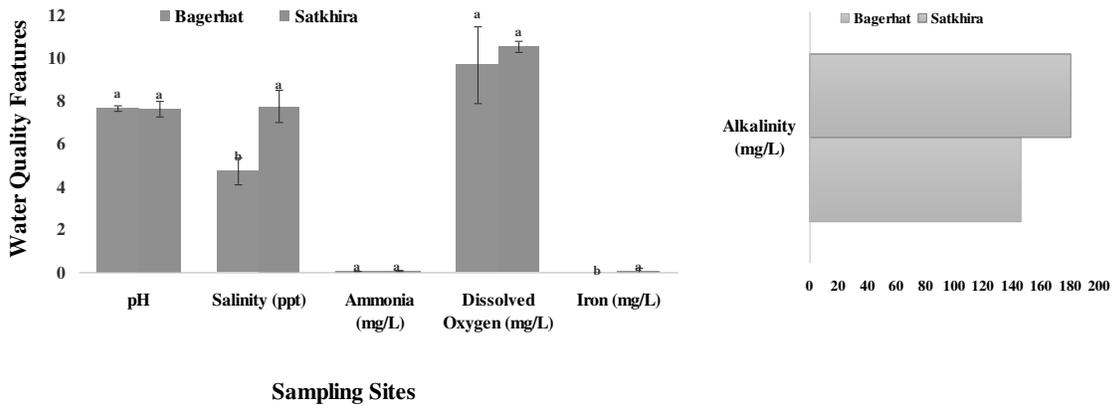


Figure 11. Chemical features of bottom soil of cluster and non-cluster shrimp ghers in the study area

Monitoring of the water quality features



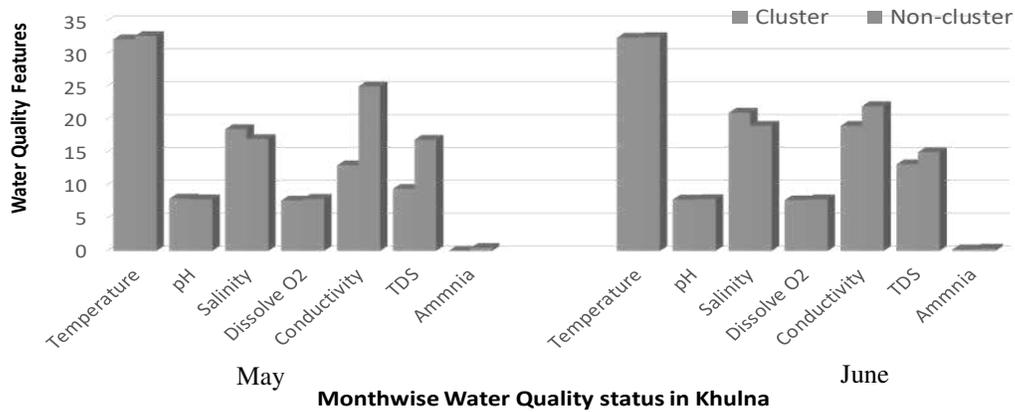


Figure 12. Water quality features of cluster and non-cluster shrimp gher in the study area

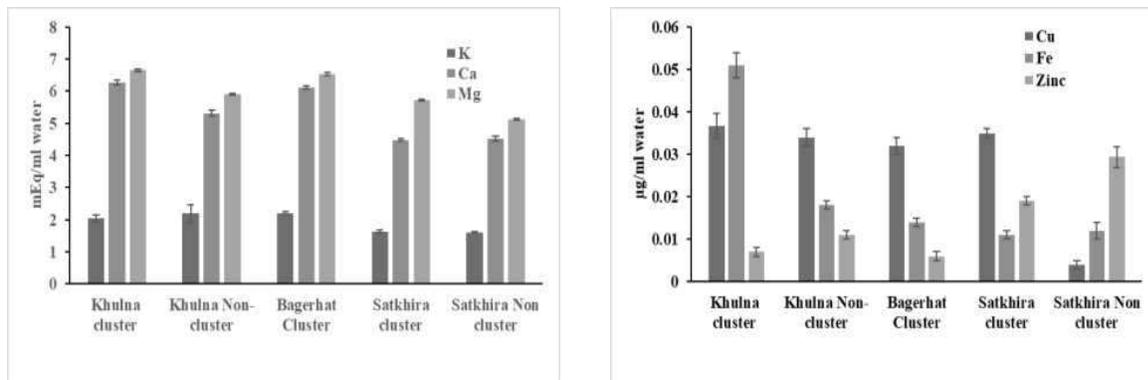


Figure 13. Minerals of water of cluster and non-cluster shrimp gher in the study area

Monitoring of the Phytoplankton abundance

In case of the monitoring of mineral elements in the water samples, it was evidenced that the available minerals were potassium, calcium, magnesium, copper, iron and zinc. As per the observed concentrations levels, magnesium, calcium, iron, and copper were the dominant elements which were comparatively higher in the water samples collected from cluster farms in comparison with the water samples obtained from non-cluster gher (Figure 13).

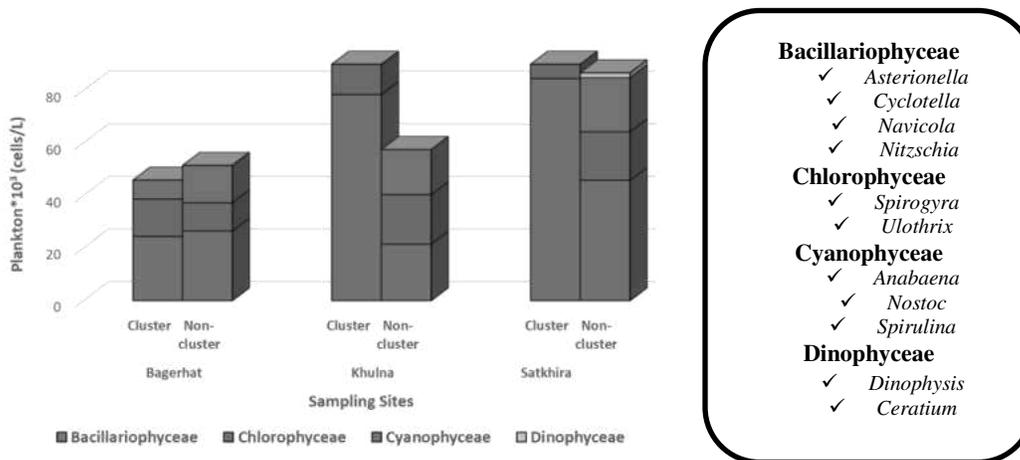


Figure 13. Monitoring of the phytoplankton of shrimp gher in the study area

Among the witnessed phytoplankton population, Bacillariophyceae was the major group where the dominant genus was *Asterionella sp.*, *Cyclotella sp.*, *Navicola sp.* along with *Nitzschia sp.* The phytoplankton abundance was prominently higher (40%) in cluster farming systems rather than in the non-cluster gher (Figure 14).

Monitoring of the Zooplankton abundance and pathogenic bacteria

In case of zooplankton monitoring, the preeminent group was Copepod where *Cyclops sp.*, *Diaptomus sp.*, and *Nauplius* were the dominant zooplankton species in cluster gher and the abundance was 45% more in comparison with the non-cluster gher (Figure 15). During the monitoring of bacterial load especially for pathogenic bacteria, we found 4.4 times higher bacterial loads in the water samples from non-cluster gher whereas, the abundance was 4 times higher in sediment samples in contrast with the cluster farming approach (Figure 16&17).

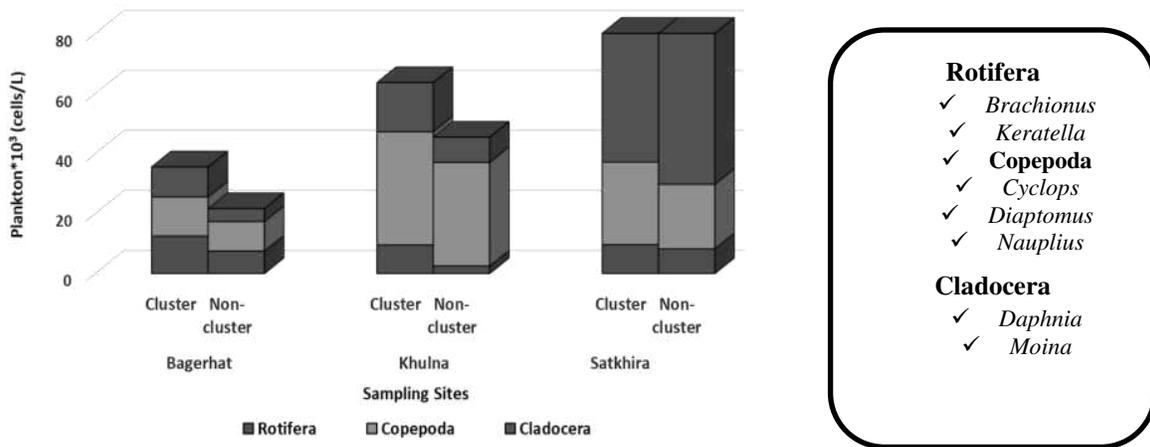


Figure 15. Monitoring of the zooplankton of shrimp gher in the study area

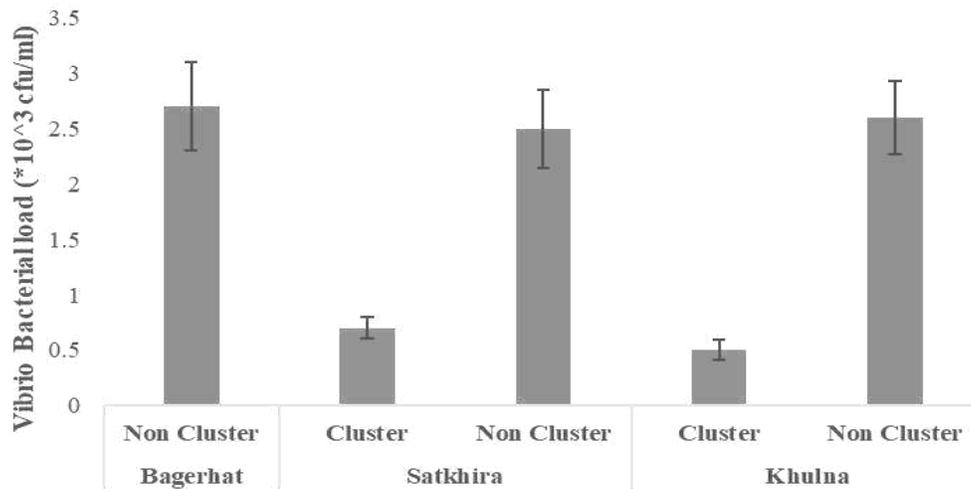


Figure 16. Abundance of pathogenic bacterial load in water shrimp gher in the study area

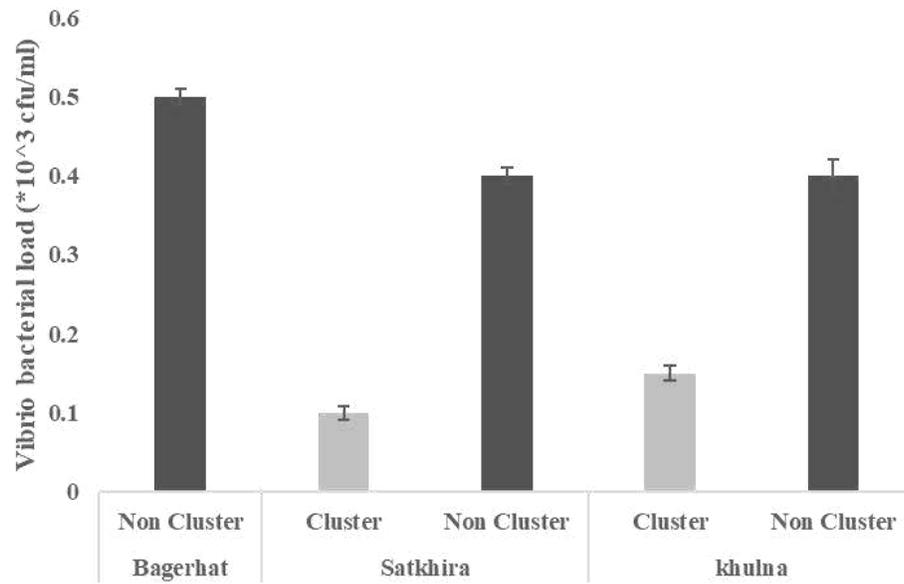


Figure 17. Abundance of pathogenic bacterial load in sediment of shrimp ghers in the study area

Isolation, production and development of indigenous microalgae based live feed supply chain for marine hatchery

Researchers

Jakia Hasan, Senior Scientific Officer
Zahidul Islam, Scientific Officer
Turabur Rahman, Scientific Officer

Objectives of the project

- To isolate commercially important live feed from the Bay of Bengal
- To utilize live feed as ready primary feed for various marine larvae
- To develop a portable photo-bioreactor model to facilitate pure live feed stock culture at field level

Achievements

Isolation and scale-up of microalgae in laboratory condition

For isolation, samples were collected from different points of the Bay of Bengal. A Plankton net was used to collect the samples and was preserved in sample bottle. Collected samples (using plankton net) were carried out into the laboratory and cultured in laboratory conditions. Different culture media (Conway medium, f/2 medium etc.) were used for culture with maintaining different pH, temperature, light intensity, aeration and salinity etc. Serial dilution method, physical separation (using Pasteur pipette) method and agar plating method were followed to isolate single species.

During this experimental period, 31 species of 27 different genera and 9 classes have been identified. Besides, two (2) different phytoplankton species have been successfully isolated during the experimental period. The isolated species are *Chlorella* sp. and *Thalassiosira* sp. (Figure 1). Presently, with these new two species, seven (07) commercially important microalgae species are available in the Live Feed Laboratory, Marine Fisheries and Technology Station, Bangladesh Fisheries Research Institute, Cox's Bazar.

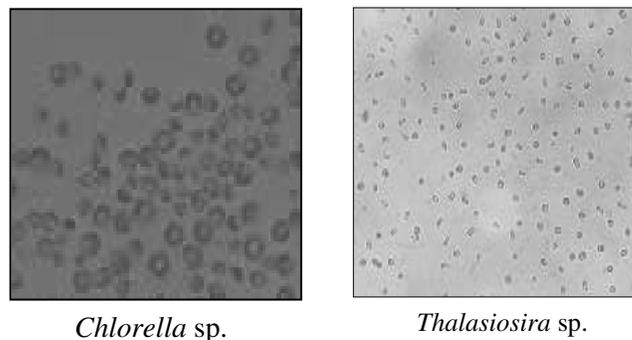


Figure 1. Isolated Species

Native strains show a better adaptability to the environmental conditions of their isolation area. In this study, different commercially important native species of the Bay of Bengal were isolated and adapted into laboratory conditions. So that, various pure stocks will be ensured for future studies. Moreover, different physiological studies (growth pattern, productivity, cell multiplication rate etc.) were done for each species.

Utilization of live feed as ready primary feed for various marine larvae

Collection of Green mussels

The target size of green mussel spats were collected from the culture setup (Green mussel raft culture system of Marine Fisheries and Technology Station, Bangladesh Fisheries Research Institute, Cox's Bazar, Bangladesh in the Bay of Bengal) and transferred into the laboratory in waterlogged conditions. The collected green mussel spats were fed with *Isochrysis* sp. before starting the experiment.

Experimental design

In this experiment, the performance of live feed was evaluated on different marine larval growth. The green mussel spat larvae were reared in aquariums with containing 2L of treated seawater (SW) at 15 spat/L density. Each aquarium was maintained with strong aeration. Feeding with *Nannochloropsis* sp., *Isochrysis* sp. and *Tetraselmis* sp. was done (45 days) and water management practices were employed and monitored. All the treatments were performed in triplicates. Regardless of the algal diet, feeding was done twice a day (morning and afternoon) based on the ingestion rate. Seventy percent of the water was replaced starting on day 5, then 50% every 2 days thereafter. Physicochemical parameters (pH, temperature, salinity, ammonia and dissolved oxygen) were monitored and found to be within the optimal level for the animal. Temperature ranged from 23 to 26 °C, with a salinity of 30-33 ppt, throughout the rearing period.

Algae culture

Pure cultures of live microalgae (*Nannochloropsis* sp., *Isochrysis* sp. and *Tetraselmis* sp.) were collected from the previously stocked Live Feed laboratory, Marine Fisheries and Technology Station, Bangladesh Fisheries Research Institute, Cox's Bazar, Bangladesh. The algae were mass cultured at outdoor conditions using modified F/2 media and commercial media.

Feeding trial

Microalgae *Nannochloropsis* sp was given in treatment 1, *Tetraselmis* sp. was given in treatment 2, and *Isochrysis* sp. was given in treatment 3. Treatment 3 was considered controlled as it was found to promote good larval growth in earlier experiments. The algae were given according to the demand which was determined based on filtration and ingestion rate (Figure 2). Both larval survival and growth were assessed after 45 days of rearing. Growth increment was determined by measuring the final shell weight, length, width, and depth of at least 20 specimens per treatment.

Statistical analysis

Mean and standard deviation of mean were calculated using MS Excel. When assumptions were met, ANOVA was applied to test the significance of the difference among the different microalgae treatments.

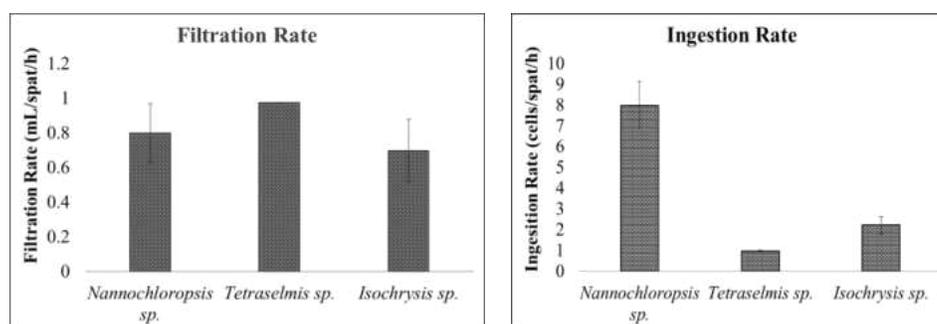


Figure 2. Filtration rate and ingestion rate of green mussel spat

The nutritional profile of the used diet

In the experimental diet, *Nannochloropsis* sp. had the highest protein followed by *Tetraselmis* sp. and *Isochrysis* sp. (Figure 3). However, the carbohydrate and lipid content also varies among the experimental microalgae diet.

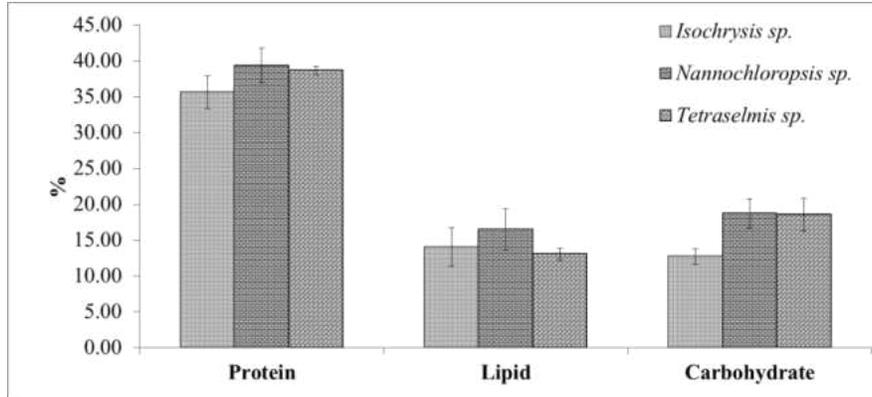


Figure 3. Nutritional profile of the used diet

Filtration rate and Ingestion rate

The filtration rate (FR) of spat was ranging from 0.977 to 0.697 mL/spat/h. *Tetraselmis* fed larvae had the highest FR of 0.997 ± 0.02 mL/spat/h. However, the other two didn't differ significantly among the treatments (Figure 2).

On the other hand, the Ingestion rate (IR) of spat were ranging from 7.99×10^6 to 0.98×10^6 cells/spat/h. *Nannochloropsis* fed larvae had the highest IR of 7.99×10^6 cells/spat/h. However, all three differ significantly among the treatments (Figure 2).

Growth and survival rate

The mean survival rate was highest in the *Isochrysis* fed larvae (71.33%), although the rates didn't differ significantly among the dietary treatments (Figure 4). Figure 5 shows that spat fed with *Isochrysis* had higher shell weight (0.226 ± 0.014 g), length (9.54 ± 0.34 mm), width (4.74 ± 0.22 mm) and depth (2.08 ± 0.05 mm). where the *Nannochloropsis* diet showed the lowest growth. However, the data are not significantly different from each other in the case of shell width and depth.

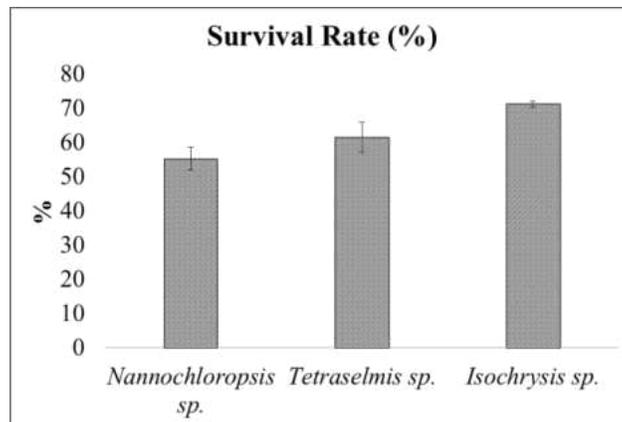


Figure 4. Survival rate (%) of green mussel spat fed with microalgae for 45 days

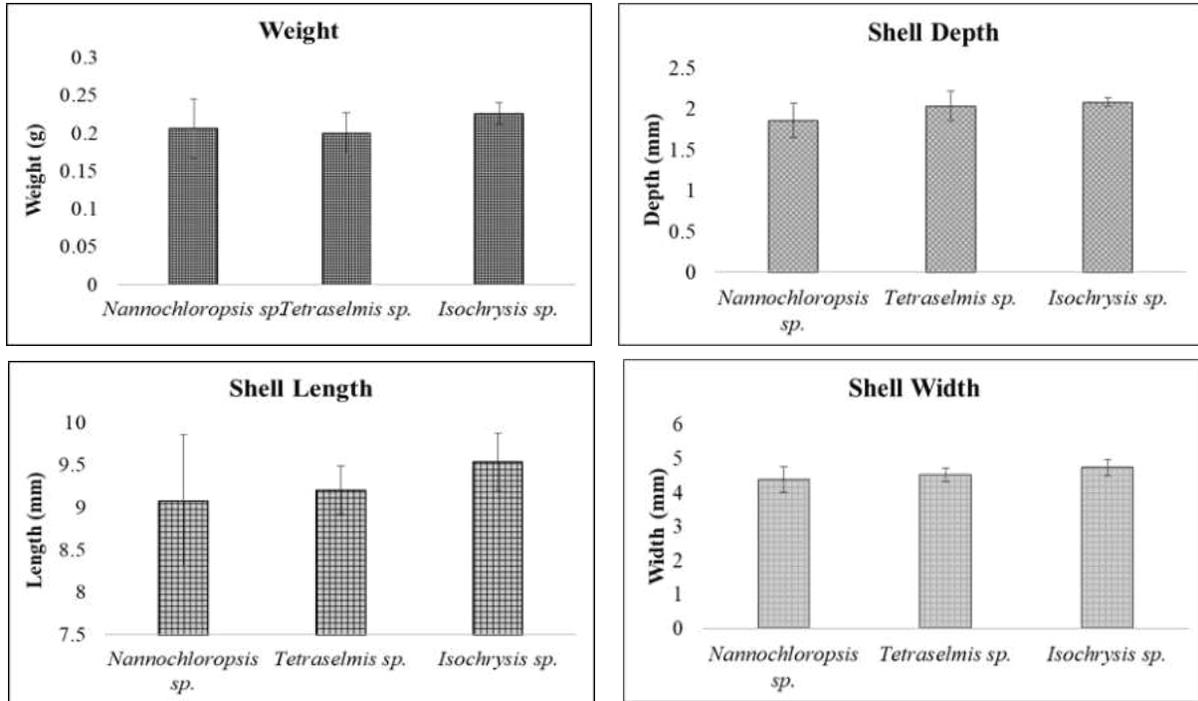


Figure 5. Growth parameters of green mussel spats fed with microalgae for 45 days

The results showed that, different microalga diets can significantly affect the performance of the spat of green mussel, as indicated by the enhanced growth *Isochrysis sp.* fed larvae. The findings agree with the previous studies on bivalve species.

Development of a portable photo-bioreactor model to facilitate pure live feedstock culture at the field level

A portable photo-bioreactor model has been developed. In this system, the physical parameters e.g. light, temperature and aeration can easily be maintained with an automatic control system. Figure 6 shows the developed portable photobioreactor system.



Figure 6. Developed portable photobioreactor system

Initially, commercially the most important species *Skeletonema sp.* was selected for culture and optimization in the photo bioreactor system.

Species collection and culture

Selected microalgae *Skeletonema* sp. was collected from previously isolated stock of Live Feed Laboratory, Marine Fisheries and Technology Station, Bangladesh Fisheries Research Institute, Cox's Bazar-4700. These collected stocks were cultured and maintained in f/2 guillard's medium at a standard temperature range (25 ± 2 °C) at $150 \mu\text{Em}^{-2}\text{S}^{-1}$ light intensity for 24 h with continuous sterile aeration.

Physical parameters optimization through Box Behnken design

The design was applied to understand the interdependence of three independent variables e.g temperature (A_1), salinity (A_2), pH (A_3) respectively on the cell density, biomass and optical density output. Optimal production of cell density, biomass and optical density was attained using Statistical Package Design Expert Version 13 (Stat Ease, Inc. Minneapolis, MN, USA). The optimization study comprised 17 sets of experiments including three replicates for the center point with different combinations as per the design package. The upper and lower limits of the variables are shown in Table 1. Optimal output was recorded as cell density (Y_1), biomass (Y_2), and optical density (Y_3) respectively. A generalized equation for output in terms of an equation comprising a linear, quadratic and interactive term is represented as:

$$Y = \beta_0 + \sum \beta_i A_i + \sum \beta_{ii} A_{ii}^2 + \sum \beta_{ij} A_i A_j + \varepsilon$$

In the above equation, β_0 represents a constant term, β_i is a linear coefficient, β_{ii} is a quadratic coefficient and β_{ij} is a cross-term coefficient. The terms A_i and A_j represent the upper and lower limit of the independent variables, and ε represents the residual error.

Table 1. The coded and actual values of independent variables

Independent Variable	Units	Symbol	Code Levels		
			-1	0	1
Temperature	°C	A1	20	25	30
Salinity	ppt	A2	20	25	30
pH		A3	7	7.75	8.5

Statistical analysis

Regression models as per the response surface methodology of Box Behnken design were determined in terms of linear, quadratic and interaction terms. A regression model was solved using the Newton Raphson method. Models were validated to be significant using Analysis of variance (ANOVA). Experiments were conducted in triplicates and mean values of replicates were presented. The significance of linear and quadratic regression coefficients was studied using the Students t-test at a probability of 0.05.

Polynomial equation

Effects of temperature (A_1), salinity (A_2), pH (A_3) on cell density (Y_1), biomass (Y_2), and optical density (Y_3) were determined using three-level factors as per response surface methodology of the Box Behnken design. The regression model for all the outputs was determined and presented through second-order polynomial equation,

Here, Cell density (Y_1), $\text{Ln}Y_1 = -29.10 + 0.45 A_1 - 1.46 A_2 + 10.65 A_3 - 0.0002 A_1^2 + 0.026 A_2^2 - 0.63 A_3^2 + 0.0006 A_1 A_2 - 0.065 A_1 A_3 + 0.0009 A_2 A_3$

Biomass (Y_2), $\text{Ln}Y_2 = -125.60 + 2.95 A_1 - 2.94 A_2 + 32.87 A_3 - 0.011 A_1^2 + 0.059 A_2^2 - 1.61 A_3^2 + 0.0008 A_1 A_2 - 0.034 A_1 A_3 - 0.013 A_2 A_3$

$$\text{Optical density (Y}_3\text{), SqrtY}_3 = -2.07 + 0.019 A_1 - 0.11 A_2 + 0.86 A_3 - 0.0002 A_1^2 + 0.002 A_2^2 - 0.043 A_3^2 + 0.0016 A_1A_2 - 0.0052 A_1A_3 - 0.0027 A_2A_3$$

The statistical significance of the regression model was analyzed using the F distribution value. The model can be validated if the P value in the F distribution analysis is less than 0.05. The F values of the model were 0.03, 0.004 and 0.04 for cell density, biomass and optical density which imply that model was significant.

Numerical optimization

Three independent variables temperature, salinity and pH were altered to attain theoretically possible maximal output responses. The numerical solution to get an optimized result for all three output results as per Response Surface Methodology based on Box Behnken design with a desirability of 83.46% is stated in Table 2. Theoretical maximum yield of cell density, biomass and optical density is 0.967×10^6 cells/mL, 1.985 g/L and 0.101 respectively and when temperature, salinity and pH were described at 27.76 °C, 29.81ppt and 7.04, respectively. Maximum yield of cell density, biomass and optical density were 0.953×10^6 cells/mL, 1.001 g/L and 0.0.09, respectively.

Table 2. The desirability of the optimized model according to Box- Behenken Design

Variable	Values
Temperature (°C)	27.76
Salinity (ppt)	29.81
pH	7.04
Responses	Values
Cell density (Cells/mL)	0.967×10^6
Biomass (g/L)	1.985
Optical Density	0.101

Theoretically optimized medium was validated experimentally. Theoretical optimized culture conditions when performed experimentally exhibited a 4.45% increase in cell density, and a 10.9% increase in optical density, respectively. On the other hand, a 49% decrease was observed in the case of biomass production Table 3.

Table 3. The actual values according to the desirability of the optimized model

Variable	Values
Temperature (°C)	27
Salinity (ppt)	29
pH	7.05
Responses	Values
Cell density (Cells/mL)	1.01×10^6
Biomass (g/L)	0.993
Optical Density	0.126

The results of theoretically optimized medium were almost similar to the predictive optimized medium (0.953×10^6 cells/mL cell density, 1.001 g/L biomass and 0.0.09 optical density) yields as exhibited in Run 16 of Table 4.

Table 4. The experimental responses according to the design

STD	Run	Temp A₁	Salinity A₂	pH A₃	CD Y₁	Biomass Y₂	OD Y₃
6	1	30.00	25.00	7.00	0.337	0.29	0.032
12	2	25.00	30.00	8.50	0.57	0.51	0.054
10	3	25.00	30.00	7.00	0.75	0.64	0.076
14	4	25.00	25.00	7.75	0.327	0.19	0.029
8	5	30.00	25.00	8.50	0.08	0.001	0.01
15	6	25.00	25.00	7.75	0.147	0.012	0
13	7	25.00	25.00	7.75	0.061	0.037	0.0053
2	8	30.00	20.00	7.75	0.45	0.5	0.042
1	9	20.00	20.00	7.75	0.44	0.381	0.037
5	10	20.00	25.00	7.00	0.27	0.146	0.0103
3	11	20.00	30.00	7.75	0.417	0.294	0.0107
9	12	25.00	20.00	7.00	0.267	0.112	0.0107
4	13	30.00	30.00	7.75	0.817	0.903	0.079
11	14	25.00	20.00	8.50	0.177	0.11	0.01
16	15	25.00	25.00	7.75	0.62	0.721	0.047
17	16	25.00	30.00	7.75	0.953	1.001	0.09
7	17	20.00	25.00	8.50	0.17	0.09	0.01

It is difficult to optimize media through autotrophic mode. Mixotrophic cultivation mode has higher advantages than other modes to optimize media. The study proves to deliver promising results of growth biomass through the optimized media in the PBR system. In addition, the findings can also be utilized in large-scale production system. However, the successful development of microalgae species management techniques will add a new dimension to stock management.

Identification and Culture Practice of Commercially Important Seaweeds in Bangladesh Coast

Researchers

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Objectives

- To make a detailed inventory of available seaweed species in Bangladesh coast
- To develop culture technique (indoor to field) of selected seaweed in St. Martin and other suitable areas
- To develop *in-vitro* tissue culture technique of some selected seaweed species
- To develop spore culture technique of some selected seaweed species

Achievements

Study-1: Inventory of available seaweed

Surveys were conducted in and around Cox's Bazar (St. Martin Island, Teknaf, Inani, Bakkhali, Patowartek, Shaplapur, and Moheshkhali) from October 2022 to March 2023. Different seaweed samples were collected, photographed, preserved, and identified during the survey. Different species of seaweed i.e., *Acetabularia calyculus*, *Caulerpa racemosa*, *Codium bursa*, *Padina tetrastromatica*, *Padina fraseri*, *Halimeda minima*, *Halimeda discoidea*, *Gracilaria tenuistipitata*, *Hypnea musciformis*, *Ulva australis*, *U. intestinalis*, *U. torta*, and *U. compressa* were collected randomly by hand-picking from the study area at the time of low-tide. Surveys were also conducted at the Sonadia mangrove forest of Cox's Bazar and the Guliakhali mangrove forest of Chattogram. Different mangrove species of seaweed i.e., *Catenella impudica*, *C. nipae*, *Colpomenia sinuosa*, *Bostrychia radicans*, *Caloglossa beccarii*, and *Chaetomorpha aerea* were collected during the survey. The collected samples were placed in plastic bags and afterward stored in an icebox for laboratory analysis. The samples were subjected to a gentle brushing procedure while being exposed to a continuous flow of seawater in the laboratory. Subsequently, they were rinsed with distilled water. The seaweed sample was subjected to drying using herbarium pressing frames as an alternative to the conventional method of direct sun drying. Over three consecutive days, wet papers were switched daily, resulting in the preservation of the dry seaweed samples within the laboratory. This year we have identified four (04) seaweed samples as a new species (Figure 2). Now the total of seaweed species identified from our coast is one hundred and fifty-eight (158).

Study-2: Seaweed culture

Experimental culture sites of seaweeds were set up in sheltered intertidal zones of Chowfoldondi (N21°30'13.1076", E91°59'38.8392"). A culture experiment was set up in late January at the Chowfoldondi site (Figure 3). The floating raft method was applied for the culture experiment which was made of bamboo poles and recycled plastic drums. A 1.50 cm mesh size plastic net was placed in the lower part of the frame to minimize the wave action and crop loss caused by plant rupture from the base, especially during adverse weather. All rafts were rope-tied, placed in the culture site, and anchored to help stabilize the structure. The structure's anchor was placed to raise and fall vertically during the tidal action. Micronutrient-enriched seaweed species *Ulva lactuca* was selected for culture experiments. Seeds were collected from the MFTS laboratory (tissue cultured seed) and the natural source. A comparative study was performed to analyze the overall growth performance of tissue-cultured seed and natural seed. Seeding was done by inserting the young fragments of seaweed with an average of 4 ± 0.5 kg fw (fresh

weight) and 5cm length in the twists of the coir ropes with the short string length at a density of seaweed seed were 16 seeds/m². The culture period was 90 days and partial harvesting was performed at 15 days intervals.

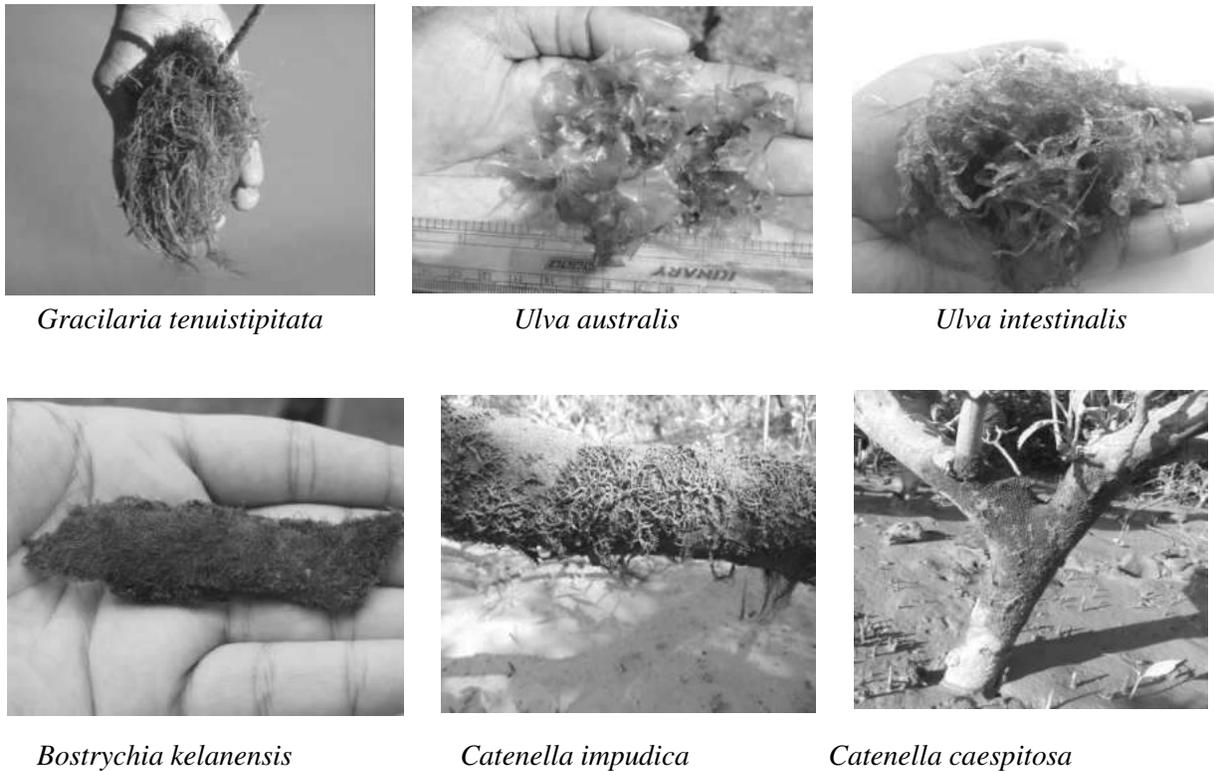


Figure 1. Seaweed species collected during inventory study

Table 1. Availability and distribution of seaweed

Area	Type	Species
St. Martin	Phaeophyta, Chlorophyta and Rhodophyta	<i>Acetabularia calyculus</i> , <i>Caulerpa racemosa</i> , <i>Codium bursa</i> , <i>Padina tetrastromatica</i> , <i>P. fraseri</i> , <i>Halimeda discoidea</i> , <i>U. intestinalis</i> , <i>U. torta</i> , <i>U. compressa</i> , <i>Hypnea musciformis</i> , and <i>Euचेuma cottonii</i>
Bakkhali	Chlorophyta and Rhodophyta	<i>Hypnea</i> sp., <i>Ulva intestinalis</i> , <i>Ulva compressa</i> , and <i>Ulva reticulate</i>
Inani	Chlorophyta	<i>Ulva australis</i> , <i>U. intestinalis</i> , and <i>U. compressa</i>
Patowartek	Chlorophyta	<i>U. intestinalis</i> , and <i>U. compressa</i>
Shaplapur	Chlorophyta	<i>Ulva</i> sp.
Sonadia	Chlorophyta and Rhodophyta	<i>Catenella nipae</i> , <i>C. impudica</i> , <i>Bostrychia radicans</i> , <i>Caloglossa beccarii</i> , <i>Chaetomorpha aerea</i> , and <i>Ulva</i> sp.
Guliakhali	Chlorophyta and Rhodophyta	<i>Catenella nipae</i> , <i>C. impudica</i> , <i>B. radicans</i> , <i>B. kelanensis</i> , <i>Caloglossa stipitata</i> , and <i>Chaetomorpha aerea</i>

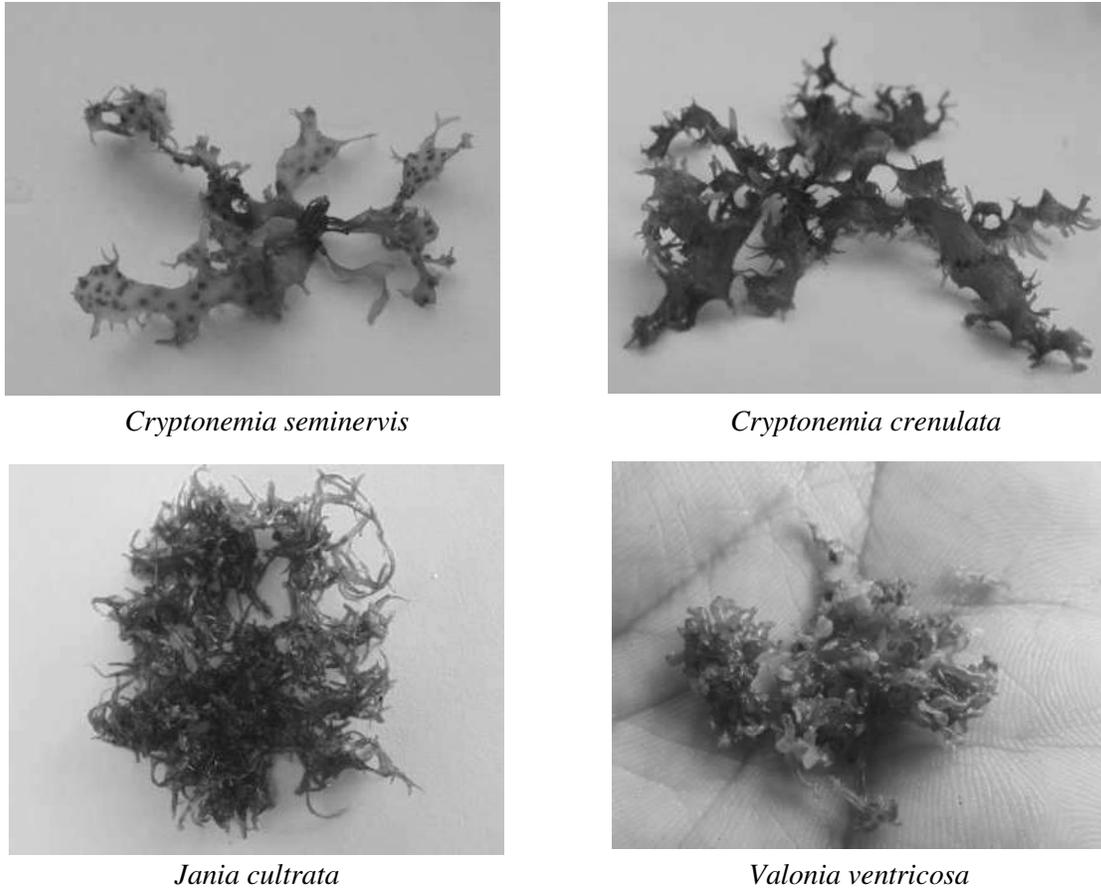


Figure 2. Newly identified seaweed species



Figure 3. Seaweed cultivation at the floating raft.

Between January 2023 to April 2023, a total of 06 partial harvests of *U. lactuca* were made in the culture site. No significant differences were found between the tissue-cultured seeds and natural seeds in terms of biomass production (kg/m^2) and daily growth rate ($\%/ \text{day}$) of *U. lactuca* (Figure 4). Harvesting at the end of the 90-day duration of the culture period resulted in the absolute biomass yield production of $18.4 \pm 1.14 \text{ kg fw}/\text{m}^2$ for natural seed and $18.1 \pm 1.48 \text{ kg fw}/\text{m}^2$ for tissue culture seed of *U. lactuca*. The daily growth rate was observed at $3.29 \pm 0.24 \%/ \text{day}$ for natural seed and $3.27 \pm 0.15 \%/ \text{day}$ for tissue culture seed of *U. lactuca*. Water quality parameters recorded during the experimental period of the study area are presented in Table 2.

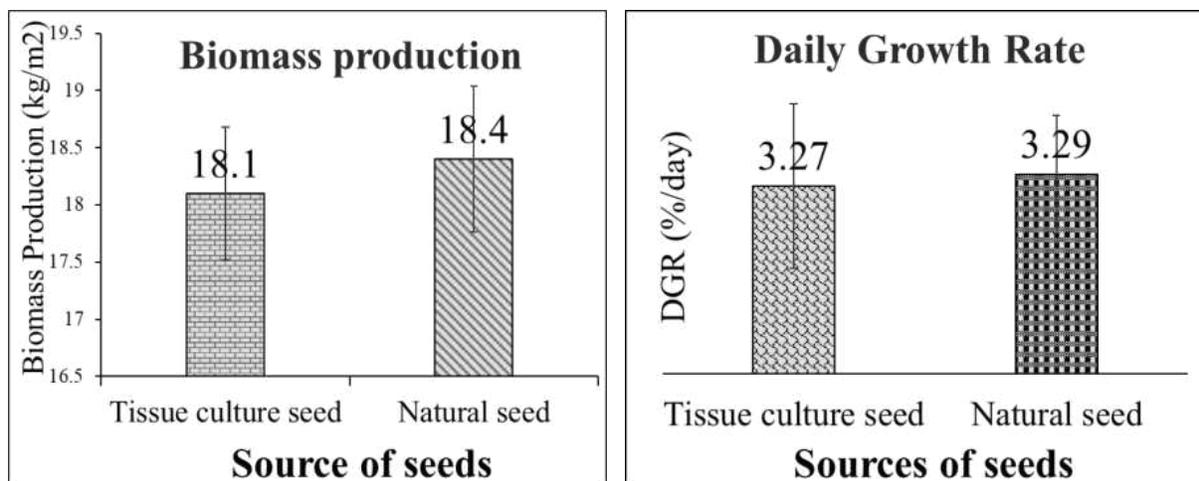


Figure 4. Biomass production (kg m⁻²) and daily growth rate (%/day) of *U. lactuca* on 90 days of the culture period.

Table 2. Water quality parameters of the study area.

Experimental site	Range values of hydrological data					
	Temperature (°C)	Salinity (‰)	DO (mg/l)	pH	Alkalinity (ppm)	Transparency (cm)
Chowfoldondi	24 – 32	30 – 36	6.5 – 8.0	7.5 – 8.5	125 – 145	40 – 55

For the pond/gher experiment

Experimental culture sites of seaweeds (*Ulva lactuca* and *Gracilaria tenuistipitata*) were set up at a gher of Whaikhyang (N21°7'16.7628", E92°11'56.2374") (Figure 5). A culture experiment was set up in late March. The floating raft method was applied for the culture experiment which was made of bamboo poles and recycled plastic water bottles. Poor growth performance was observed in the case of both seaweed species (Table 3). In the case of *U. lactuca*, no weight increase was observed during the experimental period. Due to the high water temperature color of the seaweed becomes fade. In the case of *G. tenuistipitata*, poor weight increase was observed during the experimental period. Due to the high water temperature color of the seaweed also becomes fade. Water quality parameters recorded during the experimental period of the study area are presented in Table 4.

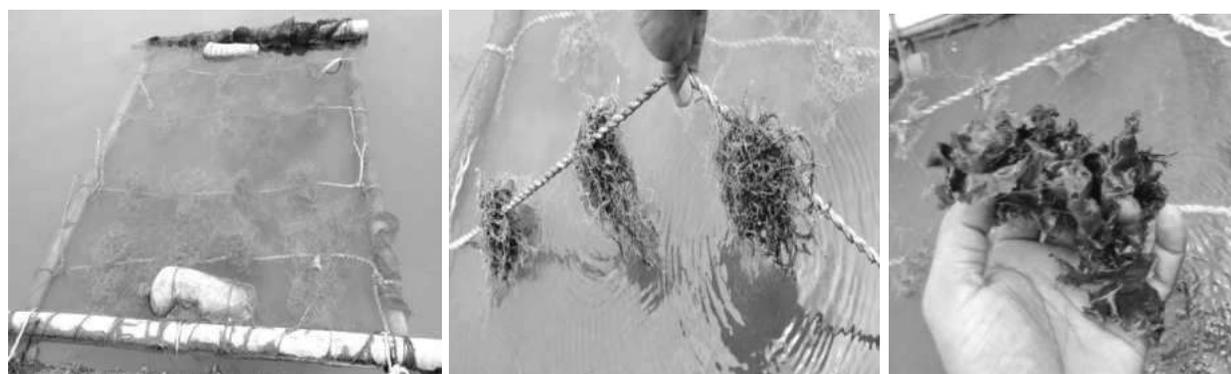


Figure 5. Seaweed cultivation at gher of Whaikhyang.

Table 3. Growth performance of seaweed at gher conditions.

Seaweed species	Weight increase (gm) (Mean ± SD)	
	Initial	20 th day
<i>Ulva lactuca</i>	16.0 ± 0.04	No growth
<i>Gracilaria tenuistipitata</i>	16.0 ± 0.04	35 ± 2.24

Table 4. Water quality parameters of the study area.

Experimental site	Range values of hydrological data			
	Temperature (°C)	Salinity (‰)	DO (mg/l)	pH
Whaikhyang	34 – 38	22 – 23	7.5 – 9.0	7.5 – 8.5

Indoor seaweed culture

Seaweed species (*Dictyota dichotoma*) were stocked in laboratory conditions of MFTS, Cox’s Bazar in the long line (4m) and tray (0.45m x 0.30m x 0.08m) method (Figure 6). Raw seawater with continuous aeration and artificial light was provided. Water was partially exchanged every seven days intervals. Growth and water quality parameters were measured every twenty days’ intervals. Weight increases of *D. dichotoma* under different culture methods in indoor conditions are shown in Table 5. Water quality parameters recorded during the experimental period are presented in Table 6.

Table 5. Weight increase of *D. dichotoma* on different culture methods.

Culture method	<i>D. dichotoma</i> weight (Mean ± SD)				
	Initial	20 th day	40 th day	60 th day	80 th day
Long line	40.0 ± 4.32	51.8 ± 5.29	62.2 ± 4.45	75.5 ± 5.55	78.4 ± 4.95
Tray	40.0 ± 3.28	52.7 ± 5.47	64.9 ± 3.81	77.1 ± 4.26	82.2 ± 4.26

Table 6. Hydrological data recorded in different culture methods at the laboratory.

Experimental method	Range values of hydrological data			
	Temperature (°C)	Salinity (‰)	DO (mg/l)	pH
Indoor	28 – 32	30 – 32	7.5 – 8.5	7.5 – 8.5



Figure 6. Indoor culture of seaweed.

Study-3: In-vitro tissue culture of seaweed

Seaweed seeds of (*Ulva lactuca*, *U. intestinalis*, *Gracilaria tenuistipitata*) have been produced in laboratory conditions through the tissue culture technique at MFTS, BFRI (Figure 7). In the field of seaweed tissue culture, the methods of callus induction and thallus/fragment regeneration are extensively utilized. The callus induction method employs a semisolid medium composed of agar and a combination of macronutrients and micronutrients specific to the cell type under consideration. In contrast, the thallus regeneration approach involves the use of liquid media, namely PES or VS media composition, to regenerate thalli or fragments. The study involved the implementation of laboratory test trials to evaluate the efficacy of seedling production by the fragmented regeneration approach. The process described enables the year-round cultivation of seaweed in terrestrial environments. The next section outlines the procedures.

Tissue isolation and purification

Fresh specimens of *U. lactuca*, *U. intestinalis*, and *G. tenuistipitata*, devoid of any additional algal contamination, were collected from their natural habitat. Subsequently, they were thoroughly rinsed in uncontaminated seawater to remove any traces of muck or extraneous substances. The specimens were then carefully transported to the laboratory in a thermocol container, ensuring cool conditions were maintained throughout the journey. Furthermore, the chosen vegetative thallus was meticulously cleansed in sterilized seawater using a gentle painter brush to eliminate any epiphytic impurities, such as soil and biofilms.

Optimize environmental conditions for seaweed tissue culture

The thalli (0.25 mg) were 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 $30 \mu\text{mole photon m}^{-2} \text{s}^{-1}$ irradiance with 12:12 light and dark photoperiod at $25 \pm 1^\circ\text{C}$. The media was added every 3 days, and the medium was changed every 10 days. After 55 to 60 days, matured thali was harvested.

PES media composition

NaNO ₃	:	350 mg
Glycerine Phosphate.Na	:	50 mg
Fe EDTA (2Na)	:	18.8 mg
PII metals	:	25 ml
Vitamin mixtures	:	1 ml
Tris	:	500 mg
pH	:	7.8
Distilled water	:	100 ml

From the fragment regeneration method, after 60 days, from 3.0 gm of fragmented *U. lactuca*, about 284 gm of matured *U. lactuca*, 3.0 gm of fragmented *U. intestinalis*, about 978 gm of matured *U. intestinalis*, and 3.0 gm of fragmented *G. tenuistipitata* about 94 gm of matured *G. tenuistipitata* was found (Table 7).

Table 7. Growth performance of seaweed species obtained in fragment regeneration method.

Sl no.	Species name	Culture period	Initial fresh fragment weight (gm)	Final fresh fragment weight (gm)
01	<i>Ulva lactuca</i>	60 days	3.0 ± 0.01	284 ± 4.59
02	<i>Ulva intestinalis</i>	60 days	3.0 ± 0.02	978 ± 5.48
03	<i>Gracilaria tenuistipitata</i>	60 days	3.0 ± 0.02	94 ± 2.32



Figure 7. Tissue culture of seaweed

Study-4: Spore culture of seaweed

Mature *U. lactuca* and *U. intestinalis* released spores at culture conditions (Figure 8). The rearing water becomes greenish after the release of the spores. Spores were then clearly visible in the microscope. Spores generally come outside through the penetration of the outer membrane of mature seaweed. The spore containing water (greenish water) was then transferred to another tank. Nutrients and other factors were provided and let them grow in the tank condition.

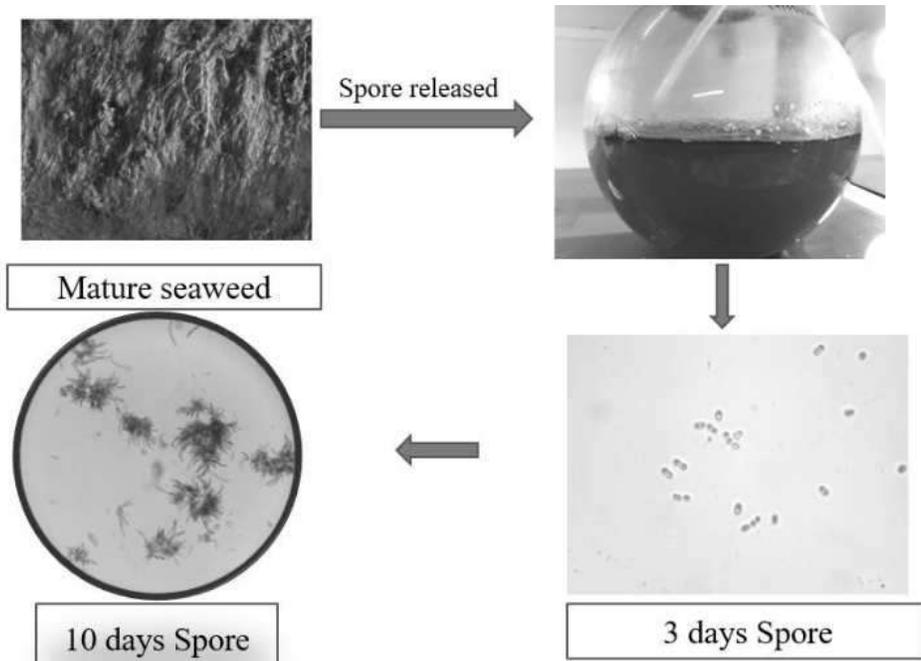


Figure 8. Spore culture of seaweed.

Development of breeding, seed production and nursery techniques of Seabass, *Lates calcarifer*

Researchers

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Md. Aktaruzzaman, SO

Objectives

- To develop the brood of seabass in captive condition
- To assess the reproductive biology of cultured seabass
- To confirm the hormones and standardize the dosages in the breeding of Seabass
- To develop the seed production and larval rearing techniques of Seabass

Achievements

Experiment 1: Development of the brood of seabass in captive condition

The Asian seabass was collected from traditional coastal aquaculture farms/ gears near chaufoldondi and Khuruskul area, Cox's Bazar. The fish were acclimatized in station seabass hatchery pond environment at 8 ppt salinity for 72 hours before stocking. The average initial weight of the fish was 600g. Then 105 fish were distributed equally (35 fish) into three MFTS cistern ponds those being fed live tilapia as food. On the other hand, 52 fish were distributed into four bloodstock rearing tanks (25000 L water volume capacity) in a RAS system in MFTS seabass hatchery (Figure 1). These fish were categorized into four groups according to their weight. These groups are named Large Group (L), Medium Group (M), Small Group -01 (S-1) and Small Group -02 (S-2). The Large Group contains 08 fish in a tank with an average weight of 3.96 kg. The Medium Group contains 11 fish in a tank with an average weight of 2.48 kg, the Small group (01) contains 14 fish in a tank with an average weight of 1.61 kg and the Small Group (02) contains 19 fish in a tank with an average weight of 0.99 kg. The length and weight of these fish are given below respectively. Those being fed chopped squid/flat fish/ sardin/Bata fish daily as feed at ad libitum.



Figure 1. Seabass rearing in RAS

Table 1. Length & weight of Asian seabass reared in broodstock tank-03 (L)

Sl. no.	Length (cm)	Weight (g)
1	70	4400
2	71	4300
3	71	4873
4	67	4040
5	65	3736
6	62	3280
7	63	3500
8	60	3590
Mean	66.13 cm	3965

Table 2. Length & weight of Asian seabass reared in broodstock brood stock tank-02 (M)

Sl. no.	Length (cm)	Weight (g)
1	60	2876
2	61	3200
3	58	2200
4	59	2100
5	63	2500
6	58	2000
7	59	2400
8	63	3000
9	59	2500
10	54	2000
11	59	2600

Table 3. Length & weight of Asian seabass reared in broodstock tank-04 (S-1)

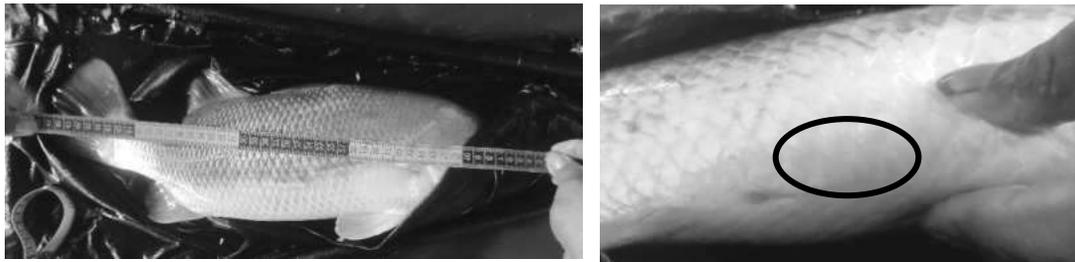
Sl. no.	Length (cm)	Weight (g)
1	57	1600
2	60	1800
3	53	1506
4	52	1738
5	50	1318
6	50	1338
7	52	1586
8	50	1398
9	51	1600
10	53	1718
11	52	1540
12	53	2046
13	52	1636
14	52	1836
Mean	52.6	1618.6

Table 4. Length & weight of Asian seabass reared in broodstock tank-01 (S-2)

Sl. no.	Length (cm)	Weight (g)
1	46	988
2	50	1034
3	53	1300
4	48	1130
5	47	1200
6	47	1176
7	43	925
8	45	1070
9	50	1280
10	51	1100
11	49	1136
12	45	1220
13	47	1026
14	47	1000
15	39	600
16	39	816
17	37	660
18	41	750
19	33	460

Experiment 2: Assessment of the reproductive biology of cultured seabass

Morphological study was done to assess the reproductive biology of Asian Seabass. Sampling was done once in two months to determine their growth and gonadal development. Among the 52 fish, it was found that 08 fish were adult, 11 fish were sub-adult and rest were immature.

**Figure 2.** Regular Sampling and Adult Asian Seabass**Water quality parameters**

The water quality parameters monitored daily i.e. temperature, salinity, pH, DO and ammonia-nitrogen ($\text{NH}_3\text{-N}$) in RAS (Table 2). Daily water quality assessments were done between 8.00 h and 9.00 AM. The Average Water Quality Parameters of four tanks are shown in Table 2.

Table 2. Mean values of water quality parameters in RAS

Tank no.	Temp. ($^{\circ}\text{C}$)	Salinity (ppt)	$\text{NH}_3\text{-N}$ (mg/L)	pH	DO (mg/L)
1	30 ± 1	16 ± 1	0.25 ± 0.1	8 ± 0.5	7 ± 1
2	31 ± 1	20 ± 1	0.25 ± 0.1	8 ± 0.5	6 ± 1
3	31 ± 1	25 ± 1	0.50 ± 0.1	7.5 ± 0.5	6 ± 1
4	30 ± 1	16 ± 1	0.50 ± 0.1	8 ± 0.5	6 ± 1

Development of mariculture practice of some important fin fishes (Seabass, Mullet) in the South-East Coast of Bangladesh

Researchers

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Objectives

- To evaluate the production and survivability of different initial size groups of seabass in an open seawater floating cage culture system
- To develop the three-tier open sea water floating cage culture system of Asian seabass for economic viability
- To optimize the nutritional requirements of seabass fingerlings in an indoor rearing system

Achievements

Study-1: Evaluation of the production and survivability of different initial size groups of seabass in an open seawater floating cage culture system

Cage preparation

A total of 06 circular cages have been prepared with double-layered, knotless nets, 12 plastic drums per cage for better bouncy. Mooring (9ft long, 3.5-inch diameter) has been done to resist the stronger tidal and wave action.

The details of the fixed net cages were as follows-

- **Shape:** Round
 - **Inner Diameter:** 4.8 meters
 - **Outer Diameter:** 5.25 meters
 - **Depth:** 1.3 meters
 - **Frame:** 110 mm HDPE Pipe were used
 - **Body Net:** Nylon net 40 mm Mesh size was used
 - **Cover Net:** Nylon net 20mm Mesh Size was used
 - **Float:** Concealed Plastic drums-Length 990 mm were used
 - **Rope:** Green fabricated Nylon 1.5inch diameter thick rope used for mooring
 - **Mooring:** 4 nos. of 50 kg weighted mooring were used for fixing the cage
-
- ✓ **Experimental Species:** Seabass (*Lates calcarifer*)
 - ✓ **Experimental Design:** Completely Randomized Design (CRD)
 - ✓ **Experimental Duration:** 4 Months
 - ✓ **Stocking Density:** 70 ind./cage
 - ✓ **Feeding regime:** 5-8% trash fish, twice a day



Figure 1. Feeding of seabass

The data on growth and feeding gathered during the trial were summarized in Table 2. The highest weight gain percentage (%WG) was obtained in small size group, and differences were significant ($p < 0.05$) than in medium and larger-size group. There was clear declining trend in growth rate values with increasing body weight. Specific growth rate (SGR) significantly ($p < 0.05$) varies with different initial size groups of seabass fishes and higher values were found in smaller size group than the other two groups. Feed conversion ratio (FCR) values were lowest in the small group. The estimated FCR varied between 8.25 and 12.73, and differences among groups were found significant ($p < 0.05$) in favor of smaller size group. The growth performance of seabass culture in a cage appears that final biomass can be maximized at optimal stocking densities for smaller size of fish than for medium and larger fish.

In conclusion, based on the findings of the study, the initial stocking size of fish is negatively correlated to final biomass and to increase biomass per unit volume, small size fish should be stocked into floating cages at the beginning of rearing season.

Table 1. Initial whole body and final flesh proximate composition (on % wet weight basis) of Seabass reared in open seawater cage for 120 days.

Experimental groups ¹	Moisture	Crude protein	Lipid or ether extract	Total ash
IBC²	76.67 ± 0.25	17.09 ± 0.14	3.68 ± 0.17	3.92 ± 0.48
FFC3				
C₁	72.45 ± 0.25	21.62 ± 0.32	5.34 ± 0.47	5.97 ± 0.26
C₂	72.34 ± 0.53	21.58 ± 0.40	5.542 ± 0.31	5.89 ± 0.17
C₃	72.65 ± 0.41	21.72 ± 0.25	5.41 ± 0.29	5.22 ± 0.31
p-value	0.721	0.626	0.572	0.716

Data are expressed as mean (n=3)

Mean values in the same column with different superscripts differ significantly ($p < 0.05$)

¹C₁. initial smaller size group; C₂- initial medium size group; C₃ - initial larger size group;

²IBC, initial body composition; ³FFC, final flesh composition

Table 2. Final Growth increment of different initial size groups of seabass reared in open sweater cages for 120 days

Parameters	Cage (C ₁)	Cage (C ₂)	Cage (C ₃)
Initial weight (g)	30.13 ^a ± 0.15	50.30 ^b ± 1.02	70.35 ^c ± 0.24
Final weight (g)	439.37 ^a ± 8.82	476.34 ^b ± 8.62	505.28 ^b ± 8.62
Weight gain (g)	409.24 ± 8.69	426.04 ± 9.58	434.93 ± 9.08
% Weight gain	1358.22 ^c ± 23.53	848.36 ^b ± 35.53	618.27 ^a ± 13.28
SGR	1.49^c ± 0.01	1.25 ^b ± 0.02	1.10 ^a ± 0.01
FCR	8.25^a ± 0.6	9.87 ^a ± 0.43	12.73 ^b ± 0.35

Study-2: Development of three-tier open sea water floating cage culture system of Asian seabass for economic viability

Cage preparation

A total of 06 rectangular cages have been prepared with double-layered fine-meshed nets, plastic drums, and bamboo poles. Mooring (9ft long, 3.5-inch diameter) has been done to resist the stronger tidal and wave action.

The details of the fixed net cages were as follows-

- **Shape:** Rectangular
 - **Depth:** 1.00 meter
 - **Frame:** Bamboo poles were used
 - **Float:** Concealed Plastic drum-Length 990 mm were used
 - **Rope:** Green fabricated Nylon 1.5inch diameter thick rope used for mooring
 - **Mooring:** 4 nos. of 50 kg weighted mooring were used for fixing the cage
- ✓ **Experimental Species:** Seabass (*Lates calcarifer*)
 - ✓ **Experimental Design:** Completely Randomized Design (CRD)
 - ✓ **Experimental Duration:** 4 Months
 - ✓ **Stocking Density:** 20 ind./cage
 - ✓ **Feeding:** 5-8% marine trash fish, 5-8% chopped tilapia fish and 5-8% formulated shrimp feed
 - ✓ **Feeding Frequency:** twice a day



Figure 2. Nursery Hapa

After acclimatization 120 fish (avg. b. wt. 6.50 ± 0.52 g) were arbitrarily dispersed in three experimental groups with two replications in three times. But, in every case only one or two fish were alive in each hapa for only three to four days due to the highly cannibalistic nature of seabass. That's why we did not get any scientific record according to the expected outcome. In conclusion further similar studies will be required to get a better outcome.

Study-3: Optimization of nutrient requirements of seabass fingerlings in the indoor rearing system

I. Optimization of protein requirements of seabass fingerlings

Experimental diet formulation and preparation

Semi-purified ingredients were used for formulation (Table-3) and preparation of four iso-lipidic (8% CL), iso-caloric (380 kcal digestible energy/100g) and hetero-nitrogenous (35-50% CP) semi-purified experimental diets viz., CP₃₅ (35% protein), CP₄₀ (40% protein), CP₄₅ (45% protein) and CP₅₀ (50% protein). All the ground ingredients except oils, and vitamin-mineral mixture were mixed uniformly followed by the addition of the required quantity of water to form a dough, which was then kept in a heat-resistant plastic bag and pressure-cooked under steam for 25 min. After cooling, the rest of the raw materials were added and dough prepared after thorough mixing was then hand pressed through a pelletizer to prepare 1 mm diameter pellets. After that, the pellets were dried at room temperature for one day followed by oven drying at 40°C until achieving around 10% of the moisture level. The dried pellets were then broken to adjust with the mouth size of the experimental fish followed by packaging polythene bags, labeling and storage at 4°C until used for feeding.

Experimental facilities and feeding trial

After acclimatization, 240 fish (avg. b. wt. 1.50 ± 0.02 g) were arbitrarily dispersed in four experimental groups such as CP₃₅, CP₄₀, CP₄₅ and CP₅₀ with three replicates under each according to a completely randomized design (CRD). Fifteen fish were stocked in each circular tank (100 L water volume). Respective diets were used for feeding the fish two times per day (10.00 and 18.00 h). Fortnightly, the body weight was checked to adjust the feeding rate.

Initial whole-body moisture, protein, lipid and ash contents of fish were 75.41, 16.99, 3.98 and 3.85%, respectively (Table-3). Though no significant variation ($p > 0.05$) was found for final whole-body moisture, crude protein and ash content, whole body lipid of fish were significantly ($p < 0.05$) affected concerning dietary protein levels (Table-4). Significantly highest and lowest whole-body lipid content ($p < 0.05$) were found in CP₃₅ and CP₄₀ groups respectively whereas CP₄₀ was statistically similar ($p > 0.05$) to the CP₅₀ group.

Growth performances such as FBW, WG and SGR were affected by dietary protein and showed insignificant ($p > 0.05$) increasing trend with increasing protein up to 45% protein level then decreased with increased protein level in diet. FCR and PER of Seabass juveniles were affected significantly ($p < 0.05$) concerning graded level of CP in the diet (Table-5). There was a significantly ($p < 0.05$) decrease of FCR with enhancing dietary protein up to 45% level and then increased ($p < 0.05$) with the further increase in protein level. Significant ($p < 0.05$) decreasing trend of PER value was observed with increasing dietary CP up to the maximum level. Based on WG, second-order polynomial regression analysis revealed that the optimum dietary crude protein requirement of Seabass juveniles under the rearing condition of 5 ppt salinity was 47.00% (Figure 3).

Table 3. Formulation and proximate composition of the experimental diets fed to Seabass juveniles cultured in saline water of 5 ppt for 60 days

Ingredients (%)	Diets (Experimental groups) ¹			
	CP ₃₅	CP ₄₀	CP ₄₅	CP ₅₀
Soybean meal	20.00	24.00	25.25	27.50
Mustard oil cake	13.90	11.00	10.00	6.00
Corn gluten meal	4.00	5.00	11.00	16.75
DORB	10.10	10.00	8.50	8.25
Casein ²	2.40	2.40	2.40	2.40
Gelatin ²	0.60	0.60	0.60	0.60
Starch ²	10.00	8.00	4.25	0.00
Dextrin ²	8.00	4.00	2.00	0.00
Wheat flour	2.50	2.50	2.50	2.50
Fish oil ³	2.25	2.25	2.25	2.25
Vegetable oil ⁴	2.25	2.25	2.25	2.25
Vit -min mix ⁵	1.50	1.50	1.50	1.50
CMC ⁶	2.50	2.50	2.50	2.50
Total	100	100	100	100
Proximate Composition (on a dry weight basis)				
Moisture (%)	8.62	8.71	8.47	8.68
Crude protein (%)	35.76	40.21	45.02	50.03
Ether extract (%)	8.30	8.21	8.63	8.69
Crude fibre (%)	5.18	5.27	5.29	5.38
Total ash (%)	2.57	2.68	2.59	2.88
NFE ⁷ (%)	48.19	43.63	38.47	33.02
GE ⁸ (kcal/100g)	434.51	435.06	441.69	446.35
DE ⁹ (Kcal/100g)	379.79	377.75	379.58	379.94
P:E ¹⁰ (mg protein/Kcal DE)	94.16	106.43	118.59	131.69

¹CP₃₅ (35% dietary crude protein), CP₄₀ (40% dietary crude protein), CP₄₅ (45% dietary crude protein), CP₅₀ (50% dietary crude protein) ²Ingredients procured from Himedia Pvt. Ltd., India; ³Procured from Seacod Oil by Sanofi India Ltd., India; ⁴Purchased from local retail shop ⁵Vitamin-mineral mixture ⁶Carboxymethyl cellulose, purchased Himedia Pvt. Ltd., India; ⁷Nitrogen free extract; ⁸Gross energy; ⁹Digestible energy; ¹⁰Protein to energy ratio.

Table 4. Whole body proximate composition (on % wet weight basis) of Seabass juveniles cultured in saline water of 5 ppt and fed with hetero-nitrogenous experimental diets for 60 days

Experimental groups ¹	Moisture	Crude protein	Lipid or ether extract	Total ash
IBC ²	75.41 ± 0.12	16.99 ± 0.04	3.98 ± 0.13	3.85 ± 0.8
FBC ³				
CP ₃₅	72.56 ± 0.15	17.94 ± 0.12	6.23 ^b ± 0.41	4.97 ± 0.06
CP ₄₀	72.82 ± 0.74	18.08 ± 0.45	5.42 ^{ab} ± 0.11	4.89 ± 0.09
CP ₄₅	72.51 ± 0.27	18.37 ± 0.15	4.98 ^a ± 0.09	4.22 ± 0.09
CP ₅₀	72.60 ± 0.12	18.15 ± 0.04	5.32 ^{ab} ± 0.16	4.33 ± 0.10
<i>p</i> -value	0.421	0.326	0.005	0.716

Data are expressed as mean (n=3)

Mean values in the same column with different superscripts differ significantly (p<0.05)

¹CP₃₅-CP₅₀, 35-50% dietary crude protein

²IBC, initial body composition; ³FBC, final body composition

Table 5. Growth and nutrient utilization of Seabass juveniles cultured in saline water of 5 ppt and fed with hetero-nitrogenous experimental diets for 60 days

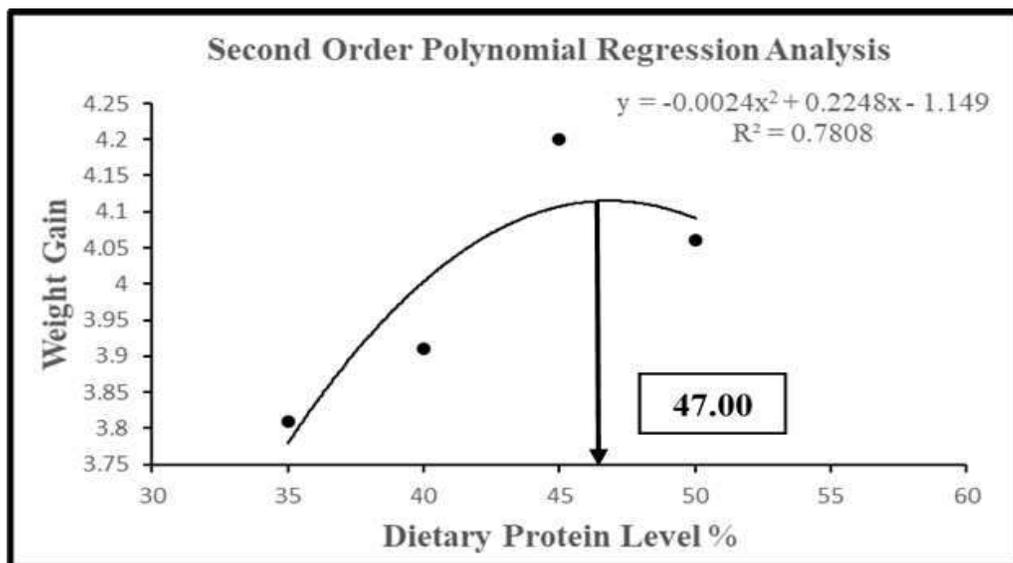
Experimental groups ¹	IBW ² (g)	FBW ³ (g)	WG ⁴ (g)	SGR ⁵ (%/day)	FCR ⁶	PER ⁷
CP ₃₅	1.36 ± 0.02	5.17 ± 0.04	3.81 ± 0.05	2.23 ± 0.03	5.20 ^b ± 0.12	28.51 ^c ± 0.63
CP ₄₀	1.40 ± 0.03	5.31 ± 0.05	3.91 ± 0.03	2.22 ± 0.03	4.84 ^{ab} ± 0.06	27.79 ^c ± 1.71
CP ₄₅	1.30 ± 0.04	5.50 ± 0.22	4.20 ± 0.25	2.41 ± 0.11	4.47 ^a ± 0.24	21.04 ^b ± 0.44
CP ₅₀	1.42 ± 0.02	5.48 ± 0.08	4.06 ± 0.10	2.25 ± 0.04	4.55 ^a ± 0.09	18.35 ^c ± 0.24
<i>p</i> -value	0.058	0.257	0.274	0.191	0.028	<0.001

Data are expressed as mean (n=3)

Mean values in the same column with different superscripts differ significantly (p<0.05)

¹CP₂₀-CP₅₀, 20-50% dietary crude protein

²IBW, Initial body weight; ³FBW, Final body weight; ⁴WG, weight gain; ⁵SGR, specific growth rate; ⁶FCR, feed conversion ratio; ⁷PER, protein efficiency ratio

**Figure 3.** Second order polynomial regression analysis

II. Optimization of lipid requirements of seabass fingerlings

Experimental diet formulation and preparation

Semi-purified ingredients were used for formulation (Table-6) and preparation of four iso-nitrogenous (47% CP), and hetero-lipidic (3-12% CL) semi-purified experimental diets *viz.*, CL₃ (3% lipid), CL₆ (6% lipid), CL₉ (9% lipid) and CL₁₂ (12% lipid). All the ground ingredients except oils and vitamin-mineral mixture were mixed uniformly followed by the addition of the required quantity of water to form a dough, which was then kept in a heat resistant plastic bag and pressure-cooked under steam for 25 min. After cooling, the rest of the raw materials were added, and dough prepared after thorough mixing was then hand pressed through a pelletizer to prepare 1 mm diameter pellets. After that, the pellets were dried at room temperature for one day followed by oven drying at 40°C until achieving around 10% of the moisture level. The dried pellets were then broken to adjust with the mouth size of the experimental fish followed by packaging polythene bags, labelling and storage at 4°C until used for feeding.

Table 6. Formulation and proximate composition of the experimental diets fed to Seabass juveniles cultured in saline water of 5 ppt for 60 days

Ingredients (%)	Diets (Experimental groups) ¹			
	CL ₃	CL ₆	CL ₉	CL ₁₂
Fish meal	27.75	27.75	27.75	27.75
Soybean meal	26.50	26.50	26.50	26.50
Mustard oil cake	2.00	2.00	2.00	2.00
Corn gluten meal	14.50	14.50	14.50	14.50
DORB	10.20	10.20	10.20	10.20
Casein ²	2.40	2.40	2.40	2.40
Gelatin ²	0.60	0.60	0.60	0.60
Starch ²	5.80	4.60	2.90	1.00
Dextrin ²	3.75	2.85	1.55	0.45
Wheat flour	2.50	2.50	2.50	2.50
Fish oil ³	0.00	1.05	2.25	4.05
Vegetable oil ⁴	0.00	1.05	2.25	4.05
Vit -min mix ⁵	1.50	1.50	1.50	1.50
CMC ⁶	2.50	2.50	2.50	2.50
Total	100	100	100	100
Proximate Composition (on dry weight basis)				
Moisture (%)	8.44	8.59	8.38	8.71
Crude protein (%)	47.16	47.22	47.44	47.51
Ether extract (%)	3.62	6.14	9.27	12.14
Crude fibre (%)	5.31	5.62	5.53	5.26
Total ash (%)	2.74	2.85	2.67	2.95
NFE ⁷ (%)	41.17	38.17	35.09	32.14
GE ⁸ (kcal/100g)	417.10	428.36	444.44	460.52
DE ⁹ (Kcal/100g)	356.07	366.57	381.57	396.57
P:E ¹⁰ (mg protein/Kcal DE)	132.44	128.64	123.59	118.91

¹CL₃(3% dietary crude lipid), CL₆ (6% dietary crude lipid), CL₉ (9% dietary crude lipid), CL₁₂ (12% dietary crude lipid)

²Ingredients procured from Himedia Pvt. Ltd., India; ³Procured from Seacod Oil by Sanofi India Ltd., India; ⁴Purchased from local retail shop; ⁵Vitamin-mineral mixture; ⁶Carboxymethyl cellulose, purchased Himedia Pvt. Ltd., India; ⁷Nitrogen free extract; ⁸Gross energy; ⁹Digestible energy; ¹⁰Protein to energy ratio

Experimental facilities and feeding trial

After acclimatization, 240 fish (avg. b. wt. 1.30 ± 0.03 g) were arbitrarily dispersed in four experimental groups such as CL₃, CL₆, CL₉ and CL₁₂ with three replicates under each according to a completely randomized design (CRD). Fifteen fish were stocked in each circular tank (100 L water volume). Respective diets were used for feeding the fish two times per day (10.00 and 18.00 h). Fortnightly, the body weight was checked to adjust the feeding rate.

Initial whole-body moisture, protein, lipid and ash contents of fish were 75.68, 16.45, 3.88 and 3.98%, respectively (Table-7). Though no significant variation ($p > 0.05$) was found for final whole-body moisture, crude protein and ash content, whole body lipid of fish was significantly ($p < 0.05$) affected with dietary lipid levels and showed an increasing trend with increasing lipid content up to maximum level.

Growth performances such as FBW, WG and SGR were affected by dietary lipid and showed insignificant ($p > 0.05$) increasing trend with increasing protein up to 9% lipid level then decreased with increased lipid level in the diet. FCR and PER of Seabass juveniles were affected significantly ($p < 0.05$) with graded level of CL in the diet (Table-8). There was a significantly ($p < 0.05$) decrease of FCR with enhancing dietary lipid up to 9% level and then increased ($p < 0.05$) with the further increase in the lipid level in the diet. Significant ($p < 0.05$) increasing trend of PER value was observed about increasing dietary lipid up to CL₉ group than decreased with increased dietary lipid.

Based on WG, second-order polynomial regression analysis revealed that the optimum dietary crude lipid requirement of Seabass juveniles under the rearing condition of 5 ppt salinity was 10.09% (Figure 4).

Table 7. Whole body proximate composition (on % wet weight basis) of Seabass juveniles cultured in inland saline water of 5 ppt and fed with hetero-energetic experimental diets for 60 days

Experimental groups ¹	Moisture	Crude protein	Lipid or ether extract	Total ash
IBC ²	75.68 ± 0.19	16.45 ± 0.08	3.88 ± 0.17	3.98 ± 0.23
FBC³				
CL ₃	73.73 ± 0.15	18.11 ± 0.12	4.59 ^a ± 0.07	4.26 ± 0.19
CL ₆	73.52 ± 0.74	18.28 ± 0.36	5.13 ^{ab} ± 0.19	4.38 ± 0.10
CL ₉	73.41 ± 0.27	18.68 ± 0.17	5.47 ^{ab} ± 0.18	4.91 ± 0.08
CL ₁₂	72.98 ± 0.12	18.15 ± 0.04	6.21 ^b ± 0.52	4.93 ± 0.11
<i>p</i> -value	0.512	0.446	0.003	0.643

Data are expressed as mean (n=3)

Mean values in the same column with different superscripts differ significantly ($p < 0.05$)

¹CL₃-CL₁₂, 3-12% dietary crude lipid

²IBC, initial body composition; ³FBC, final body composition

Table 8. Growth and nutrient utilization of Seabass juveniles cultured in saline water of 5 ppt and fed with hetero-energetic experimental diets for 60 days

Experimental groups ¹	IBW ² (g)	FBW ³ (g)	WG ⁴ (g)	SGR ⁵ (%/day)	FCR ⁶	PER ⁷
CL ₃	1.26 ± 0.02	4.37 ± 0.04	3.11 ± 0.05	2.07 ± 0.03	6.02 ^b ± 0.15	0.35 ^a ± 0.01
CL ₆	1.30 ± 0.03	4.51 ± 0.05	3.21 ± 0.03	2.07 ± 0.03	5.56 ^{ab} ± 0.09	0.38 ^{ab} ± 0.01
CL ₉	1.20 ± 0.04	4.70 ± 0.22	3.50 ± 0.25	2.28 ± 0.12	5.05 ^a ± 0.34	0.42 ^b ± 0.03
CL ₁₂	1.32 ± 0.02	4.68 ± 0.08	3.36 ± 0.10	2.11 ± 0.05	5.17 ^a ± 0.12	0.41 ^b ± 0.01
<i>p</i> -value	0.057	0.257	0.274	0.201	0.036	0.066

Data are expressed as mean (n=3)

Mean values in the same column with different superscripts differ significantly ($p < 0.05$)

¹CP₂₀-CP₅₀, 20-50% dietary crude protein

²IBW, Initial body weight; ³FBW, Final body weight; ⁴WG, weight gain; ⁵SGR, specific growth rate; ⁶FCR, feed conversion ratio; ⁷PER, protein efficiency ratio.

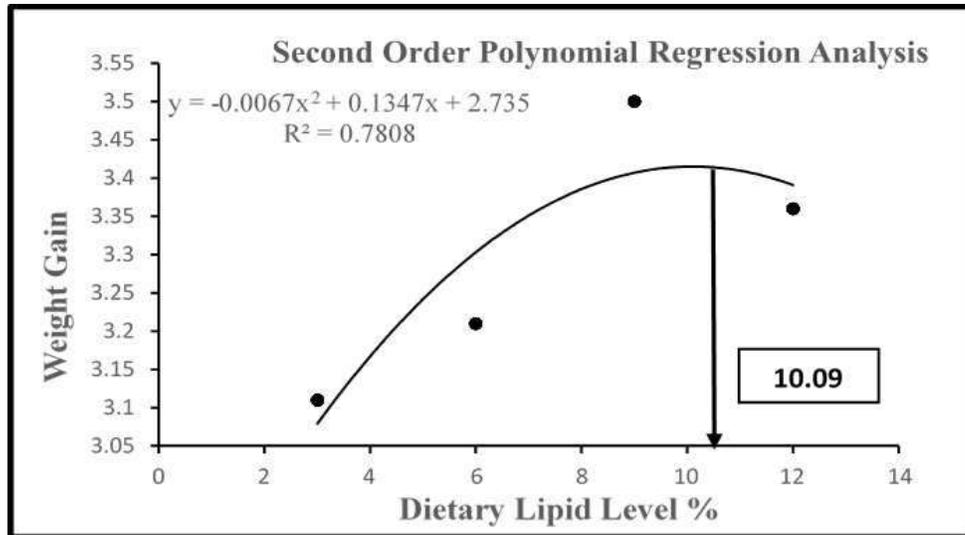


Figure 4. Second order polynomial regression analysis

Breeding and Culture Potential of Marine Oyster and Green mussel in the Bay of Bengal Bangladesh coast

Researchers

Md. Rayhan Hossain, Senior Scientific Officer
 Dr.Mritunjoy Paul, Senior Scientific Officer
 Ahmad Fazley Rabby, Senior Scientific Officer
 Saima Sultana Sonia, Scientific Officer

Objectives

- To estimate CD (Condition Index) and MI (Maturity Index) of Oyster.
- To study gonadal histology of Oyster.
- To develop culture techniques of oyster and green mussel in Cox's Bazar and other suitable areas.
- To develop breeding techniques of oyster in captivity.
- To develop larval rearing and nursery management techniques of oyster.

Achievements

Experiment-1. Estimation of CI (Condition Index) and MI (Maturity Index) of oyster

Condition index (CI) is the most widely used quantitative method for estimating the reproductive activity of marine bivalves. Average monthly variations in the mean condition index (CI) of *Crassostrea belcheri* are presented in Table 1.

Table 1. Condition index (mean± SD) of analyzed samples of *C. belcheri* recorded during the study period

Month	Condition Index (mean ± SD)
July, 2022	2.1± 0.53
August, 2022	1.9± 0.53
September, 2022	2.86± 0.36
October, 2022	3.16± 0.18
November, 2022	2.11± 0.23
December, 2022	1.35± 0.16
January, 2023	1.45± 0.21
February,2023	1.55± 0.31
March,2023	2.32 ± 0.90
April, 2023	3.41 ± 0.75
May, 2023	3.05 ± 0.35
June, 2023	2.45 ± 0.54

The maximum value of CI indicates the major peak season. From the study maximum value was recorded in October 2022 (3.16 ± 0.18) and April, 2023 (3.41 ± 0.75), respectively which indicates the peak breeding season of oyster, *C. belcheri*. As well as a sharp decline in CI of *C. belcheri* was evident in December (1.35 ± 0.16) Figure 1.



Plate-01: Oyster soft tissue



Plate-02 : Soft tissue weight

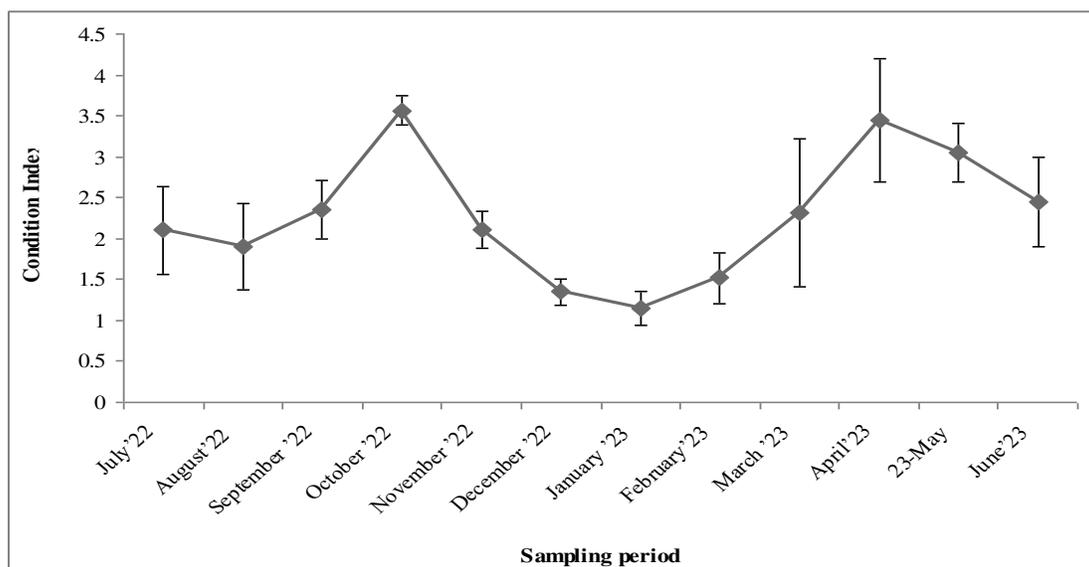


Figure 1. Monthly condition index (mean± SD) of *C. belcheri* recorded during study period.

Average monthly variations in the mean maturity index (MI) of *C. belcheri* are presented in Table 2.

Table 2. Recorded maturity index of analyzed samples of *C. belcheri* during study period.

Month	Maturity index
July, 2022	3.1
August, 2022	3.0
September, 2022	4.2
October, 2022	2.6
November, 2022	3.5
December, 2022	3.6
January, 2023	3.4
February, 2023	3.6
March, 2023	4.1
April, 2023	3.0
May, 2023	3.1
June, 2023	3.4

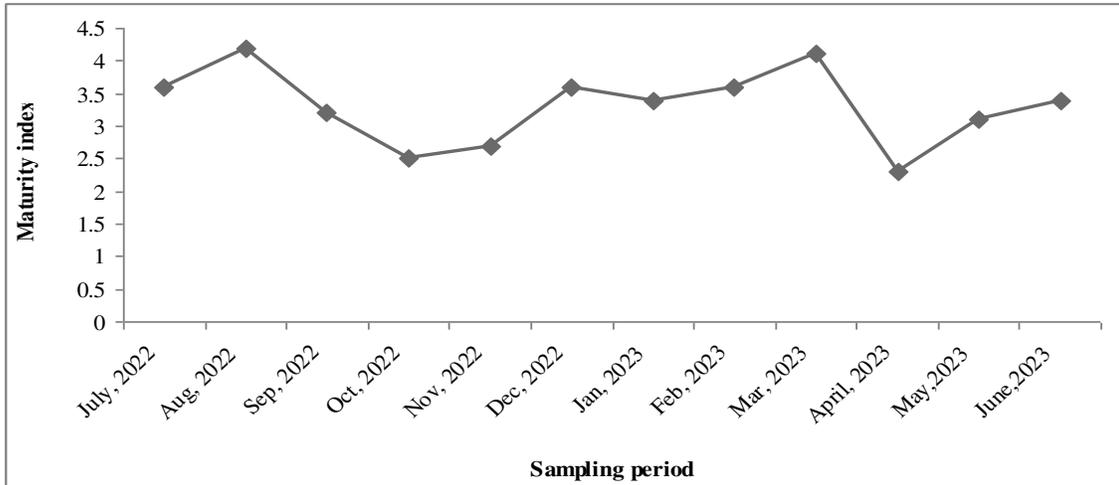


Figure 2. Maturity index of analyzed samples of *C. belcheri* during study period.



Plate 3. Solution preparation for histological slide.



Plate 4. Waxing of histological tissue.

From the study maximum value of MI was recorded in September, 2022 (4.2) and March, 2023 (4.1), respectively indicates the peak breeding season. So, peaks of *C. belcheri* species was observed in September and March. As well as a sharp decline in MI of *C. belcheri* was evident in October, 2022 (2.6) Table 2 and Figure 2.

Experiment-2. Observation of gonadal histology of Oyster

For the development of breeding technology of oyster gonad histology was compiled to observe gonadal maturity. Live oysters were collected from Sonadia, Chowfaldandi and Kutubdia of Cox’sbazar every month. Gonadal development is being monitored regularly to take the necessary step for breeding purposes. For this, we sacrificed oysters every month, took gonads apart and preserved them in Davidson’s fixative. After collecting a bunch of oyster gonad samples we then started the histological procedures consists of some steps like tissue processing, embedding, trimming, sectioning, staining, mounting, microscopic observation etc.

For developing the breeding program of oysters we collected 10 broods from wild sources, specifically from Inani Beach, Kutubdia and Moheskhal channel. Then the oyster brood was dissected to collect the gonads for artificial breeding. After that, gonads are stripped into a transparent water jar and mixed all the stripped materials for fertilization but we didn’t get any successful results. Besides that, we preserved some parts of the gonad for histological studies from July, 2022 to June, 2023. Early developing oysters appeared in July –September and November-December, in the year 2022. On the other hand, in the year

2023, early- developing oysters appeared in January-February. Late-developing oysters occurred from November, 2022-February, 2023. Ripe oysters occurred from July-October, 2022 and was absent from November-December, 2022 and January-February, 2023. Spawning commenced in July-October, 2022 and April, 2023 as evidenced by the presence of spawning oysters in the histological preparations. There was a single prolonged spawning season from July to October, 2022 with spawning peak in October, 2022 and April, 2023. The absence of spawning oysters from November, 2022 to March, 2023 showed that no spawning activity took place during these months. Spent oysters occurred from July to October, 2022 and April 2023. The undifferentiated stage as a preparatory step for the next spawning season was reported during September, 2022-April, 2023. The number of male oysters was very poor than the female oysters (Table 3).

Table 3. Number of oysters (male and female) in different stages of gonadal maturation from July, 2022-June, 2023

Month	Total	Male	Female	ED	LD	Ripe	SW	Spent	UN
July, 22	10	1	9	1	3	2	2	2	0
August, 22	10	2	8	3	1	2	3	1	0
September, 22	10	2	7	2	3	4	0	0	1
October, 22	10	2	7	0	1	2	4	2	1
November, 22	10	0	9	4	5	0	0	0	1
December, 22	10	2	4	2	4	0	0	0	4
January, 23	10	2	5	4	3	0	0	0	3
February, 23	10	0	8	3	5	0	0	0	2
March, 23	10	1	7	2	3	3	0	0	2
April, 23	10	1	7	0	2	2	4	1	1
May, 2023	10	1	6	0	1	1	2	3	3
June, 2023	10	1	7	0	2	2	2	2	2

*ED= Early developing, LD= Late developing, SW= Spawning, UN= Undifferentiated

Experiment-3. To develop culture techniques of oysters and green mussels in Cox's Bazar and other suitable areas

A. Outdoor culture system

The experiment was carried out in open water floating structures such as the raft culture system at Maheshkhali channel for 06 months. Two different culture methods were followed for developing the culture technique of oysters and green mussels *i.e.* (a) off-bottom culture and (b) bottom culture method.

(I) Off -bottom culture method

Off-bottom culture methods were followed due to rough wave action in sea. The experimental structure was setup with three different substrates: Plastic fruit basket, plastic tray and plastic net bag. Three different stocking densities of oyster and green mussel were laid on trays and allowed to grow until marketable size. Sampling of oysters and green mussels were done once a month.

(II) Bottom culture method

Bottom cultures also were implemented with three cultures substrates: Plastic tray, Bamboo tray and net bag tray. Experimental design was same as off -bottom culture method. Sampling was done monthly.

B. Indoor culture system

The growth performance of the green mussel and the oysters with seaweed in the polyculture system were measured under indoor condition. In the hatchery, three 1000L tanks were used for the rearing of green mussel and oyster. Three different stocking densities of oysters and green mussel were allowed to grow until marketable size. Oyster and green mussel growth sampling was done monthly.

A. Outdoor culture system

I. Off-bottom raft culture

Green mussel (*Perna viridis*)

Initially 30.12±1.15 g green mussels were stocked in different culture substrates such as fruit baskets, plastic trays and plastic net bags. After the last sampling of the experiment, higher final weights (80.16±2.94 g) were found in T₁ (Fruit basket substrate) followed by T₂ (76.59±4.18 g) and T₃ (70.56±3.28 g) (Table 4). Comparatively mean highest final weight was found in T₁ (84.16±1.14 g) than in T₂ (79.19±3.19 g) and T₃ (70.56±3.28 g) groups where green muscle cultured in plastic tray substrate (Table 5). However, plastic net bag substrates with higher final weight were found in T₁ (81.16±1.14g) followed by T₂ (80.89±2.19 g) and T₃ (78.26±2.28 g) respectively (Table 6). Among the three culture substrates significantly higher yield was observed in net bag substrate.

Table 4. Growth, survival and yield of green mussels under different stocking densities in fruit basket substrate.

Green mussel	Fruit basket substrate			Significance	CV (%)	p-value
	T ₁ (50 nos.)	T ₂ (70 nos.)	T ₃ (90 nos.)			
Initial weight(g)	30.11± 1.12 ^a	30.12± 1.13 ^a	30.14± 1.16 ^a	NS	2.17	0.185
Final weight(g)	80.16±2.94 ^a	76.59±4.18 ^b	70.56±3.28 ^c	*	4.44	0.012
Survival rate (%)	90.78±5.55 ^a	87.16±4.16 ^a	85.88±3.81 ^a	NS	6.58	0.066
Yield (kg/m ²)	14.43±1.24 ^c	18.73±1.32 ^b	21.74±5.02 ^a	*	2.38	0.013

Table 5. Growth, survival and yield of green mussels under different stocking densities in Plastic tray substrate

Green mussel	Plastic tray substrate			Significance	CV (%)	p-value
	T ₁ (12 nos.)	T ₂ (15 nos.)	T ₃ (18 nos.)			
Initial weight(g)	31.21± 1.15 ^a	30.52± 1.14 ^a	32.14± 1.25 ^a	NS	1.57	0.281
Final weight(g)	84.16±1.14 ^a	79.19±3.19 ^b	76.56±3.28 ^c	*	3.24	0.013
Survival rate (%)	95.78±2.35 ^a	88.12±2.17 ^a	85.88±3.81 ^a	NS	4.18	0.056
Yield (kg/m ²)	03.7±0.24 ^c	04.75±0.82 ^b	06.74±3.01 ^a	*	1.18	0.011

Table 6. Growth, survival and yield of green mussels under different stocking densities in Plastic net bag substrate

Green mussel	Plastic net bag substrate			Significance	CV (%)	p-value
	T ₁ (12 nos.)	T ₂ (18 nos.)	T ₃ (25 nos.)			
Initial weight(g)	31.51± 1.15 ^a	31.22± 1.13 ^a	32.14± 1.21 ^a	NS	1.57	0.281
Final weight(g)	81.16±1.14 ^a	80.89±2.19 ^b	78.26±2.28 ^c	*	3.24	0.013
Survival rate (%)	91.66±2.35 ^a	88.88±5.55 ^a	87.88±3.81 ^a	NS	3.18	0.143
Yield (kg/m ²)	03.71±0.24 ^c	05.17±0.82 ^b	06.88±1.01 ^a	*	1.13	0.016



Plate 5. Green mussel sampling



Plate 6. Green mussel sampling data collection

Oyster (*C. belcheri*)

At the beginning of the experiment, 50.72±1.65 g weights of the oysters were stocked in fruit baskets, plastic trays and plastic net bags. At the end of the experiment, the highest final weight of oyster was found in T₁ (75.26±0.53 g) followed by T₂ (72.45±3.17g) and T₃ (70.22±4.03 g) in fruit basket substrate systems (Table 7). When considering plastic tray substrate, the highest growth was found in T₁ (78.12±3.45g) followed by T₂ (75.13±3.13g) and T₃ (73.16±4.23 g) (Table 8). However, comparatively bigger oyster was found in T₁ (89.83±6.65 g) than T₂ (87.19±6.11 g) and T₃ (79.86±5.50 g) in net bag substrate culture methods (Table 9).

Table 7. Growth performance of oysters under different stocking densities in fruit basket substrate

Oyster	Fruit basket substrate			Significance	CV (%)	p-value
	T ₁ (15 nos.)	T ₂ (20 nos.)	T ₃ (30 nos.)			
Initial weight(g)	50.12±2.46 ^a	49.82±1.53 ^a	48.52±2.95 ^a	NS	4.17	0.175
Final weight(g)	75.26±0.53 ^a	72.45±3.17 ^b	70.22±4.03 ^c	*	2.44	0.024
Survival rate (%)	97.13±11.54 ^a	95.10±1.35 ^b	93.44±0.00 ^c	*	6.47	0.031
Yield (kg/m ²)	4.21±2.51 ^c	5.51±1.47 ^b	7.86±1.39 ^a	*	3.28	0.021

Table 8. Growth performance of oysters under different stocking densities in plastic tray substrate

Oyster	Plastic tray substrate			Significance	CV (%)	p-value
	T ₁ (6 nos.)	T ₂ (8 nos.)	T ₃ (12 nos.)			
Initial weight(g)	49.12±1.51 ^a	48.22±1.53 ^a	50.12±1.51 ^a	NS	1.16	0.062
Final weight(g)	78.12±3.45 ^a	75.13±3.13 ^b	73.16±4.23 ^c	*	1.12	0.025
Survival rate (%)	96.88±4.81 ^a	95.74±3.20 ^a	94.50±4.00 ^a	NS	5.58	0.046
Yield (kg/m ²)	1.56±0.04 ^c	2.15±0.61 ^b	3.24±1.15 ^a	*	1.48	0.029

Table 9. Growth performance of oysters under different stocking densities in net bag substrate

Oyster	Net bag substrate			Significance	CV (%)	p-value
	T ₁ (12 nos.)	T ₂ (18 nos.)	T ₃ (25 nos.)			
Initial weight(g)	48.82±2.01 ^a	47.82±4.51 ^a	48.18±0.55 ^a	NS	2.15	0.091
Final weight(g)	89.83±6.65 ^b	87.19±6.11 ^a	79.86±5.50 ^c	*	5.29	0.029
Survival rate (%)	96.66±1.54 ^a	94.56±2.56 ^a	93.66±5.46 ^a	NS	11.59	0.047
Yield (kg/m ²)	3.91±1.02 ^c	5.23±0.12 ^b	7.34±2.14 ^a	*	2.32	0.034



Plate 7. Oyster stoking in fruit basket



Plate 8. Oyster stoking in fruit basket



Plate 9. Oyster stoking in fruit basket

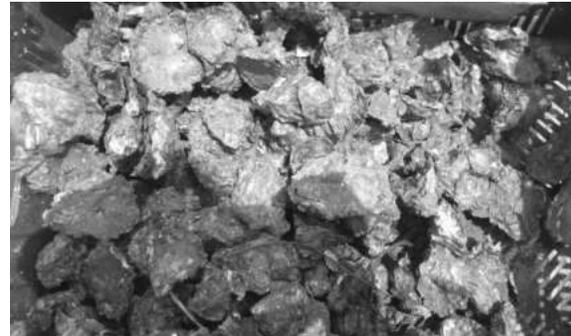


Plate 10. Oyster population

II. Bottom culture

Bottom cultures were implemented into three cultures substrates: plastic trays, bamboo trays and net bag trays. Oysters and green mussels were suspended from floating structures such as raft. Oysters and green mussel were held in tray. The rafts can be any shape and plastic oil drums were used as float of the raft. Different stocking densities of oysters and green mussels were laid on trays and allowed to grow until marketable size. Oyster and green mussel growth were sampled monthly basis.

Green mussel (*Perna viridis*)

Initially, 30.11±1.35 g, green mussels were stocked in different culture substrates such as plastic trays, bamboo trays and net bag trays. After the last sampling of the experiment, highest final weight were found in T₁ (85.16±1.14 g) followed by T₂ (80.39±3.19 g) and T₃ (78.46±4.18 g) in plastic tray substrate (Table 10). Comparatively a higher final weight were found in T₁ (83.16±1.14 g) than T₂ (74.69±3.15 g) and T₃ (71.86±2.18 g) groups where green mussel were cultured in bamboo tray substrate (Table 11). However, a superior final weight were found in T₁ (81.16±1.14 g) followed by T₂ (73.89±2.19 g) and T₃ (70.26±2.28 g) in plastic net bag substrate (Table 12). Among three culture substrates significantly higher yield was observed in bamboo tray substrate.

Table 10. Growth performance of green mussels under different stocking densities in plastic tray substrate

Green mussel	Plastic tray substrate			Significance	CV (%)	p-value
	T ₁ (12 nos.)	T ₂ (18 nos.)	T ₃ (25 nos.)			
Initial weight (g)	29.31± 2.15 ^a	31.32± 1.43 ^a	32.16± 1.45 ^a	NS	1.57	0.281
Final weight (g)	85.16±1.14 ^a	80.39±3.19 ^b	78.46±4.18 ^c	*	2.24	0.012
Survival rate (%)	95.78±2.35 ^a	90.12±2.17 ^a	88.88±2.21 ^a	NS	6.15	0.152
Yield (kg/m ²)	03.74±0.18 ^c	05.14±0.82 ^b	06.94±2.01 ^a	*	1.18	0.031

Table 11. Growth performance of green mussels under different stocking densities in bamboo tray substrate

Green mussel	Bamboo tray substrate			Significance	CV (%)	p-value
	T ₁ (40 nos.)	T ₂ (60 nos.)	T ₃ (80 nos.)			
Initial weight (g)	30.41± 2.12 ^a	32.42± 2.13 ^a	30.19± 2.36 ^a	NS	1.37	0.145
Final weight (g)	84.34±1.54 ^a	74.69±3.15 ^b	71.86±2.18 ^c	*	3.41	0.034
Survival rate (%)	98.58±2.45 ^a	96.26±4.16 ^a	95.38±2.61 ^a	NS	2.54	0.061
Yield (kg/m ²)	13.15±2.14 ^c	17.03±1.62 ^b	21.84±4.01 ^a	*	4.38	0.023

Table 12. Growth performance of green mussels under different stocking densities in plastic net bag substrate

Green mussel	Plastic net bag substrate			Significance	CV (%)	p-value
	T ₁ (20 nos.)	T ₂ (30 nos.)	T ₃ (40 nos.)			
Initial weight (g)	31.61± 1.35 ^a	30.62± 1.43 ^a	29.13± 1.31 ^a	NS	1.23	0.341
Final weight (g)	83.16±1.14 ^a	73.89±2.19 ^b	70.26±2.28 ^c	*	2.24	0.023
Survival rate (%)	95.61±3.35 ^a	92.88±5.55 ^a	90.88±3.81 ^a	NS	4.28	0.123
Yield (kg/m ²)	07.31±0.54 ^c	07.90±0.68 ^b	10.11±1.05 ^a	*	1.23	0.018

Table 13. Growth and production of oysters under different stocking densities in bamboo cage substrate

Oyster	Bamboo cage substrate			Significance	CV (%)	p-value
	T ₁ (12 nos.)	T ₂ (15 nos.)	T ₃ (18 nos.)			
Initial weight(g)	52.22±2.51 ^a	49.23±1.54 ^a	52.32±2.31 ^a	NS	1.36	0.042
Final weight(g)	79.32±2.15 ^a	76.14±4.16 ^b	74.15±3.13 ^c	*	1.15	0.018
Survival rate (%)	95.98±3.21 ^a	94.74±3.20 ^a	93.50±4.00 ^a	NS	5.58	0.046
Yield (kg/m ²)	2.85±0.21 ^c	3.35±0.32 ^b	3.85±1.25 ^a	*	1.23	0.013



Plate 11. Green mussel population



Plate 12. Green mussel weight monitoring

Oyster (*C. belcheri*)

At the beginning of the experiment, 50.12±1.35 g weights of the oysters were stocked in bamboo cages, bamboo trays and plastic net bags. At the end of the experiment, a higher final weight of oysters were found in T₁ (79.32±2.15 g) followed by T₂ (76.14±4.16 g) and T₃ (74.15±3.13 g) in bamboo cage substrate systems (Table 13). When considering bamboo tray substrate, highest growth were found in T₁

(80.16±0.33 g) followed by T₂ (78.45±3.17 g) and T₃ (72.32±4.03 g) (Table 14). However, comparatively bigger oyster were found in T₁ (86.43±2.65 g) than in T₂ (84.19±1.11 g) and T₃ (80.82±2.50 g) in net bag substrate culture methods (Table 15).

Table 14. Growth and production of oysters under different stocking densities in bamboo tray substrate

Oyster	Bamboo tray substrate			Significance	CV (%)	p-value
	T ₁ (12 nos.)	T ₂ (15 nos.)	T ₃ (18 nos.)			
Initial weight(g)	53.12±2.46 ^a	50.82±1.53 ^a	48.52±1.55 ^a	NS	3.17	0.155
Final weight(g)	80.16±0.33 ^a	78.45±3.17 ^b	72.32±4.03 ^c	*	7.44	0.026
Survival rate (%)	98.13±11.54 ^a	95.10±1.35 ^b	93.44±0.00 ^c	*	3.17	0.031
Yield (kg/m ²)	3.52±1.71 ^c	4.39±1.27 ^b	4.62±1.49 ^a	*	2.18	0.024

Table 15. Growth and production of oysters under different stocking densities in net bag substrate

Oyster	Net bag substrate			Significance	CV (%)	p-value
	T ₁ (12 nos.)	T ₂ (18 nos.)	T ₃ (25 nos.)			
Initial weight(g)	50.82±2.01 ^a	47.82±4.51 ^a	49.28±0.55 ^a	NS	2.15	0.091
Final weight(g)	86.43±2.65 ^b	84.19±1.11 ^a	80.82±2.50 ^c	*	5.19	0.023
Survival rate (%)	95.16±1.24 ^a	91.46±2.36 ^a	90.56±4.16 ^a	NS	2.59	0.042
Yield (kg/m ²)	3.81±1.02 ^c	5.38±0.32 ^b	7.11±3.14 ^a	*	2.22	0.014

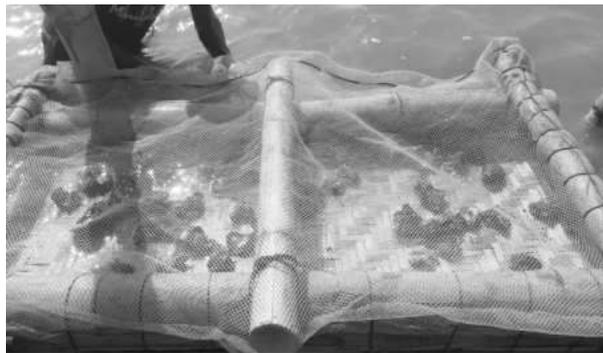


Plate 13. Bamboo tray substrate for oyster culture



Plate 14. Bamboo cage substrate for oyster culture

B. Indoor culture system

Growth performance of green mussels and the oysters, seabass (*Lates calcarifer*) with seaweed (*Ulva.sp*) in an integrated (RAS) culture system were observed under indoor condition at MFTS campus. Different stocking densities of oysters and green mussels were laid on trays and allowed to grow until marketable size.

Green mussel (*Perna viridis*)

Initially, 28.38± 1.13 g green mussels were stocked in net bag tray. After the last sampling of the experiment in net bag substrate, a higher final weight were found in T₁ (75.51±1.34 g) than that of T₂ (70.39±3.19 g) (Table 16).

Table 16. Growth performance of green mussel under different stocking densities in net bag substrate.

Green mussel	Net bag substrate		Significance	CV (%)	p-value
	T ₁ (40 nos.)	T ₂ (60 nos.)			
Initial weight (g)	28.38± 1.13 ^a	30.32± 1.23 ^a	NS	1.37	0.241
Final weight (g)	75.51±1.34 ^a	70.39±3.19 ^b	*	1.23	0.019
Survival rate (%)	80.71±.32 ^a	75.15±1.17 ^a	NS	3.15	0.146
Yield (kg/m ²)	02.64±0.38 ^c	03.16±0.42 ^b	*	1.18	0.031

Oyster (*C. belcheri*)

Initially, 50.78±1.23 g, oysters were stocked in net bag tray. Final weight were varied from 72.29±4.19 g to 75.31±1.24 g in T₁ and T₂ respectively (Table 17).

Table 17. Growth and yield of oysters at different stocking densities in net bag substrate under indoor culture

Oyster	Net bag substrate		Significance	CV (%)	p-value
	T ₁ (30 nos.)	T ₂ (40nos.)			
Initial weight (g)	50.78± 1.23 ^a	50.42± 2.23 ^a	NS	1.27	0.321
Final weight (g)	75.31±1.24 ^a	72.29±4.19 ^b	*	1.22	0.023
Survival rate (%)	85.71±.34 ^a	82.19±1.13 ^a	NS	3.15	0.124
Yield (kg/m ²)	01.85±0.32 ^c	02.34±0.42 ^b	*	1.12	0.016

Seabass

Initially, 200.78±1.23 g, size seabass (*Lates calcarifer*) were stocked in both the treatment in fiberglass tank with the substrate of net bag tray. Seabass attained the average final weight were 340.29±2.19 g in T₂ and 346.31±3.64 g in T₁ (Table 18).

Table 18. Growth of seabass at different stocking densities in fiberglass tank

Seabass	Fiberglass tank		Significance	CV (%)	p-value
	T ₁ (4 nos.)	T ₂ (6 nos.)			
Initial weight(g)	200.78± 1.23 ^a	200.82± 2.63 ^a	NS	1.27	0.321
Final weight(g)	346.31±3.64 ^a	340.29±2.19 ^b	*	1.22	0.023
Survival rate (%)	100±0.00 ^a	100±0.00 ^a	NS	3.15	0.321
Yield (kg/m ²)	01.38±0.34 ^c	01.76±0.32 ^b	*	3.48	0.023

Seaweed

Initially 500.78±2.23 g, of seaweed (*Ulva lactuca*) was stocked in the cemented tank. After the last sampling of the experiment, the final weight of seaweed were varied from 3360±1.24 g (T₁) to 3840 ±2.19 g (T₂) (Table 19).

Table 19. Growth of seaweed at different stocking densities in cemented tank

Seaweed	Cemented tank		Significance	CV (%)	p-value
	T ₁	T ₂			
Initial weight(g)	500.78± 2.23 ^a	500.42± 4.23 ^a	NS	3.27	0.121
Final weight(g)	3360±1.24 ^b	3840±2.19 ^a	*	1.22	0.023
Survival ret (%)	95.71±.62 ^a	96.18±1.34 ^a	NS	3.15	0.124
Yield kg/800L	03.36±0.32 ^c	03.84±0.32 ^b	*	2.18	0.021



Plate 15. Indoor green mussel sampling



Plate 16. Indoor oyster sampling



Plate 17. Indoor seaweed harvest



Plate 18. Indoor seabass sampling

Experiment 4. Developments of breeding techniques for oyster (*C. belcheri*) in captivity.

A. Indoor captive breeding:

Oysters of length ranging from 60-90 mm are ideal and 30% of them should be 60-75 mm in length to be sure of the presence of males. The procedure included for sex determination and ripening identification. The ripe condition has a white creamy colour with visible veining within the gonad tissue. While the poor condition one is with transparent gonad area. However, the oyster with little or no reproductive development was avoided to save time and food demand. The breeding system of oyster was proceeded in two ways.

1. Induced Spawning (Natural or chemical method)
2. Strip spawning

B. Outdoor natural close control breeding:

Off-bottom natural close control breeding was implemented in four breeding hapa with 250µ mesh net cover. Oysters were suspended from floating structures such as rafts. Oysters held in a net bag. The rafts

were floated with oil drums. Oyster was stocked at 10 individual per net bag. Oyster breeding hapa was sampled monthly.

A. Indoor captive breeding

During the histological tissue processing period striping breeding protocols were followed. Mature ova were collected but no sperm were collected. Due to improper striping process no fertilization was performed.

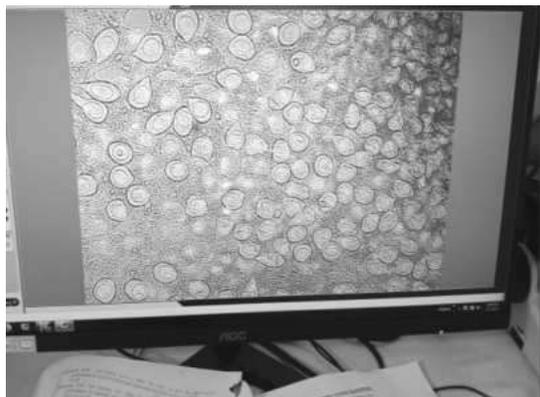


Plate 19. Mature oyster ova under microscope

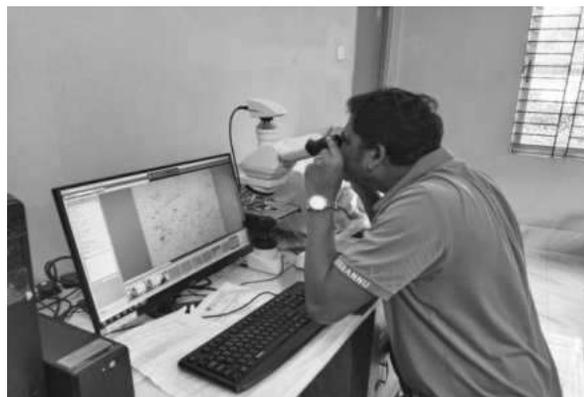


Plate 20. Microscopic observation of ova and sperms

B. Outdoor natural close control breeding:

Off-bottom natural close control breeding was started in October, 2022 and fortnightly monitoring of oyster spat was done. During the spat monitoring period oyster spat were found in January, 2023.



Plate 21. Oyster breeding hapa



Plate 22. Oyster spat observation in breeding hapa

Experiment 4: Development of larval rearing techniques of oyster (*Crassostrea belcheri*)

A. Up-welling system in an indoor environment

A closed recirculation system was designed for breeding and determined the effect of substrate conditioning on larval settlement and spat growth of oyster, *Crassostera sp.* The system consisted of a submersible pump, a 1,200 L fiberglass tank (dimensions 1.06 m × 2.13 m × 0.76 m) was used to hold setting units, a 105 L fiberglass tank (dimensions 50 cm × 70 cm × 30 cm) was used for food storage, and 10 sets of fiberglass tanks (diameter 25 cm × high 36 cm) was used as setting units. A screen with a mesh size of 180 µm was fixed by a fiberglass clamp to the bottom of each fiberglass tank.

B. Spat monitoring from wild condition

For the collection of spat, 4 types of materials such as tiles, kortal, bolder and oyster shells were used. Spat collectors hang from the raft (each with a 10-12 cm gap) having 1.5 m length. After the settlement of rope materials, regular monitoring was done to observe the spat frequency rate for every 15-day interval and water quality data were recorded. Different spat collectors of oysters and green mussels were hung under raft. After the setting of the spat collector fortnightly regular monitoring was done to observe spat settlement. Water quality data were also recorded fortnightly.

A. Up-welling system in indoor environment

No successful breeding was occurred so no upwelling operate.

B. Spat monitoring from wild condition

Among the four treatments, higher number of total spat were found in T₁ (51.00±2.00) followed by T₃ (42.00±2.00), T₄ (40.00±3.00) and T₂ (24.00±3.00).

Table 20. Different spat collectors of oysters and green mussels were stocked under a floating raft.

Spat collector	Average oyster spat/unit	Average green mussel spat/unit	Total spat/unit
T ₁ (Tiles)	16±1.00	35±2.00	51±2.00
T ₂ (Bolder)	14±2.00	10±2.00	24±3.00
T ₃ (Kortal)	17±3.00	25±3.00	42±2.00
T ₄ (Oyster shell)	30±2.00	10±1.00	40±3.00



Plate 23. Spat collector (Kortal)



Plate 24. Spat collector (Tiles)



Plate 25. Spat collector (Bolder)



Plate 26. Spat collector (oyster shell)

Domestication and Breeding of Blue swimming crab (*Portunus pelagicus*) and Horseshoe Crab (*Tachypleus* sp.) of the Bay of Bengal, Bangladesh

Researchers

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Turabur Rahman, Scientific Officer

Zahidul Islam, Scientific Officer

Objectives

- To study the food and feeding habit and reproductive biology viz; fecundity, gonadosomatic index (GSI), egg diameter, sex ratio of Blue Swimming Crab (*Portunus pelagicus*) and Horseshoe Crab (*Tachypleus* sp.)
- Domestication of the Blue Swimming crab (*Portunus pelagicus*) and Horseshoe Crab (*Tachypleus gigas*) broodstock under captive/ hatchery conditions
- To develop breeding technology of Blue Swimming Crab (*P. pelagicus*) and Horseshoe Crab (*T. gigas*) in captive/ hatchery conditions
- To develop larval, nursery and grow-out management techniques of Blue Swimming Crab

Achievements

Experiment 1: Studying the food and feeding habit and reproductive biology viz; fecundity, gonadosomatic index (GSI), egg diameter, sex ratio of the Horseshoe Crab and Blue Swimming crab

We examined the batch fecundity of female Blue Swimming crabs (*Portunus pelagicus*) that were collected monthly at landing sites from December 2022 to June 2023, calculated the relationships with body size, egg mass and month of the year and determined the size at which females became potentially reproductive in the population inhabiting Cox's Bazar (Bay of Bengal). Fecundity values ranged from 309,468 to 536,355 nos. To study the GSI of Blue swimming crab, that was purchased from BFDC fish landing center, Cox's Bazar and then calculated. At the length of 8.7cm of carapace length of the crabs, the highest GSI value was observed (Figure 2) which refers at the carapace length most of the blue swimming crabs are sexually mature.

The gut content of the blue swimming crabs was observed and intended to know food and feeding habits which will help to rear crablets in nursery and grow-out phases. Molluscan and fish remaining were the major food groups that were isolated from the gut of the crab. Crabs usually like bivalves, shrimps, small fishes etc.

Horseshoe crabs are so important for nature and for blood collection, other species around the world are in a vulnerable state. To fulfill this objective specimen should be sacrificed. So, it was done otherwise and only literature was followed.

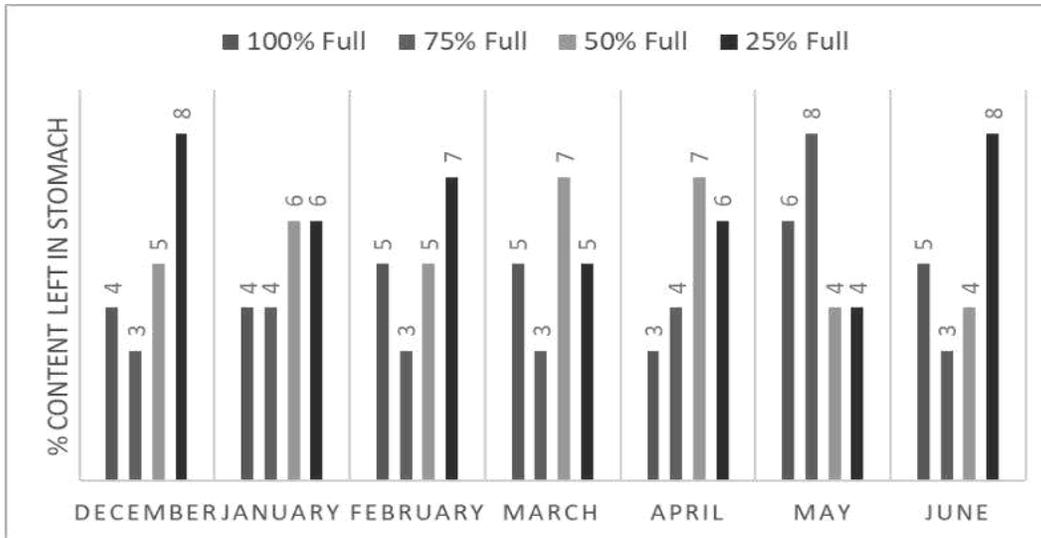


Figure 1: Gut content analysis of Blue Swimming Crab

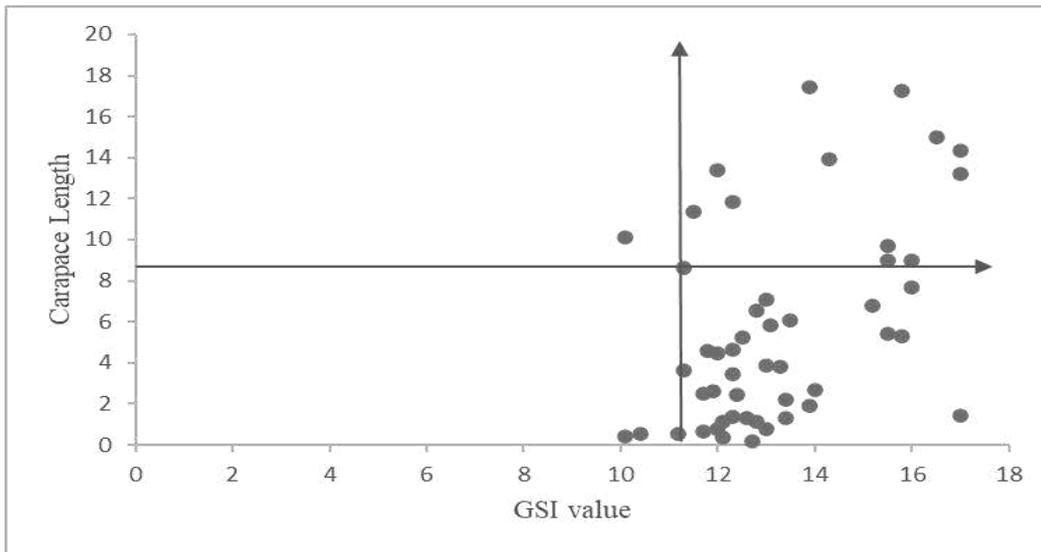


Figure 2: Relation of GSI with Carapace length of Blue swimming crab

Table 1. Monthly gut content remained in Crabs

Months	Major Food group	2nd most remanning
December	Molluscan remains	Fish remaining
January	Molluscan remains	Fish remaining
February	Molluscan remains	Fish remaining
March	Fish remaining	Molluscan remaining
April	Fish remaining	Miscellaneous
May	Miscellaneous	Fish remaining
June	Miscellaneous	Molluscan remaining

Experiment 2: Domestication of Blue Swimming crab (*P. pelagicus*) and Horseshoe Crab (*Tachypleus sp*) under captive/hatchery conditions.

Domestication of Horseshoe crab is being under processed, about 3 types of habitats had been modified as habitat where the first type was the sandy bottom habitat, the second one was a muddy bottom, and the final habitat was a combination of sandy and muddy bottom habitat. With these types of habitats for horseshoe crab, it was observed low water quality as there was little water exchange like their natural habitat. So eventually 11 individuals of horseshoe crab died as deteriorated water quality was observed. So, the habitat was changed into a RAS system where all the crabs were in the same tank. A canister filter was used to filter the water which helped to filter out ammonia and solid waste particles coming from the uneaten food and excreta of horseshoe crabs. Horseshoe crabs were being regularly fed with bivalves and other lean fish at 3-5% of the body weight. About 29 Horseshoe crabs were collected and domesticated in MFTS Hatchery. Here 26 individuals were *C. rotundicauda* and left 3 individuals were *T. gigas*. After the domestication of those crabs 23 eggs were collected from two individuals of domesticated *C. rotundicauda* and 7 eggs were collected from one individual of *T. giga*.

A total of 35 Blue swimming crabs were collected and habituated in MFTS Hatchery. Water temperature was maintained at 25-30° C, water salinity was 30 ppt with continuous aeration and daily feeding ratio was @ 5% of body weight with fresh marine squid, bivalve (Oyster) or fish meat (Tilapia, leaf fish) alternately. A total of 27 berried female crabs were identified when the water level was reduced. Berried females were then transferred individually to a 500-liter tank with aerated seawater at 30 ppt salinity. The size of the berried crab was an average 7.5 cm carapace length and 158gm total Weight.

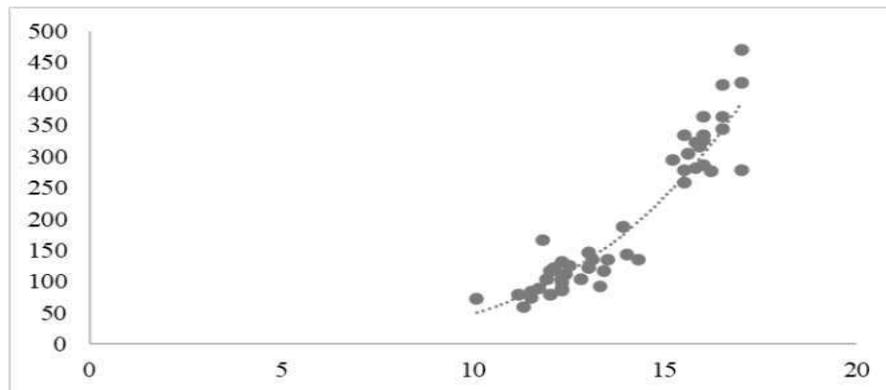


Figure 3: Length weight relationship of hatchery reared Blue swimming crab

Experiment 3: To develop breeding technology of Blue Swimming Crab (*P. pelagicus*) and Horseshoe Crab (*T. gigas*) in captive/ hatchery conditions

A total of 35 gravid brood crabs were sorted. The crabs were examined for ovarian maturity by looking through the transparent membrane between the junction of the first abdominal segment and the carapace. Mature ovaries were dark orange. De-chlorinated seawater was used for this experiment that was brought from a hatchery located in the Cox's Bazar. During the experiment, collected crabs were subjected to a bath treatment of 100µL/L of a 40% formalin solution for disinfection. After the formalin bath, every 500L fiberglass tank with sand was used for rearing brood; substrate and PVC pipes (20 cm diameter x 30 cm length) were also kept as shelters. In this system, each tank contains two crabs. Water temperature was maintained at 25-27° C, water salinity was 30ppt, and daily feeding ratio was @ 5% of body weight of fresh marine squid, bivalve or fish meat (Tilapia, leaf fish) alternately. Water quality parameters were monitored daily following standard methods and a daily management schedule was maintained for siphoning out waste material from the 500 L fibre glass tank. Eyestalk ablation was applied for selected

07 broods to spawn by a blunt scissor. After eyestalk ablation, gravid crabs were again treated in a 100 μ L/L formalin bath and then transferred to a 500 L fiber tank. About 16 crabs were used for it. In this time individual tanks were used for two crabs. Another technique was applied parallel i.e., each 3000 rectangular tanks filled with seawater contained 19 gravid crabs for early brood development. Water exchange was done weekly basis. Water temperature was maintained to 25-30°C, water salinity was 30 ppt with continuous aeration. Eggs released by the female become attached to the pleopod hairs of the abdominal flap. Sampling for egg-carrying or berried females was done. A total of 16 berried crabs were found when water levels were reduced during the water change. Berried females were then transferred individually to a 100-liter tank with aerated seawater at 32 ppt. Hatching occurs 7-14 days after berried maintains temperatures of 26.5-31°C. Each brood crab of *Portunus pelagicus* was given 0.7-3.5 million zoeae.

Horseshoe crabs from natural sources were being used for breeding. Sperm and ovum are freshly collected from nature and mixed in the jar. Then those were being brought back to the shell breeding unit of Marine Fisheries and Technology Station. Then those eggs were kept in the incubator with a re-circulatory system for the incubation. Regular monitoring was done to check any kind of change in the eggs or any sign of hatching. Unfortunately, none of the eggs were hatched out.

Table 2. Monthly artificial breeding and hatching status of Horseshoe Crabs

Species sampled	Sampling month	Domesticated/ Nature	No of male and female stimulated	No of collected eggs	Hatching status
<i>C. rotundicauda</i>	February	Nature	4	23	None
<i>T. gigas</i>	February	Domesticated	3	7	None
<i>C. rotundicauda</i>	March	Nature	33	24	None
<i>C. rotundicauda</i>	April	Nature	42	59	None
<i>C. rotundicauda</i>	May	Nature	27	191	None

Experiment 4: Development of larval and nursery management technique of Blue Swimming crab.

Larvae management

Zoeae were stocked at a density of 30 individuals per liter in 3 circular fiber tanks containing 300L seawater and fed with the rotifer *Brachionus rotundiformis* at a density of 10-15 rotifers/ml. The microalga *Nannochloropsis* sp. was maintained in the rearing tanks at 50,000 cells/ml as food for the *B. rotundiformis*. Brine shrimp *Artemia* nauplii were also given at 0.5-3/ml to late zoea 1 stage and larger larvae. In these experiments' antibiotics, probiotics and stocking density were variables. The zoeae were reared at a salinity of 28-30 ppt and water temperature of 26-30.5°C and a natural photoperiod of 11-13 hours light and 11-13 hours dark. The rearing water was replaced at a daily rate of 30% starting on day 3 and increasing up to 80% as larvae grow bigger or when disease-causing luminescent bacteria are detected in the water and larvae.

A new experiment had been set up with three treatments for the trial 1 (Different amounts of Antibiotics, for instance, 0.5ppm, 1ppm, 1.5ppm) In the next trial antibiotic and probiotics were used in the same amount as the same amount of stocking density of larvae (Trail 2= use of both Probiotics and antibiotics at same level, 0.5ppm). For Trail 2 there was two replications where the survival rate varied in high range. So, in the next trial same amount of antibiotic was used for varied amount of stocking density (Trail 3= Same amount of antibiotics with different amounts of larvae). Feeding was done five times a day where rotifer was being used initially and from late zoeal stage larvae were fed with *Artemia* with a rotation of mix feed. At 9 pm enzyme was being used for better digestion. This study showed a better survival rate in T₁ and T₃ with the 1ppm of antibiotics, though T₂ represented a better survival rate of larvae but the result

is not consistent for using antibiotics and probiotics. The mean survival rate was 4.6%, 5.1% and 5.4% respectively for the trials.

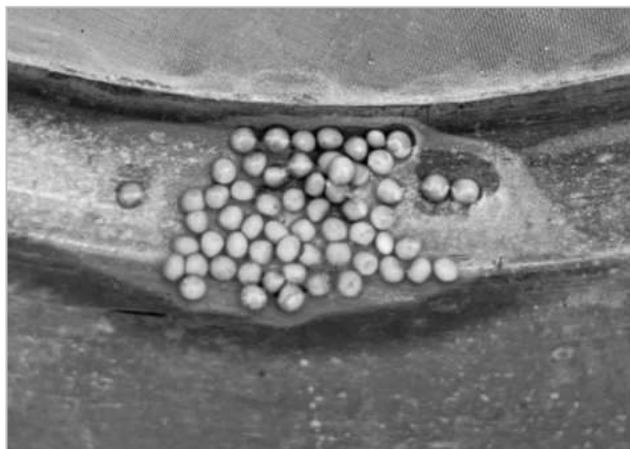


Figure 4: Freshly collected eggs are to be fertilized



Figure 5: Mixing of Sperm with eggs

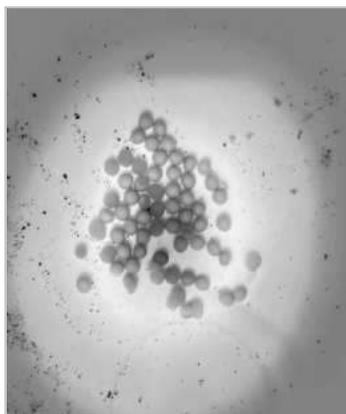


Figure 6: Eggs after

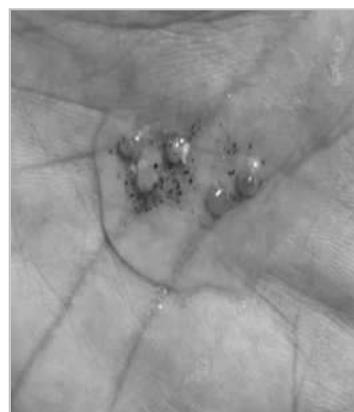


Figure 7: Unhatched eggs after 29 days

Trial 1. Different amount of Antibiotics

	Treatment 1	Treatment 2	Treatment 3
Stocking density (300-liter fiber tank)	15000	15000	15000
Amount of Antibiotic applied (ppm)	0.5	1	1.5
Days taken to be Crab inster (Days)	21	19	21
Survival Rate (%)	4.1	4.9	4.6

Food consists of newly hatched and adult *Artemia* for zoea and megalopa respectively. As soon as the megalopa molt to the crablet stage, they were fed with minced trash fish, mussels, oyster or small shrimp *Acetes* twice daily ad libitum. About 30-50% of the volume of the rearing water (26-30 ppt) was replaced daily during the first 5 days and every two days thereafter.

The survival rate from Zoea 1 to 4 days old to Megalopa was 6.8% in treatment 2. The survival from Megalopa to crablet (1-3 g bodyweight) after 20 days in hatchery tanks was <5% in treatment 2.

Trail 2. Use of both Probiotics and antibiotics

	Replication 1	Replication 2
Stocking density (300-liter fiber tank)	15000	15000
Amount of Antibiotic applied (ppm)	0.5	0.5
Amount of Probiotic applied (ppm)	0.5	0.5
Days taken to be Crab inster (Days)	22	23
Survival Rate (%)	5.1	3.7

Trail 3. Same amount of antibiotics with different amount of larvae

	Treatment 1	Treatment 2
Stocking density (300-liter fiber tank)	15000	10000
Amount of Antibiotic applied (ppm)	1	1
Days taken to be Crab inster (Days)	20	19
Survival Rate (%)	5.2	5.5

Megalopa were nursed in circular concrete tanks. The stocking density of 3-5 days old megalopa in nursery tanks was reduced to 1500-2000 inds./3000litre of water. Black nets were placed at the bottom as substrates and some were suspended in the water column.

Nursery Management

Crablets were shifted in one individual in one hapa net. These crablets were reared for one month here before they go for grow-out. Here, shrimp-egg custard was fed to those crablets. This trial has been ongoing till now.



Figure 8: Nursey unit of Crablets

Assessment of Stock and Standardization of the Spawning Potential Ratio (SPR) of commercially important marine fish groups of Bangladesh

Researchers

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Objectives

- To estimate the life-history characteristics and stocks of commercially important marine fish species of Bangladesh
- To estimate the Biological Reference Points (BRP) of marine fishes
- To standardize Spawning Potential Ratio (SPR) of marine fishes
- To identify commercially important marine fish species using Microsatellite markers and mitochondrial DNA (mtDNA) sequences

Achievements

Study-1: Estimating the life-history characteristics and stocks of commercially important marine fish species of Bangladesh

Total length and total weight of commercially important marine fishes with size at first sexual maturity of 12 species were determined from the land-mark base data i.e. *Auxis thazard* (Frigate tuna), *Euthynnus affinis* (Little tuna), *Katsuwonus pelamis* (Skipjack tuna), *Auxis rochei* (Bullet Tuna) *Thunnus albacores* (Yellowfin tuna), *Scomberomorus guttatus* (Indo-pacific king mackerel), *Scomberoides commersonianus* (Talang queen fish), *Scomberoides tol* (Needlescaled queenfish), *Scomberoides lysan* (Doublespotted queenfish), *Rastrelliger kanagurta* (Indian mackerel), *Rastrelliger faughni* (Island mackerel) and *S. commerson* (Narrow-barred Spanish mackerel) which results are followed in table 1:

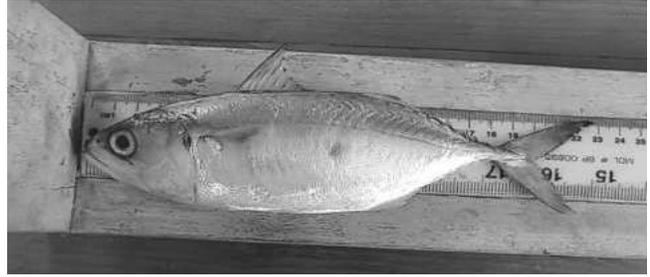
About total 820 (male=540 and female=280) individuals of *Auxis thazard* were examined. The estimated size at sexual maturity was at the length of 24.83cm. A total 986 (male= 670 and female=316) individuals of *Euthynnus affinis* were examined. The estimated size at sexual maturity was at the length of 37.79 cm. A total 1034 (male=940 and female=94) individuals of *Auxis rochei* were examined. The estimated size at sexual maturity was at the length of 38.56 cm. A total 554 (male=350 and female=204) individuals of *Katsuwonus pelamis* were examined. The estimated size at sexual maturity was at the length of 33.30 cm. The sum of 1452 (male=754 and female=698) individuals of *Thunnus tonggol* were examined. The estimated size at sexual maturity was at the length of 34.92cm. The sum of 1221 (male=840 and female=381) individuals of *Scomberomorus guttatus* were examined. The estimated size at sexual maturity was at the length of 56.29 cm. About 970 (male=410 and female=560) individuals of *Scomberoides commersonianus* were examined. The estimated size at sexual maturity was at the length of 60.95cm. About 456 (male=270 and female=186) individuals of *Rastrelliger kanagurta* were examined. The estimated size at sexual maturity was at the length of 12.82cm. A total 365 (male = 180 and female = 185) individuals of *Rastrelliger faughni* were examined. The estimated size at sexual maturity was at the length of 14.12 cm. A total 389 (male 252 and female 137) individuals of *Scomberoides tol* were examined. The estimated size at sexual maturity was at the length of 23.31 cm. A total 342 (male =172 and female = 170) individuals of *Scomberoides lysan* were examined. The estimated size at sexual maturity was at the length of 27.84 cm.

Table 1. Length at first sexual maturity of 12 marine species

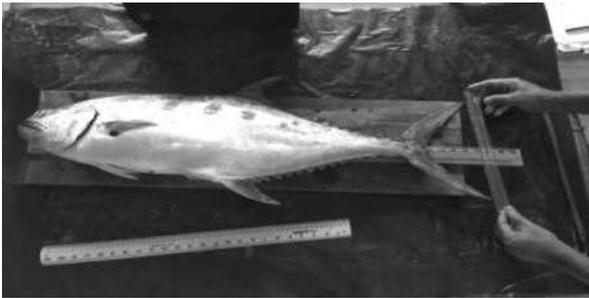
Species name	Lm
<i>Auxis rochei</i> (Bullet tuna)	38.56 (31.08 - 38.88)
<i>Auxis thazard</i> (Frigate tuna)	24.84 (18.99 - 32.21)
<i>Euthynnus affinis</i> (Little tuna)	37.69 (28.37 - 49.73)
<i>Thunnus tonggol</i> (Long tail Tuna)	34.62 (26.31 – 52.84)
<i>Katsuwonus pelamis</i> (Skipjack tuna)	33.50 (25.14 - 43.63)
<i>Scomberoides commersonianus</i> (Talang queenfish)	60.84 (44.82 - 81.52)
<i>Scomberomorus guttatus</i> (Indo-pacific king mackerel)	56.32 (41.53 - 75.07)
<i>S. commerson</i> (Narrow-barred Spanish mackerel)	60.32 (55.42 – 81.21)
<i>Scomberoides lysan</i> (Double spotted queenfish)	27.72 (21.18-36.26)
<i>Rastrelliger faughni</i> (Island mackerel)	14.12 (12.53-20.56)
<i>Rastrelliger kanagurta</i> (Indian Mackerel)	12.82 (10.15-16.36)
<i>Scomberoides tol</i> (Needlescaled queenfish)	23.11 (17.87-30.18)



Scomberomorus guttatus
Indo-Pacific king mackerel



Rastrelliger kanagartha
Indian mackerel



Scomberoides commersonianus
Talangqueenfish



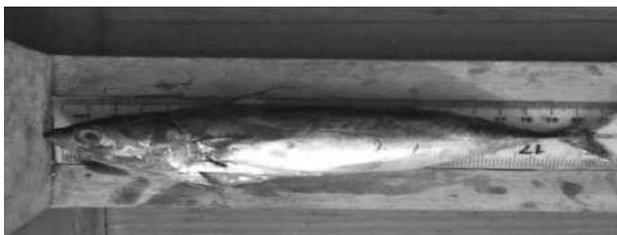
Euthynnus affinis
Little tuna



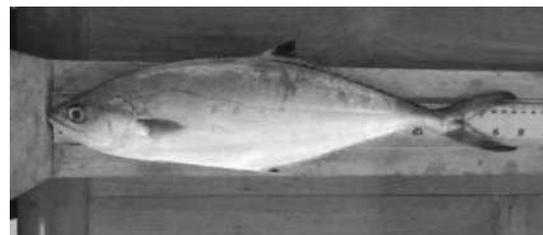
Auxis thazard
Frigate tuna



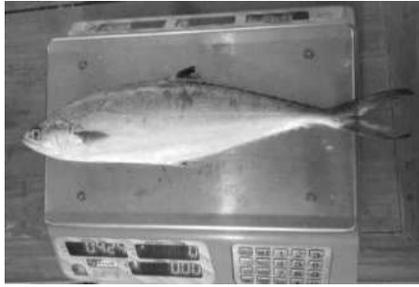
Thunnus tonggol
(Long tail Tuna)



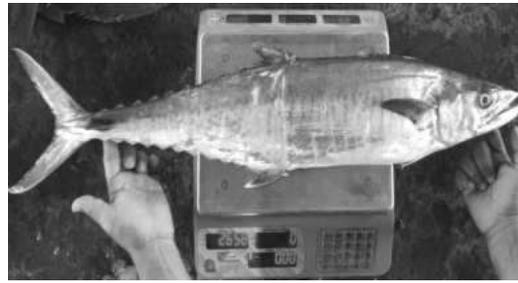
Auxis rochei
Bullet tuna



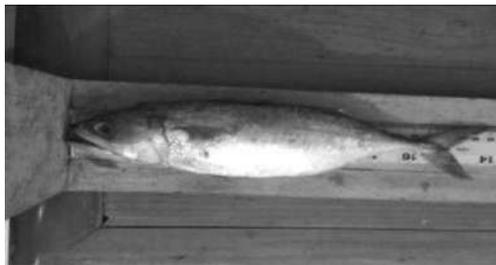
Scomberoides tol
Needlescaled queenfish



Scomberoides lysan
Double spotted queenfish



Scomberomorus commerson
Narrow-barred Spanish mackerel



Rastrelliger faughni
Island mackerel



Katsuwonus pelamis
Skipjack tuna

Figure 1. Picture of 12 commercially important identified marine fishes of Bay of Bengal, Bangladesh during July 2022 to June 2023.

The research findings of commercially important marine fish species by the LBB method in the Bay of Bengal, Bangladesh are presented below:

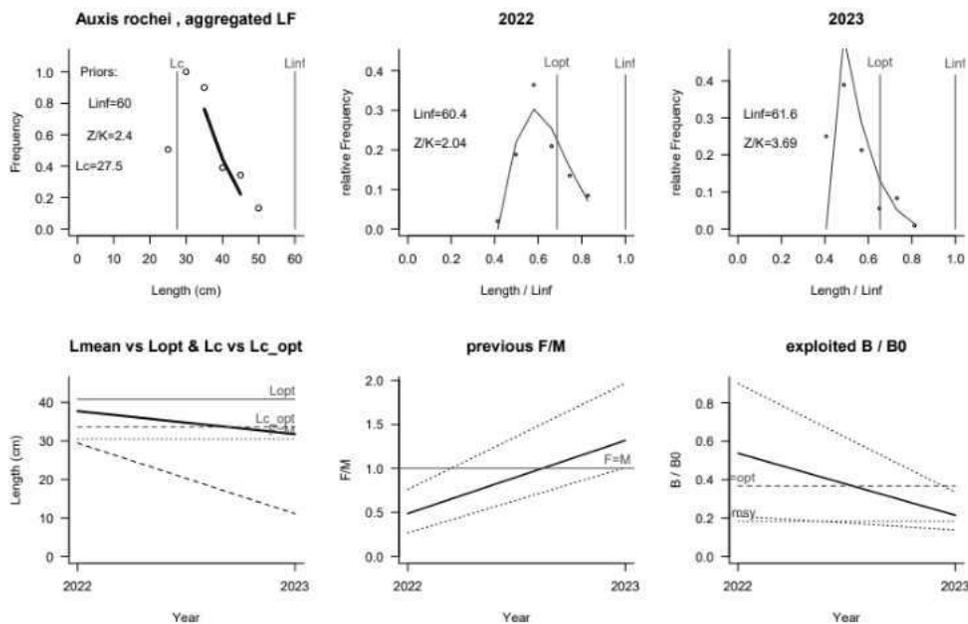


Figure 2. Graphical representation of LBB method for *Auxis rochei*. Here, L_c (length at first capture) was 27.5cm. L_{inf} is the limit body length of this species was 60 cm, and L_{opt} denotes the length at which the maximum sustainable catch is obtained.

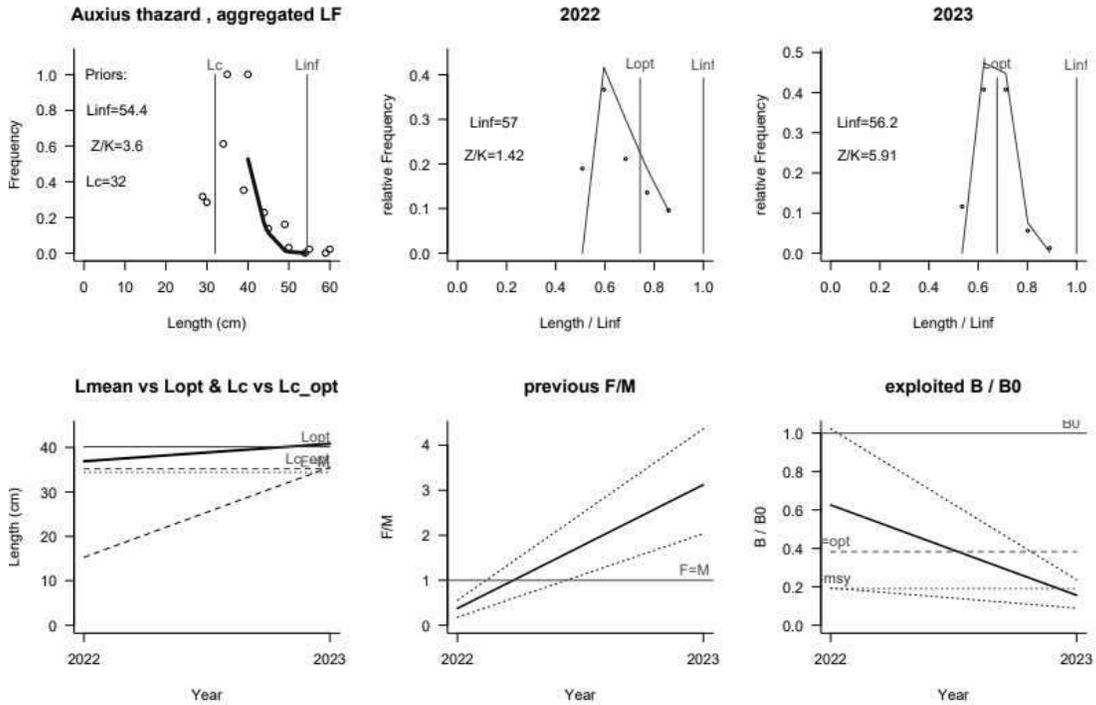


Figure 3. Graphical depiction of LBB method for *Auxis thazard*. Here, L_c (length at first capture) was 32 cm. L_{inf} is the limit body length of this species was 54.4 cm, and L_{opt} denotes the length at which the maximum sustainable catch is obtained.

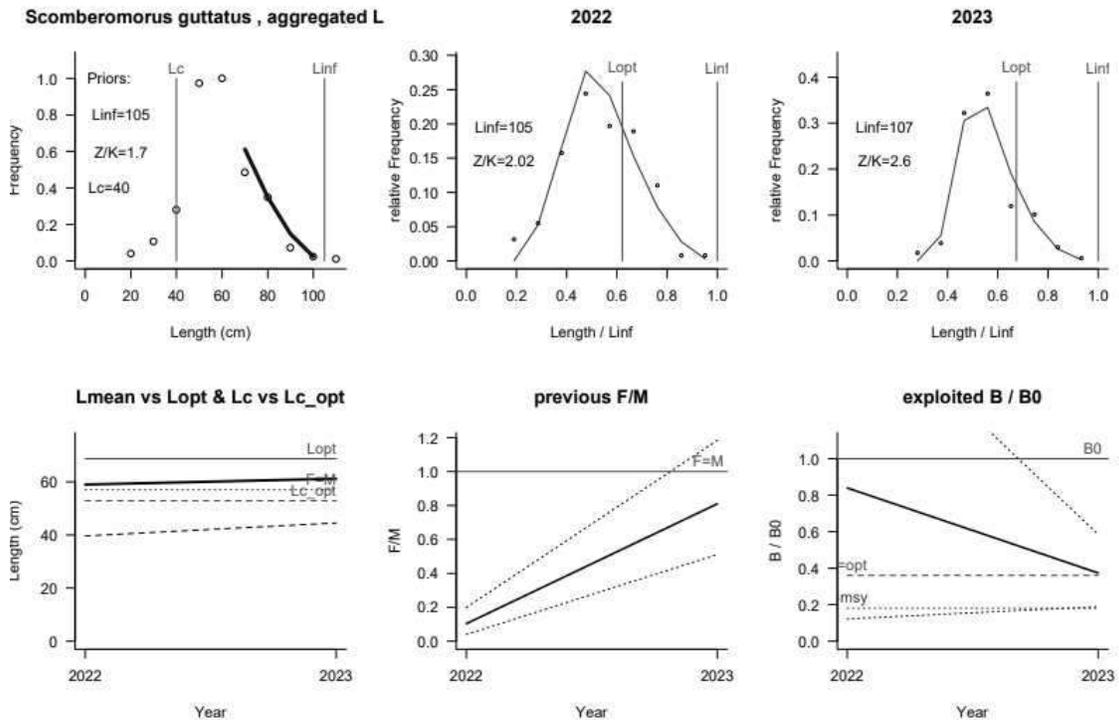


Figure 4. Graphical findings of LBB method for *Scomberomorus guttatus*. Here, L_c is the length at first capture was 40cm, L_{inf} is the limit body length of this species was 105cm.

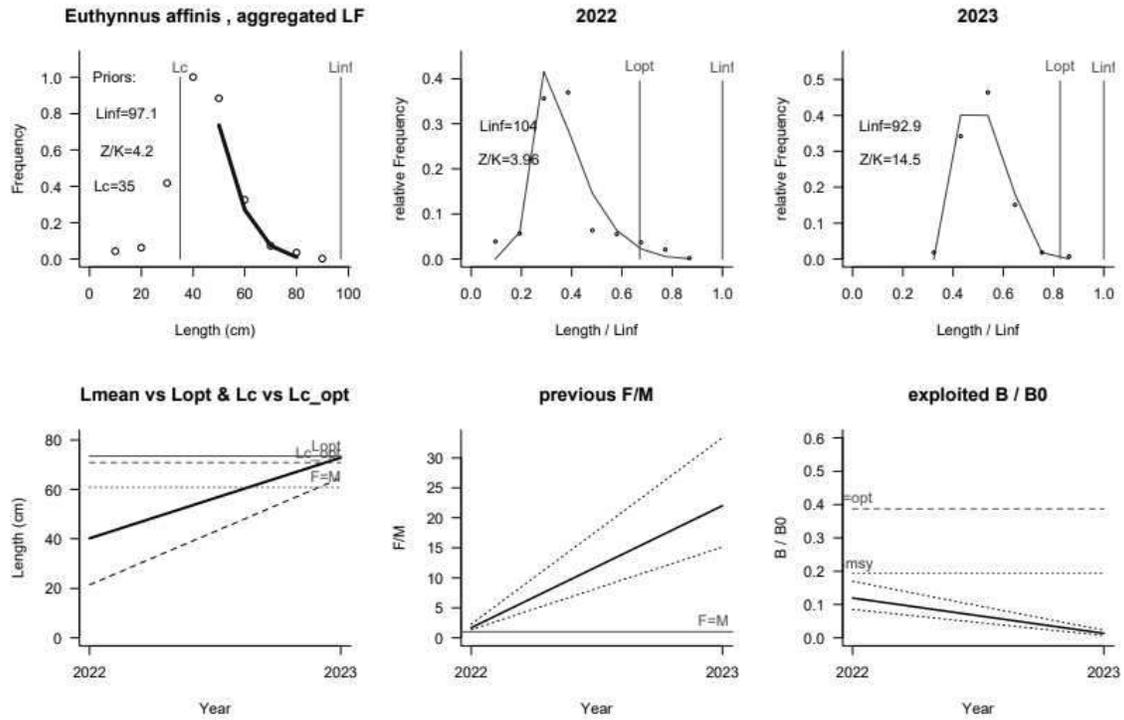


Figure 5. Graphical outcomes of LBB method for *Ethynus affinis*. Here, L_c is the length at first capture was 35cm, L_{inf} is the limit body length of this species was 97.1 cm.

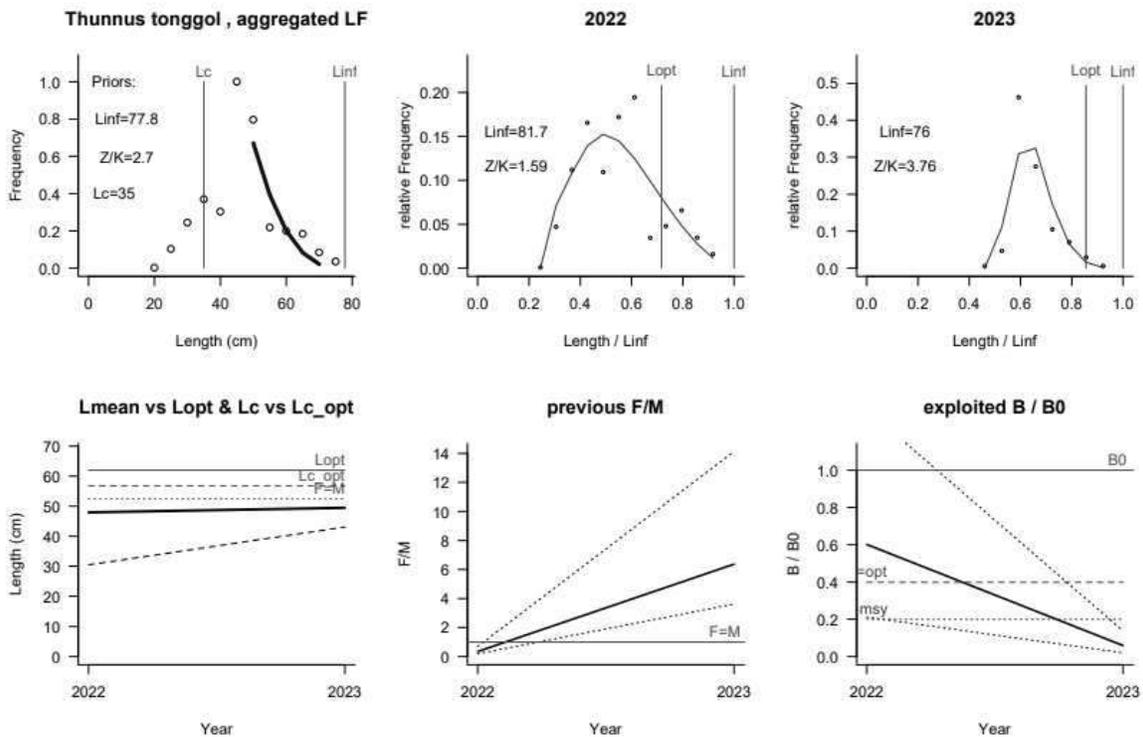


Figure 6. Graphical outcomes of LBB method for *Thunnus tonggol*. Here, L_c is the length at first capture was 35cm, L_{inf} is the limit body length of this species was 76.42 cm.

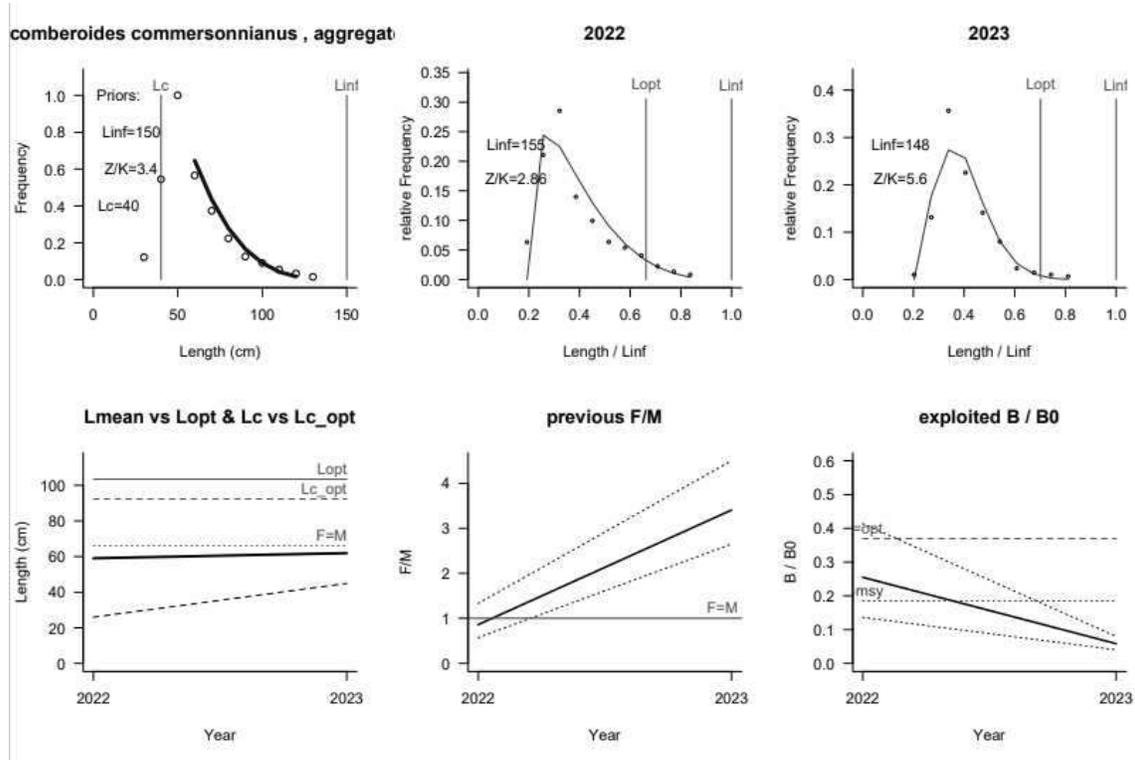


Figure 7. Graphical illustration of LBB method for *Scomberoides commersonianus*. Here, L_c is the length at first capture was 40.0cm, L_{inf} is the limit body length of this species was 150 cm.

Table 3. Estimated results of Six Marine fish species using length-frequency (LF) data assessed by length-based Bayesian biomass (LBB) method in between 2022-2023

Species Name	L_{mean}/L_{opt}	$L_c/L_{c_{opt}}$	M/K	L_{95th}/L_{inf}	B/B0	B/B _{MSY}	F/M	F/K	Z/K	Y/R'	Present Status
<i>E. affinis</i>	0.95	0.91	1.05	0.86	0.014	0.035	2.2	14	15	0.0045	Grossly overfished
<i>T. tonggol</i>	0.76	0.76	0.85	0.92	0.059	0.15	3.4	3.2	3.8	0.038	Grossly overfished
<i>S. commersonianus</i>	0.6	0.49	1.32	0.81	0.058	0.16	2.4	4.3	5.6	0.0085	Grossly overfished
<i>A. rochei</i>	0.79	0.33	1.48	0.81	0.38	0.58	1.3	2.1	3.7	0.033	Healthy stock
<i>A. thazard</i>	1.1	1	1.24	0.89	0.21	0.41	3.1	4.5	5.9	0.036	Grossly overfished
<i>S. guttatus</i>	0.85	0.84	1.64	0.93	0.37	1	0.81	1.1	2.6	0.044	Healthy stock

Table 4. Life-history characteristics of 06 Marine Fishes using FiSAT II

Species	n	L_{inf}	K	M
<i>Katsuwonus pelamis</i> (Skipjack tuna)	554	62.6	1.06	1.45
<i>S. commerson</i> (Narrow-barred Spanish mackerel)	413	119.4	0.8	0.87
<i>Rastrelliger kanagurta</i> (Indian Mackerel)	456	24.5	1.6	2.5
<i>Rastrelliger faughni</i> (Island Mackerel)	365	23.5	1.9	2.6
<i>Scomberoides tol</i> Needlescaled queenfish	389	42.5	1.53	1.81
<i>Scomberoides lysan</i> D. spotted queenfish	342	56	0.67	1.13

Study-2: Determination of the Biological Reference Points (BRPs) of marine fishes

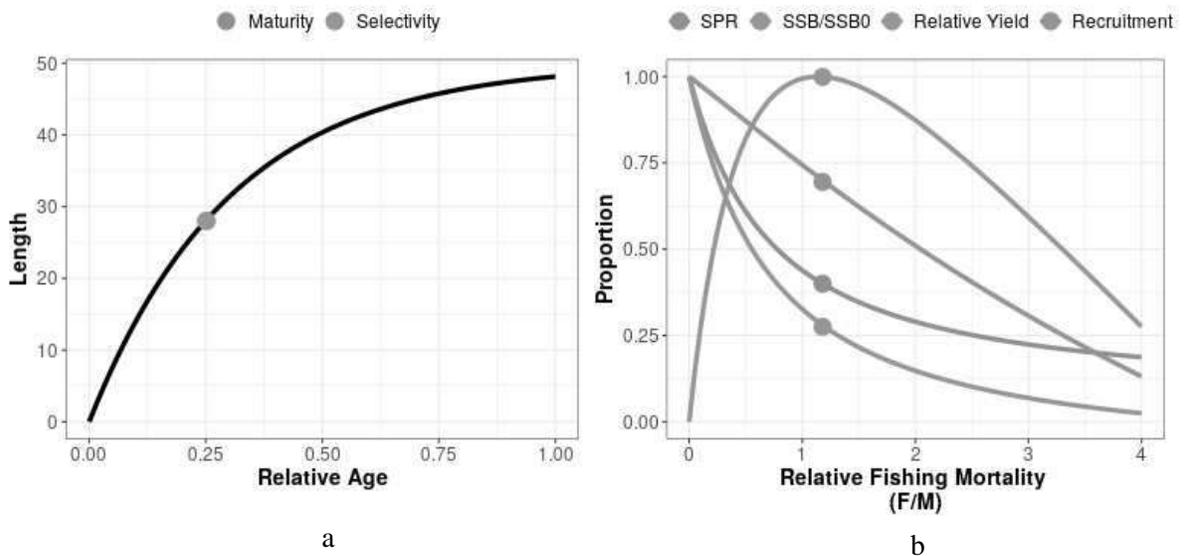


Figure 8. Estimation BRPs for *Auxis rochei*

- a) Growth curve with relative age, and
- b) SPR and relative yield curves as a function of relative fishing mortality.

In figure a, selectivity is in the maturity point i.e fishes were captured during mature stage. In figure b, The M/k value was >0.50 , which means all specimens, are mature with the length composition consisting of widely varying age and near asymptotic size.

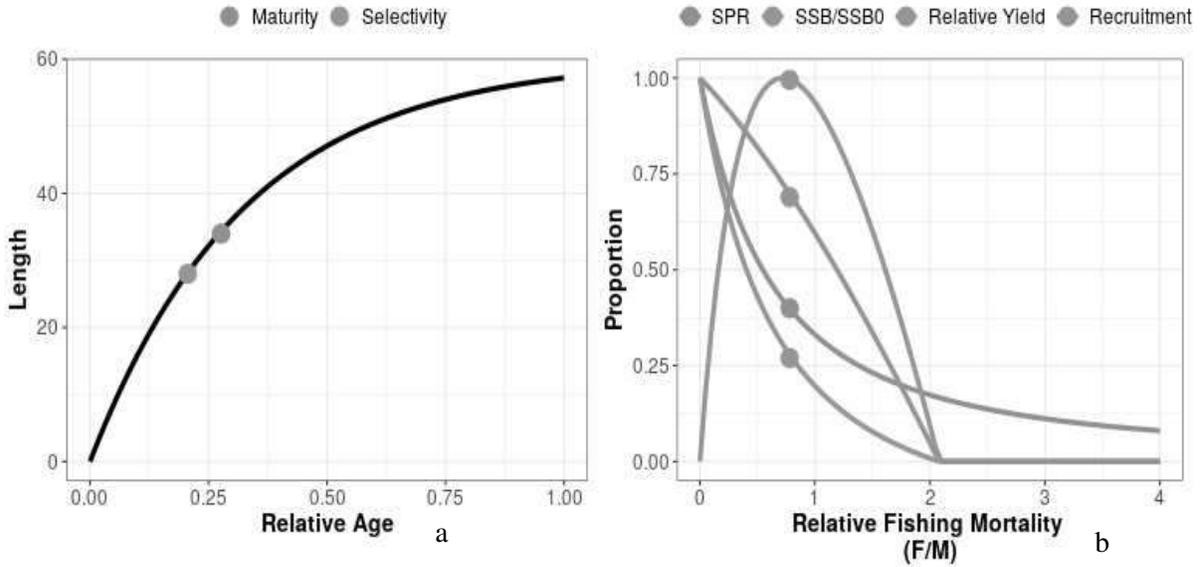


Figure 9. Calculation of BRPs for *A. thazard*

- a) Growth curve with relative age
- b) SPR and relative yield curves as a function of relative fishing mortality

In figure a, selectivity point cross the maturity point i.e fishes were caught before they reach their spawning time. In figure b, The M/k value was higher than 0.50, which means all fishes, are mature with the length composition consisting of widely different age and near asymptotic size.

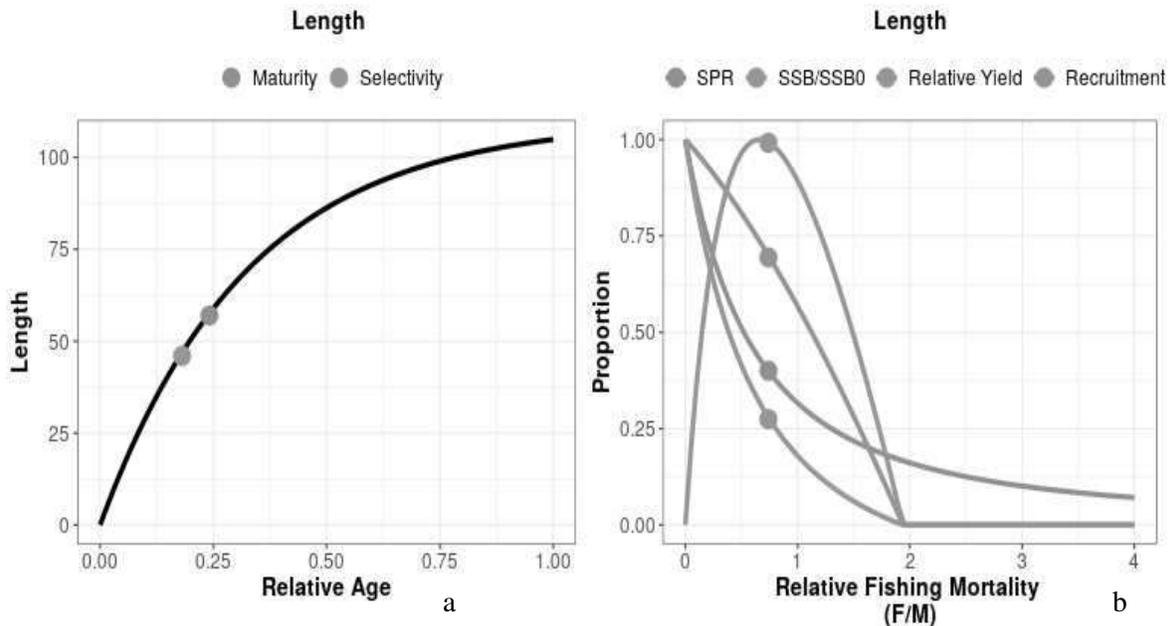


Figure 10. Estimation BRPs of *Scombermorus guttatus* using the length-based SPR software

- a) Growth curve with relative age
- b) SPR and relative yield curves as a function of relative fishing mortality

In figure a, selectivity point cross the maturity point i.e fishes were captured before mature stage. In figure b, The M/k value was greater than 0.50, which means all fishes, are mature with the length composition consisting of widely different age and near asymptotic size.

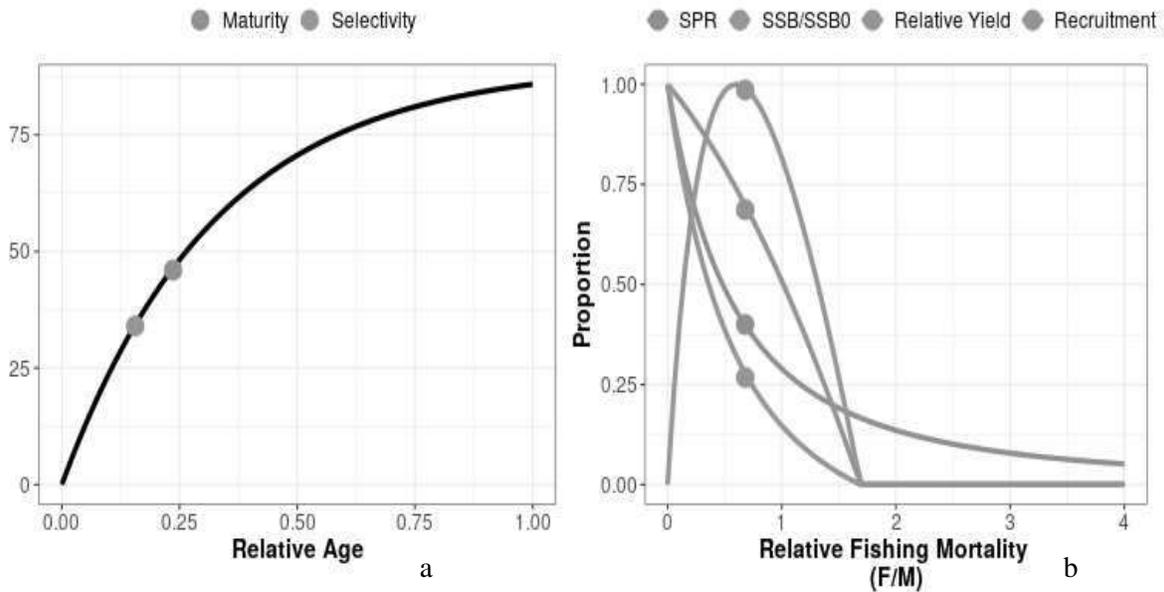


Figure 11. Estimation BRPs of *Euthynnus affinis* using the length-based SPR software

- a) Growth curve with relative age
- b) SPR and relative yield curves as a function of relative fishing mortality

In figure a, selectivity point is in front of the maturity point i.e fishes were captured before mature stage. In figure b, The M/k value was larger than 0.50, which means all fishes, are mature with the length composition consisting of different age and near asymptotic size.

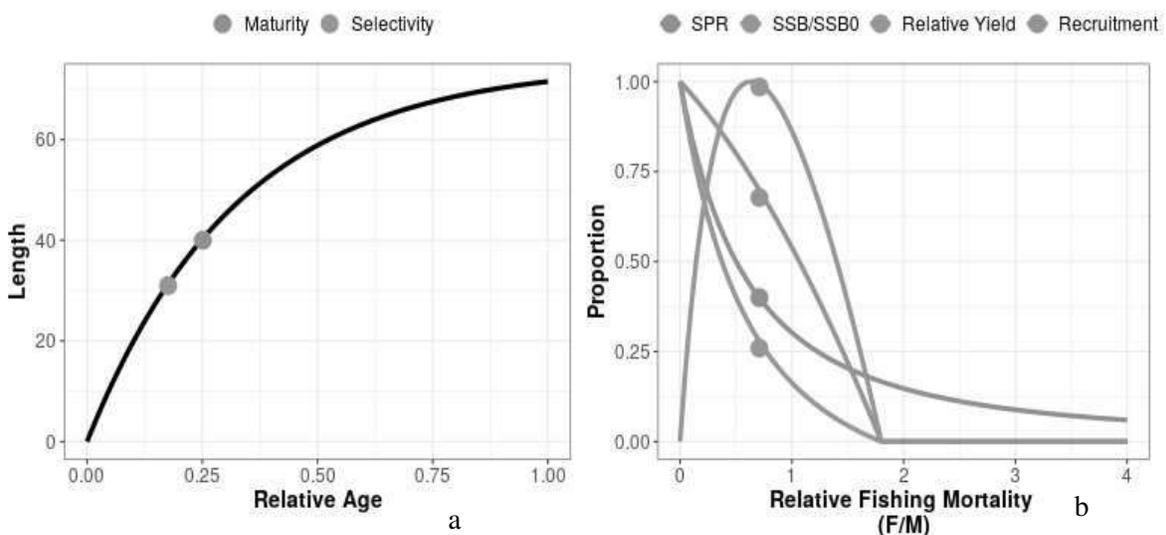


Figure 12. Determination of BRPs for *Thunnus tonggol* by the length-based SPR software

- a) Growth curve with relative age
- b) SPR and relative yield curves as a function of relative fishing mortality

In figure a, selectivity point cross the maturity point i.e fishes were captured before maturation. In figure b, The M/k value was more than 0.50, which means all fishes, are mature with the length composition consisting of widely different age and near asymptotic size.

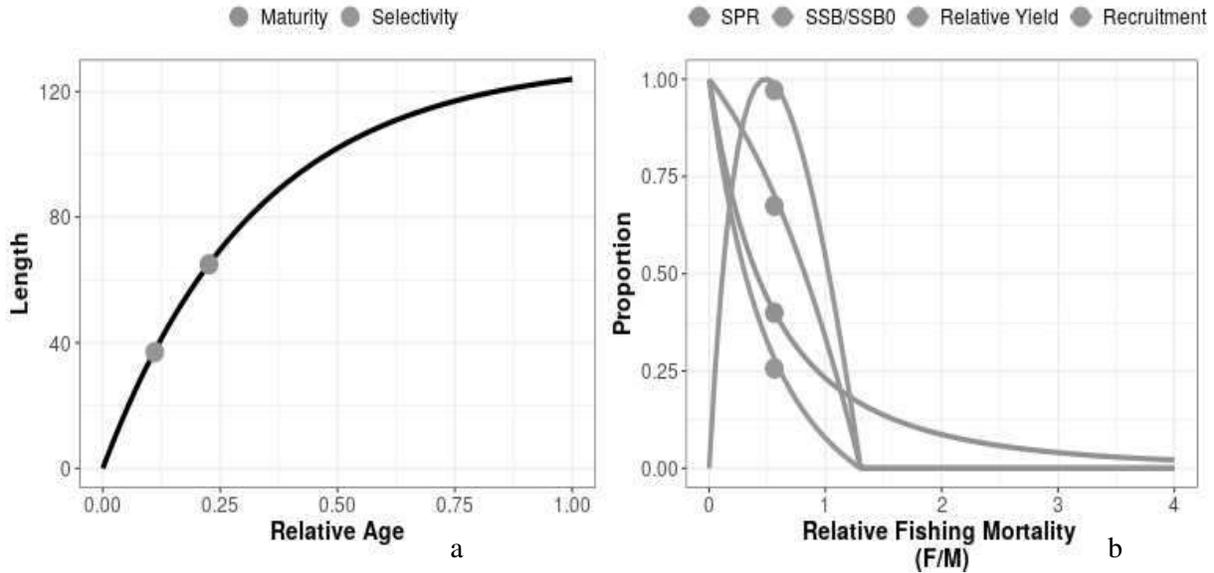
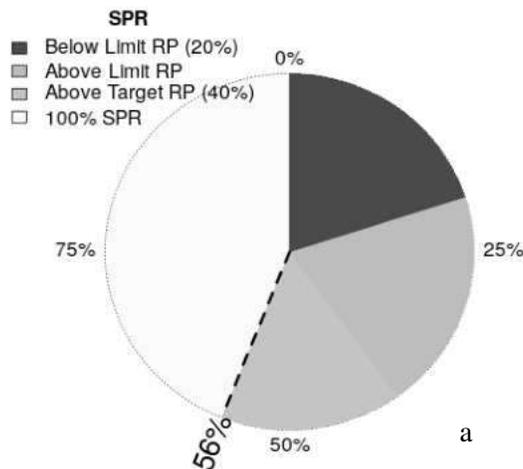


Figure 13. Estimation BRPs of *S. commersonianus* using the length-based SPR software

- a) Growth curve with relative age
- b) SPR and relative yield curves as a function of relative fishing mortality

In figure, maturity point far behind the selectivity point i.e fishes were captured before attain its maturity. In figure b, $M/k > 0.50$, which means all fishes, are mature with the length composition consisting of different age and near asymptotic size.

Experiment 3. Standardizing the Spawning Potential Ratio (SPR) of marine fishes



Estimates by Year (with 95% confidence intervals)

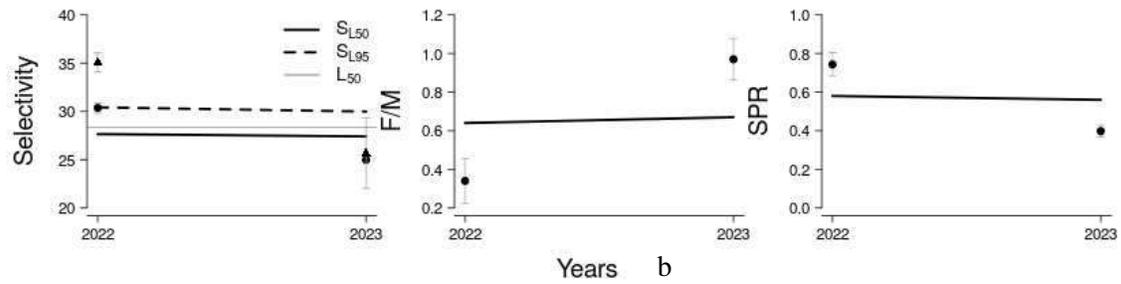


Figure 14. a) Estimation of SPR and total stock of *A. rochei* b) Estimates of selectivity parameters. SPR-based BRPs Plot showing estimates when size data are aggregated into a 2-year dataset (2022–2023). Red straight line indicates size at 50% maturity (L_{50}). Vertical lines indicate confidence intervals.

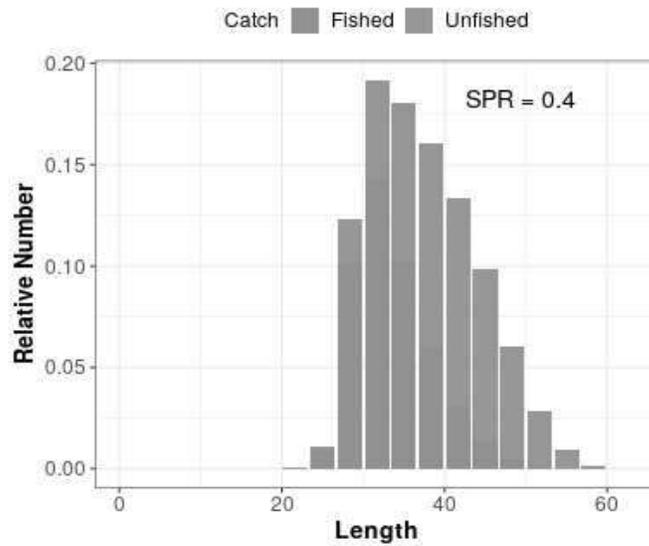
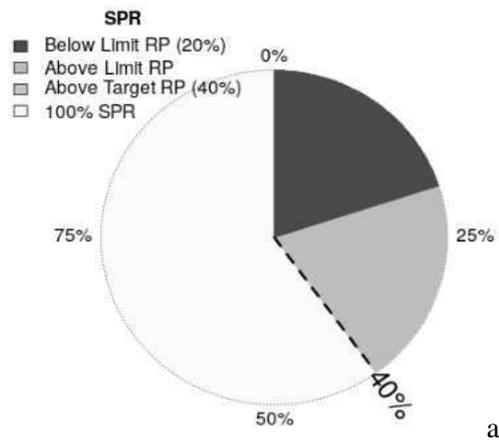


Figure 15. Expected (equilibrium) size structure of the catch and the expected unfished size structure of the vulnerable population (*Auxis rochei*)



Estimates by Year (with 95% confidence intervals)

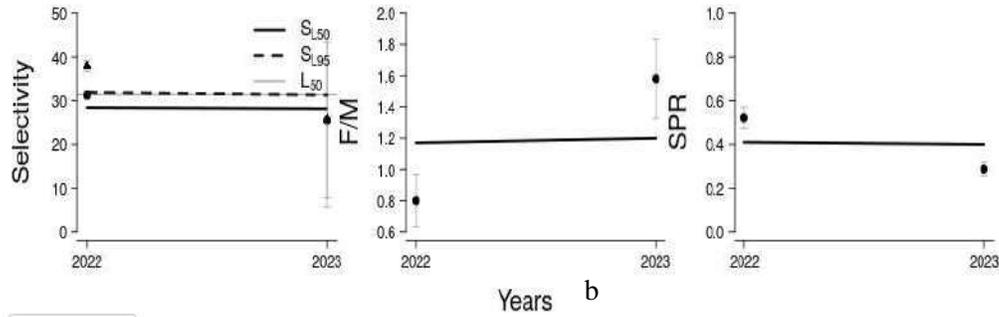


Figure 16. a) Estimation of SPR and total stock of *A. thazard* b) Estimates of selectivity parameters SPR-based BRPs Plot showing calculates when size data are aggregated into a 2 years dataset (2022–2023). Red straight line indicates size at 50% maturity (L_{50}). Vertical lines indicate confidence limits.

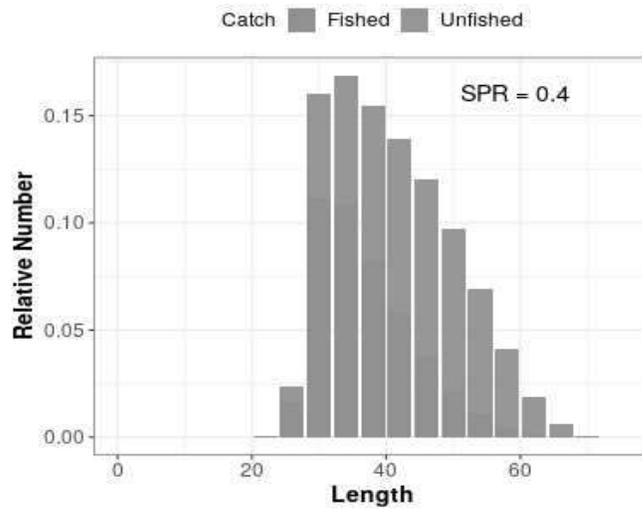
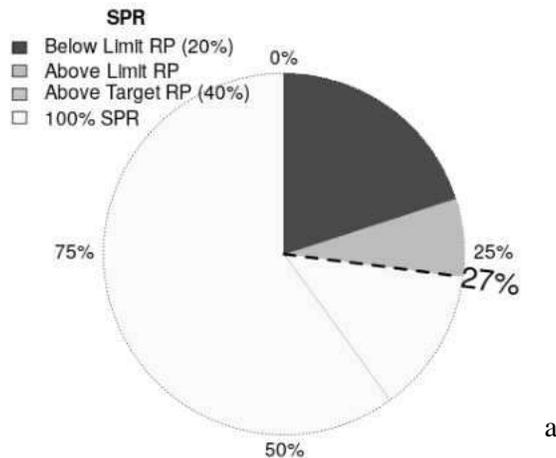


Figure 17. Expected (equilibrium) size structure of the catch and the expected unfished size structure of the vulnerable population for *A. thazard*



Estimates by Year (with 95% confidence intervals)

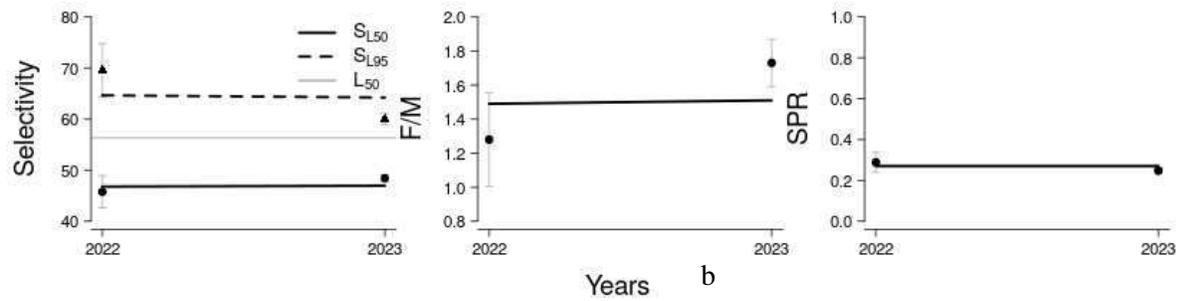


Figure 18. a) Estimation of SPR and total stock of *Scombermorus guttatus* b) Estimates of selectivity parameters SPR-based BRPs Plot showing estimates when size data are aggregated into a 2-year dataset (2022–2023). Red straight line indicates size at 50% maturity (L_{50}). Vertical lines indicate confidence intervals.

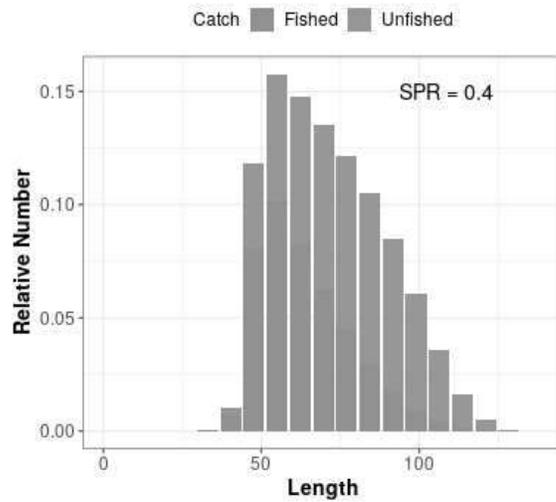
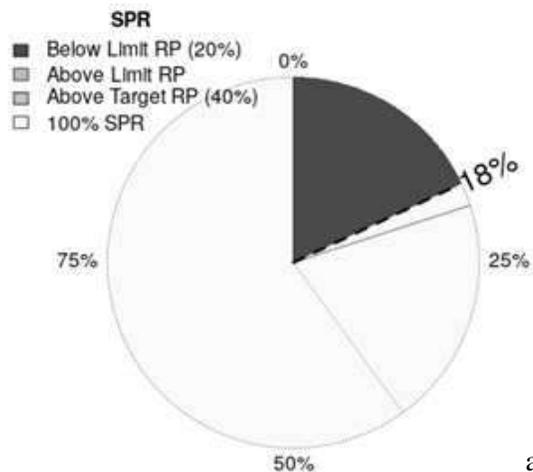


Figure 19. Expected (equilibrium) size structure of the catch and the expected unfished size structure of the vulnerable population for *Scombermorus guttatus*



Estimates by Year (with 95% confidence intervals)

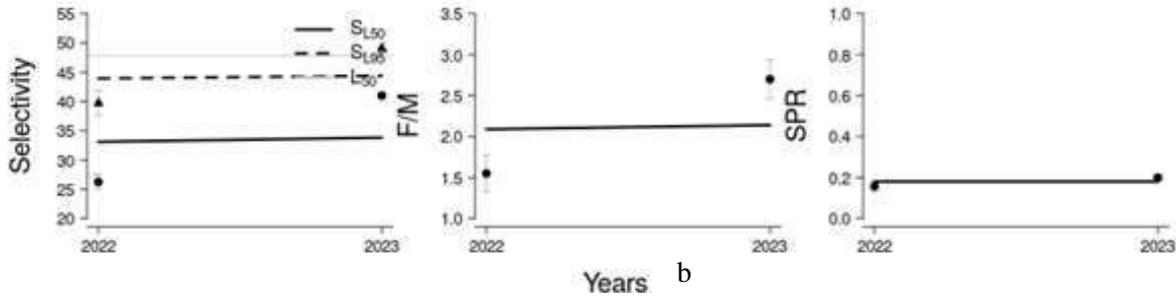


Figure 20. a) Estimation of SPR and total stock of *Euthynnus affinis* b) Estimates of selectivity parameters SPR-based BRPs Plot showing estimates when size data are aggregated into a 2-year dataset (2022–2023). Red straight line indicates size at 50% maturity (L50%). Vertical lines indicate confidence intervals.

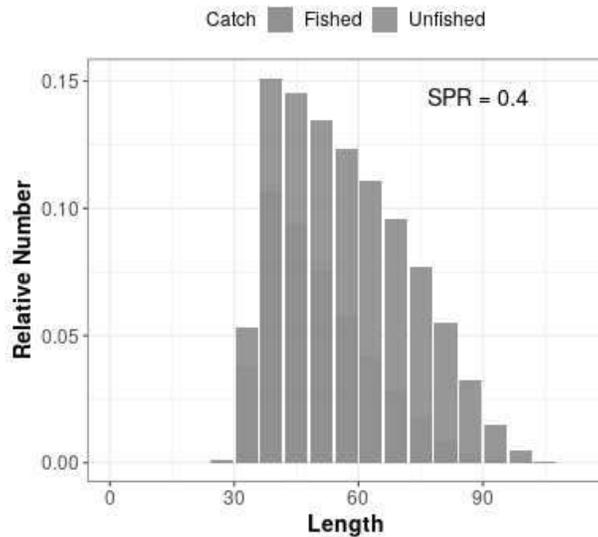
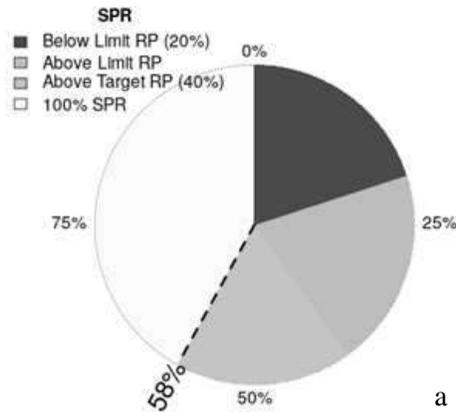


Figure 21. Expected (equilibrium) size structure of the catch and the expected unfished size structure of the vulnerable population for *Euthynnus affinis*



Estimates by Year (with 95% confidence intervals)

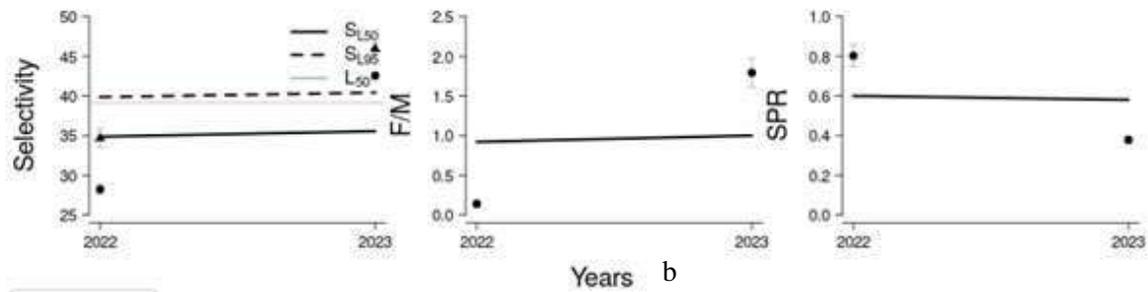


Figure 22. a) Estimation of SPR and total stock of *Thunnus tonggol* b) Estimates of selectivity parameters SPR-based BRPs Plot showing estimates when size data are aggregated into a 2-year dataset (2022–2023). Red straight line indicates size at 50% maturity (L_{50}). Vertical lines indicate confidence intervals.

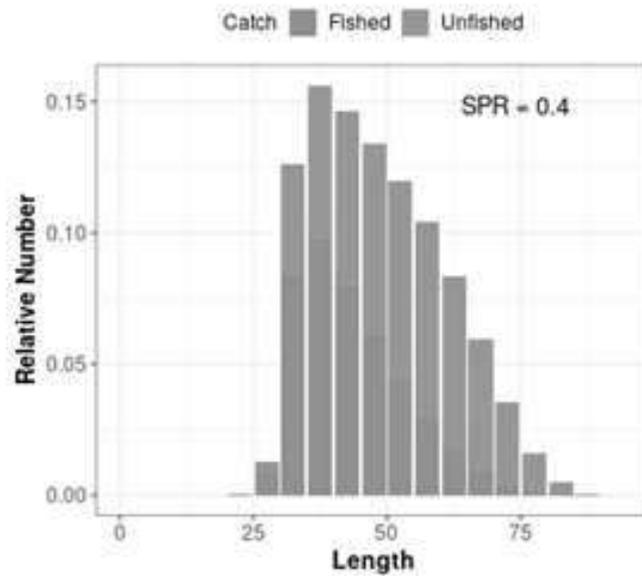
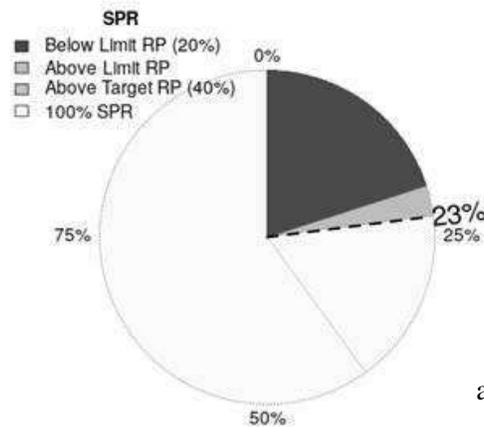


Figure 23. Expected (equilibrium) size structure of the catch and the expected unfished size structure of the vulnerable population for *Thunnus tonggol*



Estimates by Year (with 95% confidence intervals)

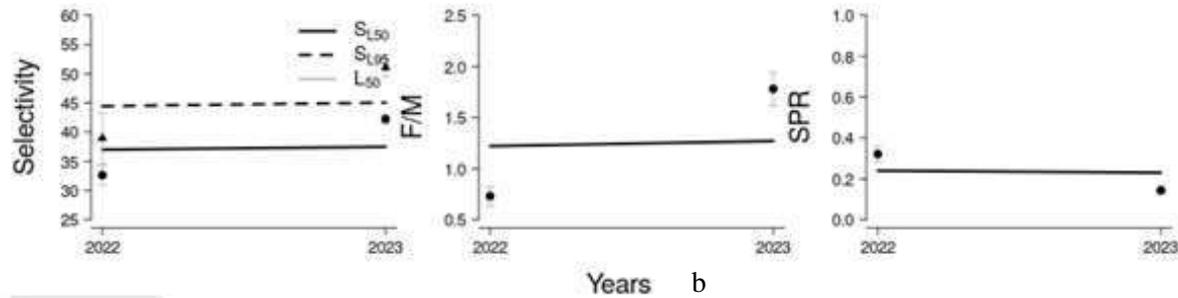


Figure 24. a) Estimation of SPR and total stock of *S. commersonianus* b) Estimates of selectivity parameters SPR-based BRPs Plot showing estimates when size data are aggregated into a 2-year dataset (2022–2023). Red straight line indicates size at 50% maturity (L_{50}). Vertical lines indicate confidence intervals.

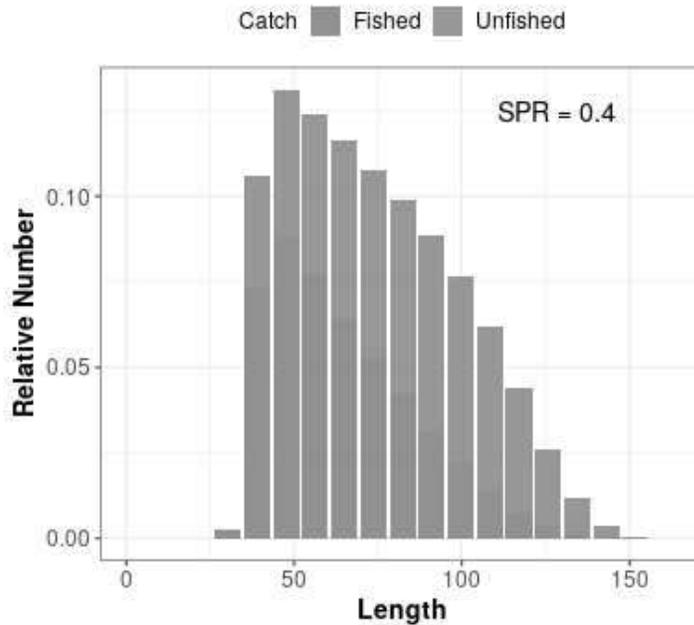


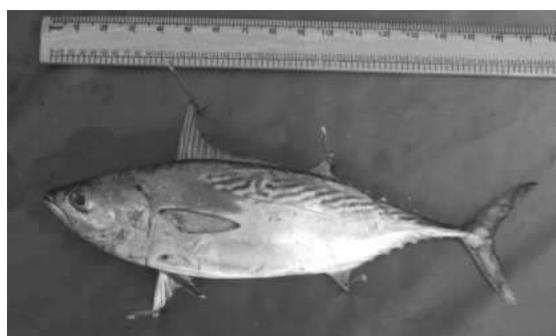
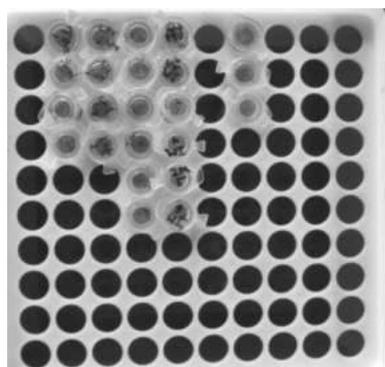
Figure 25. Expected (equilibrium) size structure of the catch and the expected unfished size structure of the vulnerable population for *S. commersonianus*

Red bars represent the current scenario and indicate the frequency of observed length with a modeled spawning potential ratio below 20%. Green bars indicate the simulated target (SPR 40%) length-frequency distribution. The current harvest pattern results in a lower spawning potential ratio than the ecological target of 40%.

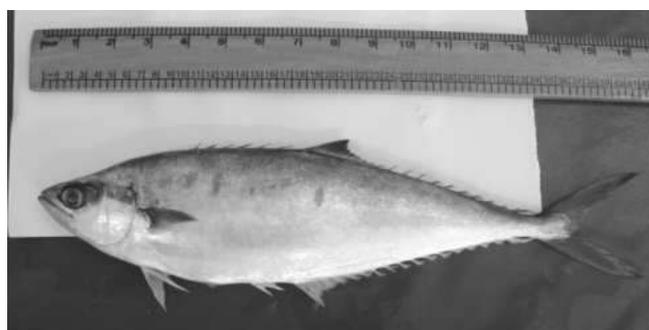
Table 5. The current status of analyzed Marine fishes

Species Name	SPR	SL50	SL95	F/M	M/K	Linf	L50	L95	Present Status
<i>E.affinis</i>	0.18	33.1	43.93	2.2	1.5	89	47.79	63.39	Maturity< Selectivity
<i>T. tonggol</i>	0.38	42.52	45.96	3.4	1.5	74	39.15	51.58	Maturity< Selectivity
<i>S. commersonianus</i>	0.23	37.47	45.05	2.4	1.5	128	64.67	86.65	Maturity< Selectivity
<i>A. rochei</i>	0.56	27.41	29.99	1.3	1.5	52	28.34	36.96	Maturity= Selectivity
<i>A. thazard</i>	0.33	28.61	31.82	3.1	1.5	58	33.33	43.63	Maturity< Selectivity
<i>S. guttatus</i>	0.27	46.94	64.22	0.81	1.5	110	56.29	75.7	Maturity< Selectivity

Study-4: Identification of Marine fishes using Microsatellite markers and mitochondrial DNA (mtDNA) sequences



Euthynnus affinis
Little tuna



Scomberoides tol
Needlescaled queenfish

Figure 26. Dorsal fin collection along with clear picture of samples for identification of Marine species.

Table 2. Descriptive statistics and assessed parameters of length–weight relationships ($BW = a \times TL^b$) for 12 commercially important marine fishes in Bay of Bengal, Bangladesh during July 2022 to June 2023.

Species	N	Total length (cm)			Body weight (gm)			Regression parameter		95%CL of a	95%CL of b	r^2
		Min	Max	Mean	Min	Max	Mean	a	b			
<i>Auxis thazard</i> (Frigate tuna)	820	13.5	46.6	33.12±5.6	286	1248	503.6±154.7	0.0358	2.804	0.0163-0.782	2.48-2.926	0.89
<i>Auxis rochei</i> (Bullet tuna)	1034	21.7	80	40.54±12.8	78	2060	671.95±214	0.121	2.548	0.08- 0.19	2.23-2.65	0.99
<i>Euthynnus affinis</i> (Little tuna)	986	28.7	75.2	47.09±11.1	315	4230	1372.7±157.3	0.0221	2.7854	0.016-0.031	2.64-2.93	0.96
<i>Katsuwonus pelamis</i> (Skipjack tuna)	554	33.12	62.5	45.26±8.03	315	2632	1098±478.3	0.0021	3.02	0.002-0.0022	2.79-3.31	0.79
<i>Thunnus tonggol</i> (Long tail Tuna)	1452	36.45	65.84	50.84±7.6	1108	3068	1937.54±354	0.0151	2.945	0.0054-0.43	2.58-3.18	0.957
<i>Scomberomorus guttatus</i> (Indo-pacific king mackerel)	1221	36.42	110.48	54.25±13.5	335	6710	1064.45±465.2	0.0089	2.896	0.0062-0.013	2.78-2.98	0.98
<i>S. commerson</i> (Narrow-barred Spanish mackerel)	413	42.8	124.5	67.43±27.74	450	10080	2333.74±876.87	0.0072	2.96	0.0061-0.0084	2.66-3.04	0.99
<i>Rastrelliger kanagurta</i> (Indian Mackerel)	456	19.5	22	20.82±1.2	62	197	99.8±27	0.0042	3.18	0.0031-0.0047	2.89-3.21	0.98
<i>Rastrelliger faughni</i> (Island Mackerel)	365	20.5	28	22.21±2.1	115	248	175.8±4.1	0.0797	2.88	0.0022-0.123	2.67-2.93	0.79
<i>Scomberoides tol</i> (Needlescaled queenfish)	389	36	42	36.5±4.3	128	468	292.3±56.21	0.0056	3.21	0.0089-0.006	3.1-3.25	0.99
<i>Scomberoides commersonianus</i> (Talang queenfish)	970	29.5	125	56.21±19.32	170	6500	989±212	0.01	2.98	0.007-0.012	2.8-3.07	0.97
<i>Scomberoides lysan</i> (Double spotted queenfish)	342	40	51	44.45±4.19	375	750	489.8±92.7	0.006	2.97	0.003-0.131	2.86-3.16	0.97

n, sample size; SD, standard deviation; Min, minimum; Max, Maximum; a, intercept; b, slope; CL, confidence limits; r^2 , coefficient of determination; parentheses indicate the range of a mean value.

Scientific Publications (2022-23)

- Tanu, M. B., Barman, A. C., Siddique, M. F., Sku, S., Hossen, M. N., Southgate, P. C., & Mahmud, Y. (2022). Impact of culture period on quality of image pearls produced by the freshwater mussel, *Lamellidens marginalis*, in Bangladesh. *Journal of Shellfish Research*, 41(1), 75–83.
- Tanu, M. B., Barman, A. C., Siddique, M. F., Sku, S., Hossen, N., Lupa, S. T., & Mahmud, Y. (2021). Determination of suitable size of shell image for better quality image pearl through inoculation in native mussel (*Lamellidens marginalis*). *Journal Of Pharmacy And Biological Sciences (IOSR-JPBS)* 16(6), 44–47.
- Tanu, M. B., Barman, A. C., Siddique, M. F., Sku, S., Hossen, M. N., Rayhan, A., & Mahmud, Y. (2021). Determining of suitable size of paraffin image for image pearl production in freshwater mussel (*Lamellidens marginalis*) in Bangladesh. *International Journal of Fisheries and Aquatic Studies*, 9(6), 222-226.
- Moniruzzaman, M., Sku, S., Chowdhury, P., Tanu, M. B., Yeasmine, S., Hossen, M. N., Min, T., Bai, S.C., & Mahmud, Y. (2021). Nutritional evaluation of some economically important marine and freshwater mollusc species of Bangladesh. *Heliyon*, 7(5), e07088.
- Das, D.R, Khanom, M., Moniruzzaman, M., Mithun, M. H., Rahman, M. K., & Mahmud, Y. (2022). First record of induced breeding of Indian potasi, *Neotropius atherinoides* (Bloch 1794) in Bangladesh. *Egyptian Journal of Aquatic Biology & Fisheries*, 26(4), 59 – 74
- Das, D. R., Dey, S.K., Mithun, M. F. I.; Moniruzzaman, M., Rahman, M. K., & Mahmud, Y. (2022). Growth and production performance of Mud Eel, *Monoplerus cuchia* (Hamilton, 1822) using different types of feed in the Northern region of Bangladesh. *Archives of Agriculture and Environmental Science*, 7(4), 509-513.
- Islam, M. L., Sakib, M. H., & Ahmmed, S. (2021). Fattening of Mud Crab *Scylla olivacea* (Herbst, 1896): An integrated multi-trophic aquaculture (IMTA) approach. *Egyptian Journal of Aquatic Biology and Fisheries*, 25(4), 1035-1047.
- Sakib, M. H., Ahmmed, S., Washim, M. R., Islam, M. L., & Chowdhury, P. (2022). Population dynamics of mud crab, *Scylla olivacea* (Herbst, 1796) from the Sundarbans of Bangladesh. *Aquaculture, Fish and Fisheries*, 2, 224–232.
- Washim, M. R., Ahmmed, S., Rubel, A. K. M. S. A., Mondal, D. K., Begum, N., & Islam, M. L. (2022). The effects of synthetic gonadotropin releasing hormone analogue (S-GnRH α) on artificial propagation of spotted scat, *Scatophagus argus* (Linnaeus, 1766). *South Asian Journal of Experimental Biology*, 12(2), 203-212.
- Mondal, D. K., Ahmmed, S., Washim, M. R., Rubel, A. K. M. S. A., & Islam, M. L. (2022). Reproductive biology of white grunter (*Pomadasy s hasta*) on the South-west coast of Bangladesh. *Egyptian Journal of Aquatic Biology & Fisheries*, 26(1), 655 – 668.
- Washim, M. R., Rubel, A. K. M. S. A., Mondal, D. K., Ahmmed, S., Sakib, M. H., Rahman, S. L., & Islam, M. L. (2022). Evaluation of growth performance of three strains of Nile tilapia *Oreochromis niloticus* (L., 1758) reared in Brackishwater ponds and relationship of growth with water physico-chemical parameters. *Journal of Aquaculture and Fish Health*, 11(2), 170-181.

- Sakib, M. H., Ahmmed, S., Mahmud, Y., & Islam, M. L. 2022. Nursery rearing of orange Mud Crab, *Scylla olivacea* (Herbst, 1896): Optimizing pond habitat and stocking density. *Journal of Bangladesh Agricultural University*, 20(1), 97–102.
- Washim, M. R., Rubel, A. K. M. S. A., Ahmmed S., Rahman, S. L., & Islam, M. L. (2022). Stocking density optimization of juvenile mudcrab (*Scylla olivacea*) cultivation in bamboo fetched earthen ponds. *AAFL Bioflux*, 15(1), 384-394.
- Ahmmed, S., Sakib, M. H., Islam, M. L., & Mahmud, Y. (2021). Larval rearing of orange mud crab, *Scylla olivacea*: improving survival rate and shortening metamorphosis period. *Bangladesh Journal of Fisheries*, 33(2), 265-273.
- Washim, M. R., Rubel, A. K. M. S. A., & Islam, M. L. (2021). Morphometric and meristic features of White grunter, *Pomadasys hasta* (Bloch, 1790) a threatened fish in the South-west coast, Bangladesh. *American Journal of Marine Science*, 9(1), 7-11.
- Washim, M. R., Rubel, A. K. M. S. A., & Islam, M. L. 2022. Morphometric and meristic traits of Spotted scat *Scatophagus argus* (Linnaeus, 1766) a mangrove fish from South-west coast of Bangladesh. *Journal of Aquatic Science*, 6(1), 1-7.
- Talukder, A.S., Punom, S. J., Eshik, M. E., Begum, M. K., Islam, H. M. R., Hossain, Z., & Rahman, M. S. R. (2021). Molecular identification of white spot syndrome virus (WSSV) and associated risk factors for white spot disease (WSD) prevalence in shrimp (*Penaeus monodon*) aquaculture in Bangladesh. *Journal of Invertebrate Pathology*, 179, 107535.
- Hossain, M. M., Mostafiz, M., Ahamed, S., Hassan, M. M., Islam, M. A., Baten, M. A., Hoq, M. E. & Akter, T. (2022). Assessing cage culture potentiality of long whiskers catfish, *Mystus gulio* (Hamilton, 1822) in relation to climate change adaptation in Bangladesh coast. *Journal of Applied Aquaculture*, 34(3), 658-673.
- Nilufa, B., Siddiky, M. N. S. M. & Begum, M. A. (2021). Comparative study of growth performance of three live feed (Microalgae) species in indoor culture condition, *International Journal of Natural and Social Sciences*, 8(3), 67-71.
- Nilufa, B., Siddiky, M. N. S. M., & Ahmmed, S. (2021). Comparison of growth performance of live feed microalgae and rotifer (*Brachionus* sp.) under different feeding medium in outdoor culture condition, *World Journal of Biology Pharmacy and Health Sciences*, 5(2), 25–32.
- Islam, M.S., Begum, N., & Shofiquzzoha, A. F. M. (2021). Efficacy of formulated feed preference and stocking density on growth and survival of baby *Pila globosa* reared in laboratory condition. *Annual Research & Review in Biology*, 36(7), 86-91.
- Lslam, Z., Khatoon, H., Rahman, M. R., Hasan, J., & Hasan, S. J. (2021). Screening of natural pigments from indigenous marine microalgae isolated from different coastal aquafarms of Bangladesh. *Bangladesh Journal of Veterinary and Animal Sciences*, 9(2): 61-72.
- Islam, Z., Khatoon, H., Rahman, M.R., Barman, S. K., Hossain, S., Usha, S. Z., Hasan, S. J., & Hasan, J. (2022). Growth, productivity and proximate profiling of indigenous marine microalgae from southern coast of Bangladesh as potential feedstuff for animal feed. *Bioresource Technology Reports*, 18, 101025.

- Hasan, J., Islam, Z., Rabby, A.F., Sonia, S.S., Aktaruzzaman, M., Rahman, T., Rahman, S., & Mahmud, Y. (2022). Dataset describing the growth pattern, amino acid and fatty acid profile of five indigenous marine microalgae species of Bangladesh. *Data in Brief*, 108643
- Sobuj, M. K. A., Rabby, A. F., Rahman, S., Hasan, S.J., Bhowmik, S., Islam, M.A., Islam, M.M., Mostofa, M.G., & Mamun, A.A. (2022). Knowledge, attitudes, and practices on food safety and hygiene of wet and dry fish handlers in Cox's Bazar, Bangladesh. *Food Science & Nutrition*, 10(12), 4139-4154.
- Flura, Moniruzzaman, M., Alam, M.A., Rahman, M. H., Didar, M. A. K., Ali, A., Rashid, M.H., Rahman, M.A., & Mahmud, Y. (2022). Length-weight relationship and relative condition factor of Hilsa (*Tenualosa ilisha*) fishes in the Bay of Bengal, Bangladesh. *American Journal of Life Science and Innovation (AJLSI)*, 1(2), 21-28.
- Flura, Moniruzzaman, M., Alam, M. A., Rashid, M. H. Rahman, M. H., Rahman, M. A., & Mahmud, Y. (2022). An Assessment of the water quality factors: A case of hilsa fishery river areas. *Asian Journal of Fisheries and Aquatic Research*, 20(1), 30-47.
- Alam, M. A., Flura, Rahman, M. A., Ali, A. Chowdhury, A. I. A., Rahman, M. H., Moniruzzaman, M., Ullah, M. R., & Mahmud, Y. (2022). Ecological risk of the river Halda: A perspective from heavy metal assessment. *International Journal of Aquatic and Fisheries Science*, 8(3), 66-79.
- Khatun, M., Mondol, M. R. K., Rahman, S., Alam, M. A., Bashar, M. A., & Mahmud, Y. (2022). Existence of panmictic Hilsa shad (*Tenualosa ilisha*) populations from two large river ecosystems in Bangladesh revealed by mitochondrial control region. *Bangladesh Journal of Fisheries*, 34(1), 77-86.
- Ahammad, A.K.S., Hasan, N. A., Bashar, A., Ahmed, M. B. U., Alam, M. A., Asaduzzaman, M., M. Bashar, A., Mahmud, Y., & Haque, M. M. (2021). Environmental factors and genetic diversity as drivers of early gonadal maturation: A gonadosomatic index-based investigation on Indian Shad, *Tenualosa ilisha* population of Bangladesh. *Frontiers in Marine Science*, 8, 758868.
- Hanif, M. A., Sharker, M. R., Hossen, S., & Bipu, M. (2021). New distributional record of oblique-banded groper, *Epinephelus radiatus* (Day, 1868) from the St. Martin Island, Bangladesh. *Aquatic Research*, 4(2), 145-150.
- Das, B. C., Akter, M., Khatun, A., Moniruzzaman, Hossain, M. A. R., & Rashid, H. (2022) Length-Weight relationship of mature Hilsa, *Tenualosa ilisha* in Bangladesh. *Bangladesh Journal of Fisheries*, 34(1), 95-108.
- Khan, A.B.S., Islam, M.A., Tanbirul, A.S.M.H., Rahman, M.A., & Mahmud, Y. (2021). Growth and yield performance of a sustainable aquaculture of cuchia, *Monopterus cuchia* (Hamilton, 1822) under different type of feeds in Bangladesh. *International Journal of Fisheries and Aquatic Studies*, 9(5), 215-220.
- Islam, M.A., Bosu, A., Hasan, M.M., Yasmin, F., Khan, A.B.S., Akhter, M., Ullah, M.R., Karim, E., Rashid, M.H., & Mahmud, Y. (2023). Culture technique of seabass, *Lates calcarifer* in Asia: A review. *International Journal of Science and Technology Research Archives*, 4(1), 006-017.

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