Seventh Biennial Fisheries Conference Research Fair 2016 29-30 October 2016





Bangladesh Fisheries Research Forum



Blue Economy: Horizon of new Opportunities Initiatives by Department of Fisheries (DoF) Ministry of Fisheries and Livestock (MOFL)

- Bangladesh has acquired a hightech multipurpose survey and research vessel 'R.V. Meen Shandhani' from Malaysia has already been arrived in Bangladesh in June, 2016.
- Hopefully, after a successful inauguration by Prime Minister, 'R.V. Meen Shandhani' will start its survey operations in the Bay of Bengal from November, 2016.



- To explore industrial tuna fishing in Exclusive Economic Zone (EEZ) and Area Beyond National Jurisdiction (ABNJ) of Bangladesh territory, the MOFL has issued 4 Long Liner Fishing Licenses.
- Bangladesh has been involved with the Indian Ocean Tuna Commission (IOTC) as a Cooperating Non Contracting Party (CNCP).



- Vessel Tracking & Monitoring System (VTMS) has been equipped in 133 industrial trawlers for tracking fishing vessels that are operating in the Bangladesh territory of the Bay of Bengal.
- As conservation measure, the MOFL has applied a 65-day annual ban on all fishing trawlers operating in Bangladesh waters every year between 20 May and 23J uly.
- The MOFL has placed a moratorium on the issuance of new licenses for industrial trawlers until further notice.





Department of Fisheries, Ministry of Fisheries and Livestock, Bangladesh



7th Biennial Fisheries Conference & Research Fair 2016

29 – 30 October 2016 Bangladesh Agricultural Research Council Dhaka, Bangladesh

Book of Abstract

Fish Biology Fish Biodiversity & Biotechnology Aquatic Resources Coastal Aquaculture Aquaculture Socioeconomics & Policy Issues Marine Resources Product Development

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Foreword

Bangladesh Fisheries Research Forum (BFRF) is a national, non-political and non-profit organization, which has developed and been developing network among fisheries professionals working in different universities, public extension, research and development organizations, nongovernment organizations, and private sectors, with a major objective of sharing and exchange of knowledge and experience gained through research, extension and development activities to promote growth in the fisheries sector. In line with this objective, BFRF since its establishment in 2002 has been organizing Biennial Fisheries Conference and Research Fair, where academicians, scientists and researchers, extension and development workers from home and abroad submit and present both oral and poster papers. Through this conference not only the present state of research and experience is shared, but future researchable issues have been identified and recommendations are made to relevant policy makers and planners to undertake and implement the programmes. The conference also provides space for fisheries related industries to present their products.

As in the past, BFRF has been organizing its 7th Biennial Fisheries Conference and Research Fair 2016 to bring together the fisheries scientists, extension agencies and relevant stakeholders for presenting and sharing their current research and development outputs and knowledge. The key presentation of this year Biennial conference is on "Blue Economy". Apart that there will be eight thematic technical sessions followed by a key presentation for each. A total of 146 abstracts have been received this year, those will be found in this Book of Abstracts, for presentation in different scientific sessions. Among the submitted abstracts, 80 will be presented orally and 30 as posters. The presented papers will be screened out for in the scale of notable scientific innovations and published in the Proceedings as Advances in Fisheries- Volume 3. Besides forwarding abstract book, I am delighted to extend my warm gratitude for getting highly positive support and feedback of BFRF members and other interested partners and institutions for regular publication of our half yearly magazine, Fisheries and Aquaculture News -Bangladesh "FAN".

I, on behalf of the editorial committee, sincerely thank the contributors to this Book of Abstracts and look forward to their presentations in the conference. The generous assistance and support of different government and non-government agencies is gratefully acknowledged for organizing the 7th Biennial Conference and Research Fair 2016 and publication of this Book of Abstract and other printed materials. I greatly acknowledge the support of all Executive Members and enthusiastic efforts of editorial members that made this publication possible timely.

Finally, I hope this compilation of Abstracts of conference papers will serve as a hub of current research areas and results and help in identifying new research areas for the development of the fisheries sector.

Dr. Md. Jahangir Alam

President, Bangladesh Fisheries Research Forum and Professor, Bangabandhu Sheikh Mujibur Rahman Agricultural University

Contents

KEYNOTE PAPER

BLUE ECONOMY- SUSTAINABLY USING OUR OCEANS FOR PROSPEROUS FUTURE	
Rear Admiral Md. Khrshed Alam (retd.) MPhil, ndc, psc	xvi
FISH BIOLOGY	
<u>Keynote Paper</u> DNA BARCODING: AN EMERGING STANDARD MOLECULAR TAXONOMIC TOOL FOR BIODIVERSITY CONSERVATION Ahmed, Md. Sagir	1
HISTOPATHOLOGICAL EFFECTS OF TOXIC <i>MICROCYSTIS AERUGINOSA</i> BLOOM ON LIVER OF <i>OREOCHROMIS NILOTICUS</i> Ahmed, Sumaiya and Md. Sagir Ahmed	2
DETECTION OF MICROCYSTINS IN NILE TILAPIA (OREOCHROMIS NILOTICUS) FROM A EUTROPHIC PONDS CONTAINING MICROCYSTIS AERUGINOSA BLOOM IN DHAKA Ahmed, M.S., S. Ahmed, B. Giese, V. Schulz and B. Luckas	4
EFFECT OF MANNAN OLIGOSACCHARIDE SUPPLEMENTATION ON DIGESTIVE ENZYME ACTIVITIES AND INTESTINAL MORPHOLOGY OF STRIPED CATFISH (<i>PANGASIANODON</i> <i>HYPOPHTHALMUS</i>) JUVENILES Akter, Nahid, Amalia Sutriana, Roshada Hashim and Siti Azizah Mohd Nor	5
GENETIC VARIATION IN FOUR POPULATIONS OF <i>CHANNA STRIATA</i> (CHANNIDAE: PERCIFORMES) REVEALED BY PCR-RFLP AND SEQUENCE ANALYSIS OF MITOCHONDRIAL GENE Alam, Mohammad Shafiqul, Tahsina Sharmin and Sabiqun Nahar	6
GENETIC VARIATION IN CLIMBING PERCH <i>(ANABAS TESTUDINEUS</i>) FROM THE CHALAN BEEL WETLAND IN BANGLADESH Arifuzzaman, Shanko Rani Deo, Sabiqun Nahar, Mohammad Abdus Sala and Mohammad Shafiqul Alam	7
GENETIC VARIATION IN CLIMBING PERCH (<i>ANABAS TESTUDINEUS</i>) FROM THE WETLAND ECOSYSTEM IN MYMENSINGH AND DHAKA Deo, Shanko Rani, Arifuzzaman, Sabiqun Nahar, Mohammad Lutfar Rahman and Mohammad Shafiqul Alam	8
EFFECTS OF <i>ACHYRANTHES ASPERA</i> TO THE IMMUNITY OF ROHU (<i>LABEO ROHITA</i>) AGAINST <i>PSEUDOMONAS FLUORESCENS</i> Hasan-Uj-Jaman, Md., Md. Mer Mosharraf Hossain, Shoumo Khondoker, Md. Eftakher Alam, Md. Farid Uz Zaman and Sanjoy Banerjee Bappa	9
APPLICATION OF GENETIC BIOTECHNOLOGY FOR THE IMPROVEMENT AND CONSERVATION OF FISHERIIS RESOURCES OF BANGLADESH Miah, Md. Faruque and M. Niamul Naser	10
EMBRYOGENESIS AND DNA POLYMORPHISM OF STRINGING CATFISH (<i>HETEROPNEUSTES FOSSILIS</i>) FROM SYLHET HAOR AREA, BANGLADESH Miah, Md. Faruque, Rizoneul H Reza and M. Niamul Naser	11

MOLECULAR CHARACTERIZATION OF <i>VIBRIO PARAHAEMOLYTICUS</i> IN ESTUARINE FISH FROM DHAKA CITY MARKETS, BANGLADESH Nitu, Fahmida Khalique, M Niamul Naser, S. Basu and M.M. Alam	12
IDENTIFICATION OF PATHOGENIC GUT MICROBIOTA OF ROHU, <i>LABEO ROHITA</i> AND SILVER CARP, <i>HYPOPHTHALMICHTHYS MOLITRIX</i> BY 16S RRNA GENE SEQUENCEING	
Punom, Nusrat Jahan, A.K.M. Mahbub Hasan, Wahida Haque, Khadiza Begum and Mohammad Shamsur Rahman	13
RECENT ADVANCES IN MOLECULAR DETECTION OF BACTERIAL FISH PATHOGENS IN BANGLADESH	
Rahman, Md. Mahbubur, Md. Javed Foysal, Md. Mahbubul Alam, Hammadul Hoque, Muntasir Rahma, Md. Saruar Hossain, Nabangshu Shekhar Das, Suzan Chandra Deb and Janmajoy Dey	14
EMBRYONIC AND LARVAL DEVELOPMENT OF MICRONUTRIENT DENSE SMALL FISH Saha, Manos Kumar, Shantanu Sarkar Utsa, Md. Mokarram Hossain, Benoy Kumar Barman and Mostafa Ali Reza Hossain	15
GENETIC CHARACTERIZATION OF GOBI FISHES (PERCIFORMES: GOBIIDAE, ELEOTRIDAE) OF BANGLADESH THROUGH DNA BARCODES Tabassum, Mehnus, Hawa Jahan, Gulshan Ara Latifa and Md. Mizanur Rahman	16
SOME ASPECTS OF MORPHOLOGY AND LENGTH-WEIGHT RELATIONSHIP OF THE SMALL INDIGENOUS SPECIES <i>AILIA COILA</i> (HAMILTON, 1822) FROM DHARLA RIVER, KURIGRAM	
Tanjiba Mahajebin, Rownok Ara Afrin, Md. Zahan Ali and Imran Parvez	17
FISH BIODIVERSITY & BIOTECHNOLOGY	
SEASONAL VARIATION OF HEALTH STATUS OF SOME SMALL ENDANGERED OPEN WATER FISHES OF SURMA AND KONGSA RIVERS Ahmed, G.U. and M.M. Rahman	18
AN ANALYSIS ON DIVERSITY IN EXOTIC AQUATICPET TRADE: A POTENTIAL THREAT TO FISHERIES RESOURCES OF BANGLADESH Akash, Muntasir	19
SEASONAL VARIATION OF PLANKTON COMMUNITY OF DHEPA RIVER IN DINAJPUR, BANGLADESH Ara, Y., Z. Ferdoushi and M. Zannat	20
DIVERSITY STATUS OF FISHES OF THE MEGHNA RIVER ADJACENT TO NARSINGDI DISTRICT, BANGLADESH Bhuyan, Md. Simul, Md. Shafiqul Islam and Aysha Akhtar	21
HEAVY METALS IN SOME COMMERCIALLY IMPORTANT FISHES OF MEGHNA RIVER ADJACENT TO NARSINGDI DISTRICT, BANGLADESH: HEALTH RISK ASSESSMENT Bhuyan, Md. Simul, Muhammad Abu Bakar, Aysha Akhtar and Md. Shafiqul Islam	22

AQUATIC HABITAT SUITABILITY ASSESSMENT IN GAZIPUR, BANGLADESH USING GEO-SPATIAL TECHNOLOGY Das, Susmita, Roland Nathan Mandal, Md. Motaleb Hossain Sarker, Goutam Kumar

Kundu, Md. Hasan Faruque, Bijoya Paul and Md. Monirul Islam

A NEW SPECIES OF *TRICHODINA* EHRENBERG, 1838 (CILIOPHORA: PERITRICHIDA) FROM THE FRESHWATER FISH OF THE BAIKKA BEEL, MOULVIBAZAR, BANGLADESH Hoque, Mohammad A., Mohammad M. Kibria and Ghazi S.M. Asmat 23

24

LIFE HISTORY TRAITS OF BANDED GOURAMI, <i>Trichogaster fasciata</i> (BLOCH AND SCHNEIDER, 1801) IN THE PADMA RIVER, NORTHWESTERN BANGLADESH Hosnara, Omma, Md. Yeamin Hossain, Md. Alomgir Hossen, Fairuz Nawer, Dalia Khatun,	
Farida Parvin, Susen Chandrar Oy and Zoarder Faruque Ahmed GROWTH, FORM FACTOR, SEXUAL MATURITY AND NATURAL MORTALITY OF	25
FIVE <i>MYSTUS</i> SPECIES FROM BANGLADESH Hossen, Md. Alomgir, Md. Yeamin Hossain, Fairuz Nawer, Dalia Khatun, Md. Nasir Uddin Pramanik, Farida Parvin, Md. Akhtar Hossain and Zoarder Faruque Ahmed	26
ESTIMATION OF CONDITION FACTOR OF THE CRITICALLY ENDANGERED CATFISH CLUPISOMA GARUA IN THE PADMA RIVER THROUGH MULTIPLE FUNCTIONS Hossain, Md. Akhtar, Md. Yeamin Hossain, Md. Alomgir Hossen, Dalia Khatun, Fairuz Nawer, Farida Parvin, Md. Nasir Uddin Pramanik and Zoarder Faruque Ahmed	27
CONSERVATION OF THREATENED SIS WITH CONSIDERATION OF CLIMATE CHANGES IN BANGLADESH Hossain, Md. Yeamin, Md. Alomgir Hossen, Fairuz Nawer and Zoarder Faruque Ahmed	28
ASSESSMENT OF FISH DIVERSITY IN KIRTANKHOLA RIVER: PRESENT STATUS, THREATS AND CONSERVATION PERSPECTIVES	
Hossen, Shaharior, Md. R. Sharker, Md. S. Alom and Zahid P. Sukhan	29
IMPACT OF CLIMATIC HAZARDS ON THE JAMUNA RIVER FISHERIES AND COPING AND ADAPTATION STRATEGIES Islam, Farah, Md. Monirul Islam, Mosammat Salma Akter and Goutam Kumar Kundu	30
ASSESSMENT OF AQUATIC FAUNAL DIVERSITY IN THE RATARGUL SWAMP FOREST AT SYLHET IN BANGLADESH	
Islam, Md. Sirajul, Nasrin Akter Sweety, Md. Ashraful Islam, Mostafa Ali Reza Hossain and Md. Humayun Kabir	31
BOTIA DARIO (HAMILTON, 1822): LOCALLY ENDANGERED SPECIESRECORDED FROM ARIAL BEEL, BANGLADESH	
Jahan, Israt Jebin, Sharmin Rahman, Gouranga Kumar Biswas, Md. Nasif Sadat	32
POPULATION BIOLOGY OF <i>CORICA SOBORNA</i> IN THE PADMA RIVER, BANGLADESH Jasmine, Saleha, Sadicunnahar Shikha, Md. Yeamin Hossain, Md. Alomgir Hossen, Md. Golam Sarwar, Dalia Khatun and Fairuz Nawer	33
IRRIGATION WATER USE OF HALDA RIVER – AN ECONOMIC ANALYSIS Kabir, Md. Humayain, Md. Manzoorul Kibria, Mohammad Mosharraf Hossain and Jewel Das	34
INVESTIGATION OF HEAVY METAL CONTAMINATION IN WATER, FISH AND SEDIMENTS IN THE SHITALAKHYA RIVER AT NARSINGDI OF BANGLADESH Kabir, Md. Humayun, Md. Sirajul Islam, Md. Enamul Hoq, Tanmoy Roy Tusher and Tandra Datta	35
FRAUDULENCE DETECTION IN FISH MARKETING OF BANGLADESH USING DNA BARCODING Smriti, Sagorika, Tahmina Islam, Khadiza Begum, Rakha Hari Sarker, Anwar Hossain and Mehammand Shamsur Pahman	26
	30
FISH BIODIVERSITY STATUS OF THE PUNARVABA RIVER OF DINAJPUR WITH SPECIAL REFERENCE TO AVAILABILITY, THREATS AND CONSERVATION MEASURES Chainika Banerjee, Rownok Ara Afrin, Abu Bakkar Siddik and Imran Parvez	37
IDENTIFICATION OF F1 CROSSBREEDS (♀NATIVE <i>CLARIAS BATRACHUS</i> AND EXOTIC <i>े CLARIAS GARIEPINUS</i>) AT ITS FINGERLING STAGE Kazal Rekha, Rukaiya Akter Rumi, Dilruba Nasrin, and Imran Parvez	38

AQUATIC RESOURCES

IMPACTS OF CLIMATE VARIABILITY AND CHANGE ON FISHERIES OF THE PADMA RIVER AND ADAPTATION STRATEGIES Khan Makidul Islam Md Monirul Islam Goutam Kumar Kundu and	
Mosammat Salma Akter	39
GROWTH, CONDITION, MATURITY AND MORTALITY OF THE GANGETIC LEAF FISH <i>NANDUS NANDUS</i> IN THE PADMA RIVER, BANGLADESH Khatun, Dalia, Md. Yeamin Hossain, Md. Alomgir Hossen, Fairuz Nawer, Md. Nasir Uddin Pramanik, Farida Parvin, Alok Kumar Paul and Md. Akhtar Hossain	40
BARRIERS TO OXBOW LAKE (<i>BAOR</i>) FISHERIES MANAGEMENT: CASES FROM SOUTH-WESTERN BANGLADESH Mondal, Gouri, Md. Monirul Islam, Goutam Kumar Kundu and Chandan Kar	41
POPULATION PARAMETERS OF IMPORTANT SPECIES IN SUNDARBANS ECOSYSTEM OF BANGLADESH Mustafa, Md. Golam and Mohammod IIyas	42
ORGANOHALOGEN RESIDUES OF FISHES FROM DIFFERENT TROPHIC LEVELS IN DIFFERENT SEASONS OF MEGHNA RIVER, BANGLADESH Mustafa, Tonima, M. Niamul Naser, Gulshan Ara Latifa, Mohammad Shoeb and Nilufar Nahar	43
GROWTH PATTERN AND CONDITION INDEX OF FRESHWATER MUSSEL LAMELLIDENS MARGINALIS (LAMARCK, 1819) FROM NORTHWEST BANGLADESH Nahar, Dil Afroz, Md. Sahadul Islam and Md. Mostafizur Rahman Mondol	44
BIOMETRIC INDEX OF STRIPED DWARF CATFISH, <i>MYSTUS VITTATUS</i> (Bloch, 1794) FROM THE PADMA RIVER, NORTHWESTRN BANGLADESH Nawer, Fairuz, Md. Yeamin Hossain, Md. Alomgir Hossain, Dalia Khatun, Md. Nasir Uddin Pramanik, Farida Parvin, Md. Akhtar Hossain and Zoarder Faruque Ahmed	45
PRESENT STATUS OF FISH BIODIVERSITY IN DEKHAR HAOR, BANGLADESH: A CASE STUDY Pandit, Debasish, Mrityunjoy Kunda, Ahmed Harun-Al-Rashid, Md. Abu Sufian and Sabuj Kanti Mazumder	46
MORPHOMETRIC AND MERISTIC TRAITS OF ENDANGERED TICTO BARB <i>PETHIA TICTO</i> FROM THE PADMA RIVER IN NORTHWESTERN BANGLADESH Parvin, Farida, Md. Alomgir Hossen, Fairuz Nawer, Md. Nasir Uddin Pramanik, Dalia Khatun, Md. Akhtar Hossain and Md. Yeamin Hossain	47
FISHERIES RESOURCES AND FISHING EFFORTS OF THE ANDHARMANIK RIVER Rahman, M. Jalilur, M. Abdul Wahab, Md. Nahiduzzaman, M. Jimi Reza, M. Mohammad Ali and M. Israil Golder	48
HEALTH CONDITION OF SOME SMALL INDIGENOUS SPECIES OF OPEN WATER BODIES: A HISTOPATHOLOGICAL STUDY Rahman, M.M., G.U. Ahmed and M.F.U. Zaman	49
INVESTIGATION OF HEAVY METAL CONCENTRATION IN WATER AND FISH FROM BANGSHI RIVER AT MIRZAPUR IN BANGLADESH Rehnuma, Mausumi, Md. Sirajul Islam, Nowara Tamanna Meghla, Sonia Sattar Tithi and Md. Humayun Kabir	50
-	-

RAPID 16S rRNA NEXT GENERATION SEQUENCING OF BACTERIAL COMMUNITY IN THE TAMA RIVER AT SUBURBAN TOKYO, JAPAN Reza, Md. Shaheed, Nanami Mizusawa, Chiharu Oikawa, Daisuke Ouchi, Ayaka Kumano, Atsushi Kobiyama, Yuichiro Yamada, Yuri Ikeda, Daisuke Ikeda, Kazuho Ikeo, Shigeru	
Sato, Takehiko Ogata, Ko Yasumoto, Mitsuru Jimbo, Toshiaki Kudo and Shugo Watabe	51
HAOR FISHERIES MANAGEMENT: PRESENT STATUS, CHALLENGES AND OPPORTUNITIES Roy, Nirmal C.	52
STOCK STRUCTURE ANALYSIS OF MOLA (<i>AMBLYPHARYNGODON MOLA</i>) FROM DIFFERENT REGIONS OF BANGLADESH USING MORPHOMETRIC, MERISTIC CHARACTERS ALONG WITH LANDMARK BASED TRUSS NETWORK MEASUREMENTS Saha, Manosh Kumar, Shantanu Sarkar Utsa, Mostafa Ali Reza Hossain and Benoy Kumar Barman	53
IMPACTS OF TEMPORAL AND SPATIAL FISHING BAN ON FISH AND SHELLFISH BIODIVERSITY IN TWO FISH SANCTUARIES IN BANGLADESH Saha, Samapti, Goutam Kundu, Md. M. Islam, Bijoya Paul and Gouri Mondal	54
BIOMETRIC INDICES OF MOLA CARPLET (<i>AMBLYPHARYNGODON MOLA)</i> IN THE PADMA RIVER, BANGLADESH Sarwar, Md. Golam, Md. Yeamin Hossain, Sadicunnahar Shikha, Md. Alomgir Hossen, Fairuz Nawer, Dalia Khatun, Farida Parvin and Saleha Jasmine	55
PHYSICO-CHEMICAL PARAMETERS AND PLANKTON ABUNDANCE OF THE NATURAL BREEDING GROUND OF KAPTAI LAKE, BANGLADESH Uddin, Kazi Belal, M.A. Bashar, A.K.M. Saiful Islam, S. Sanjib Basak, Masud Hossain Khan and Yahia Mahmud	56
MULTISPECIES FISH PASSAGE BEHAVIOUR IN A VERTICAL SLOT FISHWAY IN LABORATORY SYSTEM Zaman, Maria, M. Niamul Naser, Rezanur Rahman ¹ and Umme Kulsum Navera	57
COASTAL AQUACULTURE	
STOCKING DENSITY AND MALE MORPHOTYPES FORMATION OF PRAWN MACROBRACHIUM ROSENBERGII IN PROBIOTIC BASED CULTURE SYSTEM Ashrafi, S. and M.S. Shah	58
OPTIMIZATION OF STOCKING DENSITY OF GIANT FRESHWATER PRAWN MACROBRACHIUM ROSENBERGII UNDER PROBIOTICS ADMINISTERED CULTURE Azad, Md. Abul Kalam, Shikder Saiful Islam, Joyanta Bir and Khandaker Anisul Huq	59
PROBIOTIC INFLUENCE ON PRODUCTION PERFORMANCE OF GIANT FRESHWATER PRAWN <i>MACROBRACHIUMROSENBERGII</i> IN EARTHEN POND Azad, Md. Abul Kalam, Shikder Saiful Islam, Joyanta Bir and Khandaker Anisul Huq	60
ENVIRONMENTAL IMPACT OF SHRIMP FARMING IN BANGLADESH: HABITAT, LANDSCAPE AND BIODIVERSITY Hossain, M.A.R., S.A.A. Nahid, D. Soto, M.R. Hasan and M. Robson	61
ABUNDANCE OF PHYTOPLANKTON IN FRESHWATER PRAWN MACROBRACHIUM ROSENBERGII FARMING WITH DIFFERENT CARBON AND NITROGEN RATIOS IN BIOFLOC AVSTEM	
Islam, Md. Amirul, Chinmoy Sadhu Khan, Wasim Saddir, Prosen Majumder, Md. Naser All Mahadi and Khandaker Anisul Huq	62
OPTIMIZATION OF CARBON NITROGEN RATIO INBIOFLOC BASED PRAWN (MACROBRACHIUMROSENBERGII) FARMING SYSTEM	
isiani, mai zinnai, vyyäntä bii, nimi Nakivui Isiaili, Etysetti Majuttueti, Mui Naset	

CO-CULTURE-INDUCIBLE PROBIOTIC ACTIVITY OF <i>LACTOBACILLUS</i> ISOLATES AGAINST SHRIMP PATHOGENS Karim, M. Manjurul, Farzana E. Hossain, Md. Shakiluzzaman and Abu M. Ramim	64
FACTORS THAT INFLUENCE THE PRODUCTION OF TIGER SHRIMP (<i>PENAEUS MONODON</i>) AT BAGERHAT, BANGLADESH Mahashin, Md. and M. Niamul Naser	65
PLANKTON VARIABILITY IN PROBIOTIC TREATED ANDNON-TREATED PRAWN (<i>MACROBRACHIUM ROSENBERGII</i>) CULTURE SYSTEM MAINTAINING CARBON AND NITROGEN RATIO 15:1 Majumder, Prosen, Md. Naser All Mahadi, Alokesh Kumar Ghosh, Joyanta Bir, Shikder Saiful Islam, Md. Amirul Islam and Khandaker Anisul Huq	66
EFFECTS OF <i>AEGLE MARMELOS</i> LEAVES EXTRACT AGAINST WHITE SPOT SYNDROME VIRUS (WSSV) INFECTION IN SHRIMP <i>PENAEUS MONODON</i> Mohim Al Mostaqur, Md., Ghausiatur Reza Banu and Md. Abu Sayeed	67
DEVELOPMENT OF A MULTIPLEX PCR PROTOCOL USING NOVEL PRIMER FOR RAPID DETECTION OF WHITE SPOT SYNDROM VIRUS IN SHRIMP Parvez, Md. Shahin and Md. Nazmul Ahsan	68
OPTIMIZATION OF DNA EXTRACTION PROTOCOL FOR RAPID DETECTION OF WSSV IN SHRIMP USING NON-PATENTED BULK REAGENTS Parvez, Md. Shahin and Md. Nazmul Ahsan	69
ANTIVIRAL POTENTIAL OF <i>MOMORDICACHARANTIA</i> LEAVES EXTRACT AGAINST WHITE SPOT SYNDROME VIRUS (WSSV) OF BLACK TIGER SHRIMP <i>Penaeus monodon</i> Sayeed, Md. Abu, Md. Mohim Al Mostaqur, Ghausiatur Reza Banu	70
STUDY ON WATER AND SOIL QUALITY PARAMETERS OF SHRIMP AND PRAWN FARMING IN THE SOUTHWEST REGION OF BANGLADESH Zafar, M.A., M.M. Haque, M.S.B. Aziz and M.M. Alam	71
AQUACULTURE	
<u>Keynote Paper</u> CURRENT CHALLENGES AND FUTURE PROSPECTS OF AQUACULTURE IN BANGLADESH Hoque, Monowarul	72
EFFECT OF GAS REMOVAL CHEMICAL (G.R. PLUS) ON GROWTH AND HEALTH CONDITION OF THAI SARPUNTI (<i>PUNTIUS GONIONOTUS</i>) Ahmed, G.U., A. Yeasmin, M.M. Rahman and M.N. Alam	73
MEASURING VULNERABILITY OF AQUACULTURE TO CLIMATE VARIABILITY AND CHANGE IN 64 DISTRICTS OF BANGLADESH Barman, Aparna, Md. Monirul Islam, Md. Alamgir Kabir, Goutam Kumar Kundu and Bijoya Paul	74
GROWTH AND PRODUCTION PERFORMANCE OF CARP POLYCULTURE IN HILLY CREEKS OF KAPTAI LAKE, BANGLADESH Bashar, M.A., S. Sanjib Basak, Kazi Belal Uddin, A.K.M. Saiful Islam, Masud Hossain Khan and Yahia Mahmud	75
IMPACT OF PROBIOTICS ON THE GROWTH AND PRODUCTION OF TILAPIA (OREOCHROMIS NILOTICUS) IN FRESHWATER Begum, N., M.S. Islam and J. Ferdousy	76
GROWTH PERFORMANCE OF MONOSEX TILAPIA (<i>OREOCHROMIS NILOTICUS</i>) UNDER DIFFERENT STOCKING DENSITIES IN CAGES IN THE <i>HAOR</i> AREAS, BANGLADESH Bhuiyan, Shahidul Islam, Fozlul Kabeer and A.K.M. Nowsad Alam	77

PRODUCTION ENHANCEMENT OF MONOSEX TILAPIA (<i>OREOCHROMIS NILOTICUS</i>) RAISED IN FIBRE GLASS TANKS, WITH DL-METHIONINE SUPPLEMENTATION Bhuiyan, Shahidul Islam, Fozlul Kabeer and A.K.M. Nowsad Alam	78
EFFECTS OF STOCKING DENSITY ON GROWTH PERFORMANCE OF CAGE REARED CLIMBING PERCH (<i>ANABAS TESTUDINEUS</i>) OF HIGH YIELDING VIETNAMESE STRAIN Bhuiyan, Shahidul Islam, Fozlul Kabeer and A.K.M. Nowsad Alam	79
A SUSTAINABLE AQUACULTURE METHOD ON PRODUCTION OF CUCHIA (<i>MONOPTERUS CUCHIA</i>) IN BANGLADESH Chakraborty, B.K.	80
UNDERSTANDING FISHERY EXIT AND ENTRY IN CHITTAGONG COAST OF BANGLADESH Chowdhury, M.E.B., M.S. Islam and M.M. Islam	81
LIVE FISH TRANSPORT AND MARKETING IN RAJSHAHI REGION: AN ATTEMPT TO DELIVER FISH AS SAFE FOOD Ehshan, Md. Aminul, Md. Israil Golder and Md. Shahed Ali	82
AN ASSESSMENT TO THE ABUNDANCE OF <i>PENAEUS MONODON</i> POST LARVAE (PL) AND TO QUANTIFY THE DAMAGE OF DIFFERENT AQUATIC FAUNA DURING COLLECTION OF <i>P. MONODON</i> PL IN MONGLA TIDAL RIVER Ferdousy, J., M.S. Islam and N. Begum	83
POTENTIAL OF IRON NANOPARTICLES TO INCREASE GROWTH AND DEVELOPMENT OF THAI SARPUNTI (<i>BARBONYMUS GONIONOTUS</i>) Haque, M.A., M.J. Alam, M.A.S. Jewel and P. Aliga	84
WATER QUALITY AND PLANKTON COMPOSITION IN FED MOLA (<i>AMBLYPHARYNGODON MOLA</i>) POND STOCKED AT DIFFERENT DENSITY Haque, Md. Mozzammel and Sharoz Mahin Haque	85
EFFECTS OF <i>ACHYRANTHES ASPERA</i> TO THE IMMUNITY OF ROHU (<i>LABEO ROHITA</i>) AGAINST <i>PSEUDOMONAS FLUORESCENS</i> Hasan-Uj-Jaman, Md., Md. Mer Mosharraf Hossain, Shoumo Khondoker, Md. Eftakher Alam, Md. Farid UZZ aman and Sanjoy Banerjee Bappa	86
GROWTH PERFORMANCE AND FATTY ACID PROFILE OF NILE TILAPIA (<i>OREOCHROMIS NILOTICUS</i>) FED WITH DIFFERENT PHYTOPLANKTON Hossain, Md. Babul, Nahid Sultana, Mahmuda Begum, Nusrat Jahan Punom, Khadiza Begum, Md. Rakibul Hasan and Mohammad Shamsur Rahman	87
ASSESSMENT OF POND PRODUCTIVITY FOR CARP FISH SPECIES IN RAJSHAHI Hossain, Md. Istiaque and Nasmul Haque	88
INTEGRATED FLOATING CAGE AQUAGEOPONICS SYSTEM (IFCAS): A CLIMATE ADAPTIVE INNOVATIVE SOLUTION FOR CO-PRODUCTION OF FISH AND VEGETABLE IN SALINE PRONE AREAS OF BANGLADESH Islam, F.U., M.K.I. Bhuiyan, M.M. Haque ¹ and R. Jahan	89
STUDY ON COMPARISON OF PRODUCTION PERFORMANCE AND ECONOMICS OF DIFFERENT CARP POLYCULTURE SYSTEMS IN GANGNI UPAZILA OF MEHERPUR Islam, M.J., M.N. Hasan, M. Kunda, M.A. Sultana and D. Pandit	90
POTENTIALITY OF SPROUTED WHEATGRASS POWDER AS FISH MEAL ALTERNATIVE FOR STINGING CATFISH FRY NURSING Islam, Tania and M.A. Salam	91
FIRST RECORD OF SEED PRODUCTION OF SWAMP MUD EEL (<i>MONOPTERUS CUCHIA</i>) IN CAPTIVITY BY ENVIRONMENT MANIPULATION Khan, Macksood Alam, Harunur Rashid, Kaniz Fatema, Zahid Parvez Sukhan, Mostafa A.R. Hossain and S.M. Rahmatullah	92

HEALTH STATUS OF A CATFISH (<i>MYSTUS VITTATUS)</i> FROM THREE FISH MARKETS OF MYMENSINGH, BANGLADESH Paul, Shyamal Kumar	93
ACUTE TOXICITY OF TWO HEAVY METALS ON LABORATORY CULTURED TUBIFICID WORMS Rahman, Md. Abedur, Goutam K. Kundu, Gouri Mondal and Salma Akter	94
HEALTH CONDITION OF SOME INDIGENOUS SPECIES OF OPEN WATER BODIES: A HISTOPATHOLOGICAL STUDY Rahman, M.M., G.U. Ahmed and M.F.U. Zaman	95
DEVELOPMENT AND INTRODUCE AQUAPONIC SYSTEMS FOR FISH AND VEGETABLES PRODUCTION THROUGH DECEIVING AQUACULTURE WASTE WATER Salam, M.A.	96
FISH AND VEGETABLE CULTURE IN THE BACKYARD: INTEGRATION OF HYDROPONICS WITH AQUACULTURE Salam, M.A.	97
EFFECT OF MIXED FEEDING SCHEDULE ON THE GROWTH OF <i>CLARIAS</i> BATRACHUS IN RAJSHAHI AREA Samad, Md. Abdus, Habiba Ferdaushy, M.R. Haque ¹ , Alok Kumar Paul	00
BIOLOGICAL CONSIDERATIONS IN HATCHERY MANAGEMENT: A CASE STUDY IN HATCHERIES OF JESSORE, BANGLADESH Shakil, M.S. and M.S. Shah	98
EFFECTS OF AERATION ON GROWTH PERFORMANCE OF TILAPIA IN INTENSIVE AQUACULTURE SYSTEM IN EARTHEN PONDS	100
Sultana, 1. and M.M. Haque	100
SOCIOECONOMICS & POLICY ISSUES	100
SOCIOECONOMICS & POLICY ISSUES ENHANCED RESILIENCE OF HILSA FISHING COMMUNITIES IN BANGLADESH Brakel, Martin L. van, Farzana Naoshin, Rumana Akter, Safina Naznin, A.B.M. Mahfuzul Haque, Md. Nahiduzzaman and Md. Abdul Wahab	101
SOCIOECONOMICS & POLICY ISSUES ENHANCED RESILIENCE OF HILSA FISHING COMMUNITIES IN BANGLADESH Brakel, Martin L. van, Farzana Naoshin, Rumana Akter, Safina Naznin, A.B.M. Mahfuzul Haque, Md. Nahiduzzaman and Md. Abdul Wahab SOCIOECONOMIC CONDITIONS OF FISHERFOLK: INSIGHT FROM THE JAMUNA RIVER FISHING COMMUNITIES, BANGLADESH Islam, Farah, Md. Monirul Islam, Salma Akter and Goutam Kumar Kundu	101
SOCIOECONOMICS & POLICY ISSUES ENHANCED RESILIENCE OF HILSA FISHING COMMUNITIES IN BANGLADESH Brakel, Martin L. van, Farzana Naoshin, Rumana Akter, Safina Naznin, A.B.M. Mahfuzul Haque, Md. Nahiduzzaman and Md. Abdul Wahab SOCIOECONOMIC CONDITIONS OF FISHERFOLK: INSIGHT FROM THE JAMUNA RIVER FISHING COMMUNITIES, BANGLADESH Islam, Farah, Md. Monirul Islam, Salma Akter and Goutam Kumar Kundu UNDERSTANDING THE LIVELIHOOD CHARACTERISTICS OF THE MIGRATORY AND NON-MIGRATORY FISHERS OF THE PADMA RIVER, BANGLADESH Khan, Makidul Islam, Md. Monirul Islam, Goutam Kumar Kundu and Salma Akter	101 102 103
SUITAIIA, T. AND M.M. HAQUE SOCIOECONOMICS & POLICY ISSUES ENHANCED RESILIENCE OF HILSA FISHING COMMUNITIES IN BANGLADESH Brakel, Martin L. van, Farzana Naoshin, Rumana Akter, Safina Naznin, A.B.M. Mahfuzul Haque, Md. Nahiduzzaman and Md. Abdul Wahab SOCIOECONOMIC CONDITIONS OF FISHERFOLK: INSIGHT FROM THE JAMUNA RIVER FISHING COMMUNITIES, BANGLADESH Islam, Farah, Md. Monirul Islam, Salma Akter and Goutam Kumar Kundu UNDERSTANDING THE LIVELIHOOD CHARACTERISTICS OF THE MIGRATORY AND NON-MIGRATORY FISHERS OF THE PADMA RIVER, BANGLADESH Khan, Makidul Islam, Md. Monirul Islam, Goutam Kumar Kundu and Salma Akter FISHERIES CO-MANAGEMENT: KEY LESSONS DRAWN FROM PAST EXPERIENCE AND ECOFISH ^{BD} PROJECT Mustafa, M.G., M. Nahiduzzaman and M.A. Wahab	101 102 103 104
SUITAITA, T. AND M.M. HAQUE SOCIOECONOMICS & POLICY ISSUES ENHANCED RESILIENCE OF HILSA FISHING COMMUNITIES IN BANGLADESH Brakel, Martin L. van, Farzana Naoshin, Rumana Akter, Safina Naznin, A.B.M. Mahfuzul Haque, Md. Nahiduzzaman and Md. Abdul Wahab SOCIOECONOMIC CONDITIONS OF FISHERFOLK: INSIGHT FROM THE JAMUNA RIVER FISHING COMMUNITIES, BANGLADESH Islam, Farah, Md. Monirul Islam, Salma Akter and Goutam Kumar Kundu UNDERSTANDING THE LIVELIHOOD CHARACTERISTICS OF THE MIGRATORY AND NON-MIGRATORY FISHERS OF THE PADMA RIVER, BANGLADESH Khan, Makidul Islam, Md. Monirul Islam, Goutam Kumar Kundu and Salma Akter FISHERIES CO-MANAGEMENT: KEY LESSONS DRAWN FROM PAST EXPERIENCE AND ECOFISH ^{ED} PROJECT Mustafa, M.G., M. Nahiduzzaman and M.A. Wahab IMPROVEMENT OF LIVELIHOOD AND ADAPTATION TECHNIQUES OF FISHER COMMUNITY THROUGH THE ASSISTANCE RECEIVED UNDER CLIMATE PROGRAMS IN NOAKHALI AND LAKSHMIPUR, BANGLADESH Naher, Nurun and Mahabubur Rahman	100 101 102 103 104

INVOLVEMENT OF CHILD LABOUR IN HILSA FISHING AND ITS SUSTAINABILITY Naser, M. Niamul, Farzana Rahman and A.K.M Firoz Khan	107
WOMEN AND CHILD LABOUR GOVERNANCE ISSUES IN COASTAL HILSA FISHING VILLAGES OF BANGLADESH Naser, M. Niamul, Farzana Rahman and A.K.M Firoz Khan	108
GOVERNANCE OF HILSA SHAD (<i>TENUALOSA ILISHA</i>) FISHING DURING SPAWNING AND JATKA BAN PERIOD: COMPARED TO NON-BAN PERIOD Naser, M. Niamul, Sania Salim Sarna and A.K.M Firoz Khan	109
IMPACT OF BANNING PERIOD ON THE LIVELIHOOD OF THE HILSA FISHERMEN OF LOWER MEGHNA RIVER, BANGLADESH Naser, M Niamul, Sania Salim Sarna and A.K.M Firoz Khan	110
SOME TECHNICAL AND BUSINESS CONSTRAINTS IN CARP NURSERY OPERATION IN CHANCHRA, JESSORE, BANGLADESH Rahman, Md. Saidur and Md. Saifuddin Shah	111
ESTABLISHMENT OF WOMEN LED MOLA-CARP DEMONSTRATION POND IN DIFFERENT REGIONS OF BANGLADESH Saha, Manos Kumar, Shibaji Roy, Kamrul Hasa, Jewel Das, Md. Aslam Parvez, Sheikh Farid Uddin Ahammed and Md. Munim Hasan Chowdhury	112
IMPACTS OF NATIONAL AGRICULTURAL TECHNOLOGY PROJECT (NATP) ON GROWTH AND PRODUCTION OF TILAPIA DEMONSTRATION PACKAGE IN BANGLADESH Uddin, M. Shafique, M. Fazlul Awal Mollah, M. Mahfujul Haque and M. Hammadur Rahman	113
MARKETING CHANNEL AND SEASONAL PRICE VARIATION OF FISHES IN DINAJPUR, BANGLADESH Zannat, M., Y. Ara and Z. Ferdoushi	114
MARINE RESOURCES	
IDENTIFICATION OF CORAL ASSOCIATED FISH USING MORPHOMERISTICS AND MOLECULAR APPROACH FROM THE BAY OF BENGAL, BANGLADESH Baki, Mohammad A., Shilpi Saha, Kazi A. Habib, Subrina Sehrin and Anirban Sarker	115
LIVELIHOOD CHALLENGES OF MARINE FISHERS IN ANDHRA PRADESH, INDIA Dasu, Arjilli	116
GENETIC DIVERSITY AND POPULATION STRUCTURE OF <i>TENUALOSA ILISHA</i> IN THE BAY OF BENGAL AND THE PERSIAN GULF Habib, K. Ahsan, Jasmin Shathi, Mohammad N. Islam, Mohammad E. Hoque and A.H.M. Shafiullah Habib	117
DNA BARCODING REVEALS THAT MUD CRAB IN SUNDARBANS, BANGLADESH IS SCYLLA OLIVACEA (BRACHYURA: PORTUNIDAE), NOT S. SERRATA Habib, K. Ahsan, Sharmin Akter, Choong-Gon Kim, Muntasir Rahman and Md. Abdus Salam	118
NUTRITIONAL EVALUATION OF SOME SEAWEEDS FROM THE BAY OF BENGAL IN CONTRAST TO INLAND FISHES OF BANGLADESH Hoq, M. Enamul, M. Ashraful Haque, M. Shahzad Kuli Khan, M. Mozzammel Hoque and M. Mohidul Islam	119
COMMUNITY ECOLOGY OF CRAB LARVAE IN THE RIVERS OF SUNDARBANS MANGROVE FOREST, BANGLADESH Hoq, Md. Enamul	120

SEAWEED CULTURE IN DIFFERENT LOCATIONS OF BAY OF BENGAL COAST, BANGLADESH	
Islam, M. Mohidul, M. Enamul Hoq, Md. Shazad Kuli Khan, Jakia Hasan, Debbrota Mallick and Yahia Mahmud	121
PREVALENCE AND INTENSITY OF PARASITES WITH HISTOPARHOLOGICAL STUDY OF INFECTED ORGANS IN CROAKERS FROM COASTAL BANGLADESH	
Kabir, Nasima, Subrina Sehrin, Anirban Sarker, Md. Sagir Ahmed and Mohammad A. Baki	122
NURSERY REARING OF SEEDS OF MUD CRAB (<i>SCYLLA</i> SP.) IN EARTHEN POND Khan, Md. Shahzad Kuli, Md. Mozzammel Haque, Md. Mohidul Islam and Md. Enamul Hoq	123
RELATIONSHIP BETWEEN LINEAR DIMENSIONS OF SCALES IN FOUR MULLET SPECIES (MUGILIDAE) FROM THE KARACHI COAST, PAKISTAN	
Masood, Zubia, Rehana Yasmeen Fahrooq, Md. Yeamin Hossain, Fairuz Nawer and Md. Alomgir Hossen	124
BLUE ECONOMY: NEW HORIZON FOR ECONOMIC DEVELOPMENT OF BANGLADESH Miah, M. Ruyel, Nurnabi Nishad, Kobad Mia, M. Mokter Hossain, Jannatul Kubra, M Atick Chowdhury, Uttam	125
EXPLORING THE OPTIMUM TEMPERATURE AND DIET FOR GROWTH AND GASTRIC EMPTYING TIME OF JUVENILE MALABAR BLOOD SNAPPER (<i>LUTJANUS MALABARICUS</i>)	100
Mazumder, Sabuj K., Mazian, A. Ghaffar and Simon K. Das	126
PARTIAL HYDROLYSIS OF PHOSPHOLIPIDS OBTAINED FROM THE HEAD OF AUTUMN CHUM SALMON Shah, A.K.M. Azad, Toshihiro Nagao, Hideyuki Kurihara and Koretaro Takahashi	127
STUDY ON SARDINE USING MORPHOMETRIC AND DNA BARCODING TOOL FROM THE COAST OF BAY OF BENGAL Shamsunnahar M. Abdul Baki, A. Sarker, M. Sagir Ahmed and A.B.M. Zafaria	128
Shanisunnanar, M. Abuur Baki, A. Sarker, M. Sagir Annieu and A.B.W. Zarana	120
PRODUCT DEVELOPMENT	
<u>Keynote Paper</u> VALUE ADDED SEAFOOD PRODUCTS: LEAD SALES GROWTH AND MEET CURRENT CONSUMERS DEMAND	
Syed M. Istiak	129
SAFETY AND HYGIENE ISSUES: STATUS OF AWARENESS AMONG THE DRIED FISH PROCESSORS AT CHALAN BEEL AREA, BANGLADESH Alam, Md. Bayezid, M. Manjurul Alam, Muhammad Afzal Hussain, Syeda Nusrat Jahan and Fawzia Adib Elowra	120
MICROBIOLOGICAL QUALITY ASSESSMENT OF MOLA (AMBLYPHARYNGODON MOLA).	150
KACKI (<i>CORICA SOBORNA</i>) AND SANITATION STATUS OF A FISH PROCESSING INDUSTRY Bhowmik, Balai C., Golam S. Sonet, M. Mahamudul Hassan and Soma Saha	131
POST-HARVEST HANDLING AND QUALITY LOSS OF INDIAN MAJOR CARPS IN THE DISTRIBUTION CHANNEL OF NOAKHALI, BANGLADESH Chwakravorty, Palas, Mahabubur Rahman and Prianka Rani Majumder	132
SPECIES AVAILABILITY AND MARKETING SYSTEM OF TRADITIONALLY DRIED FISH IN RANGPUR DIVISION, BANGLADESH	400
rerooushi, Z., M. Kashed, M.A. Zatar, V.C. Koy and S. Islam	133

ANTIBACTERIAL AND ANTIOXIDANT EFFECTS OF GREEN TEA (<i>CAMELLIA SINENSIS</i>), TEJPATA (<i>CINNAMOMUM TAMALA</i>) AND ANAR (<i>PUNICA GRANATUM</i>) EXTRACTS AS NATURAL PRESERVATIVES OF RAW FISH Hague M. Jaburul Nasima Khan and Maria Zaman	134
QUALITY ASSESSMENT OF ANTIBIOTIC TREATED MRIGAL FISH (<i>CIRRHINUS</i> <i>CIRRHOSUS</i>) IN ICE STORAGE CONDITION Haque, Sved Ariful, M.S. Reza, M.N.A. Khan and M.K. Rahman	135
NUTRITIONAL STATUS, HEAVY METALS AND PESTICIDES RESIDUES IN SOME MARINE DRIED FISHES OF BANGLADESH COAST Hoq, M. Enamul, Mousumi Kar, M. Sirajul Islam and M. Monirul Islam	136
QUALITY ASPECTS OF FISH BALL FROM UNWASHED AND WASHED MIXED MINCE OF PANGAS (<i>PANGASIUS HYPOPHTHALMUS</i>) AND TUNA (<i>SARDA ORIENTALIS</i>) Hoque, Md. Sazedul, Shatabdi Roy, Shihab Sharar Mukit and Md. Boktheir Rahman	137
POST-HARVEST QUALITY LOSS OF SMALL INDIGENOUS SPECIES (SIS) IN SYLHET REGION: ENSURE QUALITY UP TO CONSUMER LEVEL Hossain, Md. Motaher and A.K. Apurbo Barman	138
BACTERIOLOGICAL QUALITY OF FROZEN AND UNFROZEN PABDA (<i>OMPOK PABDA</i>) IN THE FISH PROCESSING PLANT OF SYLHET, BANGLADESH Hossain, Md. Motaher, Protik Kumar Mojumder, Md. Abdul Baten and Md. Abu Sayeed	139
DETECTION AND QUANTIFICATION OF ORGANOCHLORINE PESTICIDES IN DRIED PUNTI FISH <i>PUNTIUS SOPHORE</i> AVAILABLE IN SYLHET, BANGLADESH Hussain, Md. Ashraf, Md. Lutful Kabir, Md. Abu Sayeed, Md. Sultan Ahmed and Tofael Ahmed Sumon	140
CONSUMERS PREFERENCE ON DRY FISH AND THEIR PACKAGING IN DHAKA CITY Islam, Md. Tariqul, Md. Touhidul Islam,Syeda Nusrat Jahan and Fawzia Adib Flowra	141
EFFECT OF HIGH AND LOW (0° C AND 8° C) TEMPERATURE ON SENSORY, MICROBIOLOGICAL AND CHEMICAL CHANGES DURING STORAGE OF FISH FILLETS Istiak, Syed M.	142
COMPARATIVE QUALITY INDEX FOR SHELF LIFE ASSESSMENT OF TILAPIA (<i>OREOCHROMIS NILOTICUS</i>) RAISED IN CAGE AND POND IN HAOR Kabeer, Fozlul, Shahidul Islam Bhuiyan, Pronoy Mondal and A.K.M. Nowsad Alam	143
POTENTIAL OF TEA LEAVE EXTRACT AS NATURAL PRESERVATIVE INCORPORATING WITH ICE FOR RETARDATION OF QUALITY LOSS AND EXTENSION OF SHELF LIFE OF TILAPIA	
Kabeer, Fozlul, Shahidul Islam Bhuiyan and A.K.M. Nowsad Alam	144
URGENCY OF FOOD SAFETY THROUGHOUT AQUACULTURE PRODUCTION AND SUPPLY CHAIN	
Karim, Mahmudul	145

FISH BIODIVERSITY & BIOTECHNOLOGY (Additional)

EVOLUTIONARY RELATIONSHIPS OF CYPRINID FISHES INFERRED FROM MORPHOLOGICAL TRAITS AND MITOCHONDRIAL GENE CYTOCHROME B Alam, Md. A. and Imran Parvez	146
SOME BIOLOGICAL ASPECTS OF THREE ENDANGERED FISHES OF THE GENUS BARILIUS FROM THE ATRAI RIVER, DINAJPUR, BANGLADESH Iffat-Ara, Most., Rasheda Aktar, Tanjiba Mahajebin and Imran Parvez	147
SEED PRODUCTION OF WILD <i>CIRRHINUS REBA</i> (HAMILTON 1822) TO INTRODUCE IN AQUACULTURE AND FOR REVIVAL Parvez, Imran, Rasheda Aktar, Tousif Ahmed, Md. Arafath Hossain, and Chandra Pahan	148
AQUATIC RESOURCES (Additional)	
THREATENED FISHES OF THE WORLD: <i>RAIAMAS BOLA</i> (HAMILTON, 1822) (CYPRINIFORMES: CYPRINIDAE) Alam, Md. Ashraful, Imran Parvez and Chainika Banerjee	149
ASHURA BEEL IN DINAJPUR DISTRICT: LIMNOLOGICAL ASPECTS AND FISH AVAILIBILITY Ferdoushi, Z., K. K. U. Ahmed, T. Khatun, M. Rana and Y. Ara	150
THE DHEPA RIVER FISH SANCTUARY IN PROTECTION AND RESTORATION OF THREATENED FISH BIODIVERSITY Parvez, Imran, Hirsikesh S. Sujan, Md. A. Alam, Kalipada Roy, and Md. R. Haque	151
FISH BIODIVERSITY AND CONSERVATION STATUS OF THE DHEPARIVER, DINAJPUR, BANGLADESH Rana, Masum, Imran Parvez, Tanjiba Mahajebin and Md. R. Haque	152

KEYNOTE PAPER

BLUE ECONOMY- SUSTAINABLY USING OUR OCEANS FOR PROSPEROUS FUTURE

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Oceans provide a substantial portion of the global population with food and livelihoods and are the means of transport for 80% of global trade, support all life today by generating oxygen, absorbing carbon dioxide, recycling nutrients and regulating global climate and temperature, offer vast potential for renewable "blue energy" production from wind, wave, tidal, thermal and biomass sources. The marine and coastal environment also constitutes a key resource for the important global tourism industry. Advancing technologies are opening new frontiers of marine resource development from bio-prospecting to the mining of seabed mineral resources. The emergence and recent evolution of the concept of the Blue economy in several flora bears testimony to its importance as an alternative economic model for sustainable development that acknowledges our dependency on the oceans and seas. It also reflects a modern view that further development can also be feasible while maintaining sustainability and social justice including intergenerational equity as main guiding principles.

"Blue Economy" comprises of activities that directly or indirectly takes place in the seas, oceans and coasts using oceanic resources and eventually contributing to sustainable, inclusive economic growth, employment, well-being, while preserving the health of ocean. It includes activities such as exploration and exploitation/development of ocean resources, appropriate use of ocean and coastal space, protection of ocean environment and use of ocean products. Blue Economy approach has broad relevance as the Oceans, including humankind's common heritage of the High Seas, represent in many respects the final frontier for humanity and its quest for sustainable development. Bangladesh as a coastal developing country have remained at the forefront of this Blue Economy advocacy as it offers an approach to sustainable development better suited to our circumstances, constraints and challenges. The following summarizes all maritime economic activities that have been identified and whose developments are at various stages;

- a) Marine fisheries, aquaculture, biotechnology and eco-system services- harvesting sustainably blue opportunities
- b) International Shipping and Port Facilities, coastal shipping, inland waterway transport, shipbuilding, ship recycling -Gateway to the Blue horizon
- c) Energy like oil and gas, wave power, tidal energy, marine currents, offshore wind, ocean thermal energy conversion, securing fresh water supply, salt production and marine minerals mining -a treasure trove of future energy resources-
- d) Coastal tourism, cruise tourism, coastal protection and development of artificial islands and greening coastal belt -turning to the oceans for value added service-

Blue economy is the biggest opportunities for our region and beyond to collectively create sustainable economic opportunities through long term investments in sustainable fisheries and other economic activities. With a view to improving food security, eradicating poverty and delivering shared prosperity, Ministry of Foreign Affairs along with the other ministries of the government, business leaders, civil society and international organizations initiating to explore how to set action-oriented programmes and policies, governance arrangements, legislation, investment frameworks and incentives to facilitate the transition to a low carbon economy utilizing all the tools at its disposal including the ocean's enormous potential for renewable energy generation, ports and shipping, mangrove and other resources of the sea for our economic emancipation.

KEYNOTE PAPER

DNA BARCODING: AN EMERGING STANDARD MOLECULAR TAXONOMIC TOOL FOR BIODIVERSITY CONSERVATION

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Bangladesh having an area of 147,570 km², contains 141 crustaceans, 253 inland fishes, 402 marine fishes, 49 amphibians, 167 reptiles, 566 birds (resident & migratory) and 138 mammals. It is a low-lying country with diverse aquatic habitats as a form of rivers, haor, baor, beels, floodplains, canals, ponds, ditches, streams, etc. The country is very rich in ichthyo-faunal diversity as well and ranked third largest in Asia after China and India. It is assumed that country has many new species, new records and cryptic species yet to explore. An attempt has been made to genetic identification of freshwater fishes through DNA barcoding, a molecular method that uses a short standardized DNA sequence as a species identification tool. The standard 652 base-pair region of the mitochondrial cytochrome oxidase subunit I gene (COI) was sequenced in freshwater fish specimens collected from different locations of the country. The work has been started at the Department of Zoology, University of Dhaka, initially with freshwater fishes. So far, we have sequenced 50 species and high efficiency of species identification was demonstrated in the study. The average genetic distance was over 50-fold higher between species than within species, as Kimura two parameter (K2P) genetic distances averaged 16.75% among congeners and only 0.32% for intraspecific individuals. This DNA barcode resource will enhance capacity in many areas of fish conservation biology that can benefit from improved knowledge of genetic provenance. These include captive breeding and restocking programs, life history studies and ecological research into the interactions between populations of native and exotic species. The country now needs to establish a national barcode of life database system to keep all genetic diversity and biological information for public access.

HISTOPATHOLOGICAL EFFECTS OF TOXIC *MICROCYSTIS AERUGINOSA* BLOOM ON LIVER OF *OREOCHROMIS NILOTICUS*

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The effect of toxic *Microcystis aeruginosa* on liver tissue of Nile tilapia (*Oreochromis niloticus*) was investigated under laboratory condition. Fish were placed in three aquaria and exposed to 35×10^2 colony/ml, 72×10^2 colony/ml, 149×10^2 colony/ml concentration of *M. aeruginosa* bloom cells for 15 days. A control was reared with artificial feed in the same condition and observed no histopathological changes. In exposed fish, histopathological alternations were characterized by swollen and granular cytoplasm, vascular proliferation, bile stasis, fatty change and focal necrosis. Histopathologocal changes were observed within 5 days in moderate and highest bloom concentration where as it took 15 days for lower concentration. Result showed the severity or toxicology of natural *M. aeruginosa* bloom, possible fish death and human health hazard.



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Fig. 1. Section of liver of *Oreochromis niloticus*. A. control group showing normal nucleus and hypatocytes. H, hepatocytes; N, nucleus; BV, blood vessel; 10×45 (H&E stain) B. Experimented group $(149\times10^2 \text{ colony/ml}: 5 \text{ days treatment})$ showing condense cytoplasm and swelling in hepatocytes; 10×10 (H&E stain). C. Experimented group $(149\times10^2 \text{ colony/ml}: 15 \text{ days treatment})$ showing fattplice; 10×10 (H&E stain). D. Experimented group $(72\times10^2 \text{ colony/ml}: 10 \text{ days treatment})$ showing fattplice; 10×45 (H&E stain). E. Experimented group $(149\times10^2 \text{ colony/ml}: 15 \text{ days treatment})$ showing accumulation of bile in the endothelial cell; 10×45 (H&E stain) F. Experimented group $(149\times10^2 \text{ colony/ml}: 15 \text{ days treatment})$ showing focal necrosis and bile stasis; BS, bile stasis; FN, focal necrosis.

DETECTION OF MICROCYSTINS IN NILE TILAPIA (OREOCHROMIS NILOTICUS) FROM A EUTROPHIC PONDS CONTAINING MICROCYSTIS AERUGINOSA BLOOM IN DHAKA

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Anthropogenic eutrophication and global climate change ahve created harmful algal blooms and contaminated surface waters all over the world. Cyanobacterial blooms and the accumulation of several cyanotoxins in water bodies pose ever ecological consequences with high risk to aquatic organisms and global public health. The toxins, called cyanotoxins, are responsible for intermittent but repeated widespread poisonings of wild life, domestic animals and human. Cyanobacteria blooms are very common phenomenon in eutrophic aquaculture ponds in Bangladesh. Although microcystins (MCs) have been detected from different aquaculture ponds and lakes in Bangladesh, the accumulation of toxins in fish tissue and their toxic effect on aquatic lives have not yet been reported. This paper reports for the first time of the accumulation of MCs in fish tissue and evaluates the possible public health risk in the country.

MCs that accumulated in different organs of the freshwater fish *Oreochromis niloticus*, collected from a eutrophic aquaculture pond in Dhaka city containing heavy blooms of *Microcystis aeruginosa*, were investigated using High Performance Liquid Chromatography (HPLC/MS). Two types of microcytins, MC-RR (0.25 µg/g), and MC- LF (0.22 µg/g) were detected from the liver tissue of *O. niloticus*. The total microcystin concentration was 0.47 µg/g in liver tissue. No microcystin was detected from the gut and muscle of the fish. The concentration of MCs found in *O. niloticus* was higher than the WHO tolerable daily intake (8ng/g/tissue). As MCs are heat stable compounds, and neither boiling water nor cooking fish prior to consumption is expected to reduce the potential for exposure. The present study thus suggests that fish farms should be monitored for the presence of toxic cyanobacterial blooms to minimize the exposure of potent hepatotoxins to fish and humans through the food chain.



Fig. 1. A & B. HPLC chromatograms of fish liver extract showing the MC-RR and MC-LF.

EFFECT OF MANNAN OLIGOSACCHARIDE SUPPLEMENTATION ON DIGESTIVE ENZYME ACTIVITIES AND INTESTINAL MORPHOLOGY OF STRIPED CATFISH (*PANGASIANODON HYPOPHTHALMUS*) JUVENILES

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Disease has been considered as one of the most significant concerns for the sustainable development of striped catfish, *Pangasianodon hypophthalmus* farming, therefore, an experiments was carried out to determine the most suitable level of prebiotic mannaan oligosaccharide (MOS), that can promote the growth of juvenile striped catfish. Triplicate groups of juvenile striped catfish (initial weight 20.41±1.64 g) were fed twice daily at 2.5% body weight, with 0 (Control), 0.2%, 0.4%, 0.6% and 0.8% MOS diets for a period of 12 weeks. At the end of feeding trial, the growth performances, digestive enzyme activities, intestinal morphology and microflora were evaluated.

The growth performance and feed utilization parameters (Table 1), villi and microvilli length were significantly highest for 0.6% and 0.8% MOS diet fed groups than the remaining treatments, while only fish fed the 0.6% MOS diet had significantly better apparent protein and dry matter digestibility, amylase, protease and lipase activities than the control fed group. Supplementing diets with MOS also increased total lactic acid bacteria counts significantly compared to the control fed group.

Table 1. Growth performance and feed utilization of juvenile striped catfish fed a diet containing varying levels of mannan oligosaccharide (MOS) for 12 weeks

	Treatments				
Parameters	Control	0.2% MOS	0.4% MOS	0.6% MOS	0.8% MOS
Wt. Gain	17.39±1.18 ^b	14.68±0.12 ^ª	19.85±0.55 [°]	27.59±0.38 ^d	28.11±0.72 ^d
SGR (%)	0.74±0.03 ^b	0.65±0.01 ^ª	0.82±0.01 ^c	1.01±0.02 ^d	1.03±0.03 ^d
FCR PER	2.28±0.12 ^c 1.21±0.06 ^{ab}	2.70±0.07 ^d 1.02±0.03 ^a	1.97±0.04 ^b 1.40±0.02 ^b	1.62±0.23 ^ª 1.71±0.23 [°]	1.42±0.06 ^a 1.92±0.08 ^d

Based on the results of this study, it is concluded that MOS supplementation at 0.6%, appears to be the most effective dose in influencing the growth performance, digestive enzyme activities, intestinal morphology and the beneficial microflora in the intestine of the striped catfish.

GENETIC VARIATION IN FOUR POPULATIONS OF *CHANNA STRIATA* (CHANNIDAE: PERCIFORMES) REVEALED BY PCR-RFLP AND SEQUENCE ANALYSIS OF MITOCHONDRIAL GENE

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Asian snakehead (Channa spp.) inhabit in freshwater covering a natural distribution across the Southern and South-East Asian countries including Bangladesh. Among them shol (C. striata), gozar (C. marulius) and taki (C. punctatus) are available in Bangladesh. The shol (C. striata), has a high market demand that found in natural water bodies especially in lowland ecosystem in our country. In the present study, PCR-RFLP and sequence analysis of mtDNA Cyt b gene were used to investigate genetic variation in four populations of C. striata from Kishoregoni, Netrokona, Gazipur and Mymensingh. At least 35 samples were used in this study and five haplotypes were found from PCR-RFLP analysis using Apol, Avall and Hindll restriction enzymes. The highest and lowest haplotype diversity was found in Netrokona population (1.00) and Mymensingh population (0), respectively. Six haplotypes were found in sequence analysis of mtDNA Cyt b genes and the highest haplotypes (5) showed by Netrokona whereas Gazipur and Kishoregonj shared several haplotypes (3) and Mymensingh had single haplotype. The Fst value between Mymensingh and Kishoreganj was 0.6 indicating higher genetic differentiation and the ranges among other populations were 0 to 0.3. Gene flow (Nm) was high (2.57) among populations. However, lower level of genetic variation was found within the populations, whereas some degree of genetic variation was observed between the populations. The preliminary phylogenetic tree with online data produced two major clades whereas Bangladeshi C. striata produced distinct and separate group in one clade. The laboratory protocol and molecular markers developed in this study could be used in future studies for detail clarification of present findings with more samples from all the regions of Bangladesh that might be helpful to manage C. striata in open water bodies, and broodstock development when needed.



Fig. 1. A preliminary phylogenetic tree of *C. striata* in Bangladesh and other countries.

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GENETIC VARIATION IN CLIMBING PERCH (ANABAS TESTUDINEUS) FROM THE CHALAN BEEL WETLAND IN BANGLADESH

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The present study evaluated genetic variation within and among three populations of Anabas testudineus from the Chalan beel wetland in Bangladesh by PCR-RFLP and sequence analysis of mitochondrial gene. The fish samples of the Chalan Beel wetland were collected from Sirajgong, Pabna and Natore. In addition, the samples from Gazipur were also included for comparative study. Ten samples from each population were used to study morphometric and meristic analysis and the result confirmed the species as A. testudineus morphologically. Then, at least three samples for PCR-RFLP and two samples for sequence analysis of mtDNA D-loop region were used from each population. Restriction analysis using four endonucleases (Apo I, Ava II, Hind II and EcoR II) generated two types of composite haplotypes (ANAA and BNAA) from four populations. Natore population showed high level of genetic variation (haplotype diversity = 1, Number of haplotype =2) whereas haplotype diversity was zero between Pabna, Sirajganj and Gazipur populations. Besides, mtDNA sequence analysis of D-loop region (908bp) showed four haplotypes (h1, h2, h3 and h4) whereas all the populations shared haplotype h2. Furthermore, Pairwise F_{st} values among the populations in the present study were zero indicating strong migration of individuals in the Chalan Beel wetland in Bangladesh. The comparative F_{st} values with the sequence data from gene bank, and present study was also estimated and it ranged from 0.694 to 1. The preliminary phylogenetic tree showed separate clade formation of Bangladeshi A. testudineus from exotic group and it need further study for detail clarification. However, present study would provide valuable initial genetic information of A. testudineus in the Chalan Beel wetland. Finally, present study would be useful as a reference to analyze more populations with large sample size for better understanding of the genetic structure of A. testudineus in the Chalan Beel wetland in Bangladesh.

GENETIC VARIATION IN CLIMBING PERCH (ANABAS TESTUDINEUS) FROM THE WETLAND ECOSYSTEM IN MYMENSINGH AND DHAKA

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The climbing perch (Anabas testudineus) is locally known, as "Koi" is very tasty and has high market demand in Bangladesh. Besides, Thai and Vietnam Koi are being cultured commercially and available in the market. There is limited study on genetic variation of local koi in Bangladesh. The present study identified genetic variation within and between four populations of A. testudineus in Mymensingh and Dhaka region by PCR-RFLP and sequence analysis of mitochondrial DNA. Forty samples were collected from four populations of Mymensingh, Netrokona, Kishoregani and Gazipur district and samples were examined by morphometric and meristic method and confirmed as A. testudineus morphologically. Then at least three samples for PCR-RFLP and two samples for sequence analysis of mtDNA D-loop region were used from each population. PCR-RFLP analysis using four endonucleases (Apol, Avall, Hindll, and *EcoRII*) generated one type of haplotype (ANAA) from four populations. The haplotype diversity was zero among all populations. Besides, mtDNA sequence analysis (908bp) showed five haplotypes (h₁, h₂, h₃, h₄ and h₅) whereas all the population shared haplotype h₂. The overall genetic distance from sequence analysis of four populations indicated that the four populations were very closely related to each other. The Fst values of present study were compared with previous findings of local, Thai and Vietnam koi populations and it ranged from 0 to 1. The Fst values indicated that Mymensingh and Dhaka region koi fish is maintaining more separated population than Northern region koi in Bangladesh and it has merit to find interesting result of genetic variation in future studies with A. testudineus in Bangladesh. The preliminary phylogenetic tree showed separate clade formation of local A. testudineus from exotic group and it need further study for detail clarification. However, present findings might be act as a guideline for future studies on Koi in Bangladesh.

EFFECTS OF ACHYRANTHES ASPERA TO THE IMMUNITY OF ROHU (LABEO ROHITA) AGAINST PSEUDOMONAS FLUORESCENS

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The study evaluated the efficacy of dietary doses of Achyranthes aspera extract on immunological parameters and disease resistance against *Pseudomonas fluorescens* infection in Indian Major Carp, Rohu, *Labeo rohita* (average weight 28.1 \pm 1.2 g). Fishes were fed with four different doses of herbal diet containing 0%, 2%, 4% and 6% of *A. aspera* extract. Among the doses 6% *A. aspera* showed highest significant responses in phagocytic activity, specific and non-specific immune responses on week 4 compared to control diet whereas the changes did not manifest on first week. In addition, the 6% *A. aspera* resulted in lowest mortality (20%) indicating highest protection from *Pseudomonas fluorescens* infection than 0%, 2% and 4% *A. aspera* diets that resulted 73.33%, 46.67% and 33.33% mortalities, respectively. The results suggested that the dietary supplementation of *Achyranthes aspera* extract acted as immunostimulants, reduced mortality and increased disease resistance in *Labeo rohita* against *Pseudomonas fluorescens* infection.

APPLICATION OF GENETIC BIOTECHNOLOGY FOR THE IMPROVEMENT AND CONSERVATION OF FISHERIIS RESOURCES OF BANGLADESH

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Fisheries sector in Bangladesh represents one of the most productive and dynamic sectors that plays a significant role in employment, nutrition and foreign exchange earnings in the economy. More than11% peoples are directly or indirectly earn their livelihoods from fisheries related activities. Bangladesh ranks the 4th aquaculture producing country in the world. Genetic biotechnology is making important contributions in aquaculture and fisheries development as well as in the conservation of genetic resources. This paper discusses the use of genetic biotechnology in fisheries resources with special interests on culture, growth, production, environmental concern and health management as well as economic consideration, safety, environmental and ethical issue, etc. Important applications of genetic biotechnology are discussed based on conventional biotechnology such as polyploidy, sex reversal, genetic hybridization, genetic sex selection, nuclear transplantation, cell culture, cryopreservation, artificial insemination and in vitro fertilization, embryo manipulation, etc., in addition to advance biotechnology like cloning, marker techniques, tagging, gene sequencing, gene transfer and gene expression, etc. Conventional biotechnology is already being established as very useful tools in fish breeding while advance biotechnology is in a developing phase but more interesting and succeeding compare to conventional one in Bangladesh.

EMBRYOGENESIS AND DNA POLYMORPHISM OF STRINGING CATFISH (HETEROPNEUSTES FOSSILIS) FROM SYLHET HAOR AREA, BANGLADESH

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In this study, induced breeding, embryonic chronology, larval development and DNA polymorphism of stinging catfish Heteropneustes fossilis were studied. Sexually matured male and female (2:1) were injected intramuscularly with synthetic hormone PG at the dose of 10 mg/kg and 70 mg/kg body weight of fish, respectively. All the brood fish were found to be ovulated after a period of 7-9 h of injection where natural fertilization occurred. The adhesiveness of the egg membrane became apparent and had a reddish spot (blastodisc) on one pole. The incubation period was from 23-24 h at an average temperature of 29±1°C. The yolk absorption was completed within three days after hatching. The aerial breathing behavior of the larvae was observed from 10th day after hatching. The larvae resembled the adult in its external features and were metamorphosed to young juveniles within 20th day post-hatching. Larval development was observed until 60 days and differentiation of larvae ware checked through morphometric anlysis. DNA polymorphism was assessed between the wild and experimental population of H. fossilis by RAPD assay considering three different primers (OPF-14, OPB-05 and OPB-19) and in total 84 DNA bands were found whereas 42 bands were recorded for each population. All markers showed 100% polymorphism in both populations, but wild population resulted higher polymorphic loci than the experimental population.

MOLECULAR CHARACTERIZATION OF *VIBRIO PARAHAEMOLYTICUS* IN ESTUARINE FISH FROM DHAKA CITY MARKETS, BANGLADESH

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Little is known on the biosafety level of *Vibrio parahaemolyticus* in estuarine fish in Bangladesh. The purpose of this study was to investigate the prevalence and concentration of *V. parahaemolyticus* in estuarine fishes using the polymerase chain reaction (PCR) method. The study was conducted on 37 different species from different types of estuarine fish commonly sold at Dhaka City Markets. Samplings were done on the intestinal tract and gills of each fish. The prevalence of *V. parahaemolyticus* was found to be 29.72% with higher percentages detected in samples from the gills (89.28%) followed by the intestinal tract (10.71%). The average density of *Vibrio* spp. in the gill of estuarine fishes was 4.4 x10³CFU/g and in the intestine samples was $1.5x10^3$ CFU/g. The outcome on the biosafety assessment *V. parahaemolyticus* in estuarine fish indicates a potential source of food safety issue to the consumers.

IDENTIFICATION OF PATHOGENIC GUT MICROBIOTA OF ROHU, LABEO ROHITA AND SILVER CARP, HYPOPHTHALMICHTHYS MOLITRIX BY 16S RRNA GENE SEQUENCEING

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The gut of fish is a potential route for pathogens to invade and infect their host. Current study was, therefore, carried out to investigate and compare the gastrointestinal pathogenic bacteria of the two commercial fish species, rohu and silver carp. Samples of three different markets of Dhaka Metropolitan City were studied using various selective agar media, classical biochemical tests and 16S rRNA sequencing. Antibiotic susceptibility of selected isolates was also carried out against 14 antibiotics. Two hundred and sixteen colonies were differentiated morphologically and among them, 18 isolates were characterized by biochemical tests. Finally, the identification of 10 isolates were confirmed by sequencing the 16S rRNA gene. Biochemical assays provisionally determined seven different bacterial genera from rohu and seven from silver carp. Six different genera of Gram-negative bacteria (four genera from rohu and two from silver carp) were identified as Aeromonas, Proteus, Pseudomonas, Enterobacter, Citrobacter, Klebsiella sp. by 16S rRNA sequencing (Genbank accession numbers KU992678-KU992687). This study also revealed that all 18 representative isolates including reference strain (E. coli DH5α) were sensitive to ciprofloxacin and resistant to sulphamethoxazole. The findings might be due to the poor quality of the aqueous environment and reflects fish as the potential reservoir of pathogenic bacteria causing fish-borne disease outbreaks.

	Samp	le name
Bacterial density (cfu/g)	Rohu	Silver carp
Total bacterial count	5.27±2.01×10 ^{7a}	3.02±1.42×10 ^{7b}
Total <i>Vibrio</i> count Total <i>Salmonella- Shigella</i> count Total <i>Aeromonas</i> count Total Staphylococcal count	$\begin{array}{c} 1.58 \pm 3.51 \times 10^{6} \\ 6.94 \pm 7.15 \times 10^{6a} \\ 1.31 \pm 1.06 \times 10^{7} \\ 1.03 \pm 0.52 \times 10^{7a} \end{array}$	$2.38\pm3.63\times10^{3}$ $1.11\pm0.97\times10^{6b}$ $6.09\pm4.61\times10^{6}$ $5.48\pm3.98\times10^{6b}$
Total coliform count	1.68±0.98×10′	1.39±2.35×10′

Table 1. Bacterial density (cfu/g) in the gut of rohu and silver carp

Table 2. List of identified a	species by	provisional	and mol	ecular method

Isolate no.	Identified sp. by provisional method	Identified sp. by molecular method
njp1	Vibrio metschnikovil	Aeromonas hydrophila subsp. dhakensis
njp2	Proteus mirabilis	Proteus penneri
njp3	Pseudomonas citronellolis	Pseudomonas plecoglossicida
njp4	Staphylococcus caprae	Aeromonas caviae
njp5	Enterobacter nimipressuralis	Enterobacter sp.
njp6	Pseudomonas sp.	Pseudomonas aeruginosa
njp7	Aeromonas sp.	Aeromonas sp.
njp8	Pseudomonas graminis	Citrobacterfreundii
njp9	Staphylococcus aureus	Klebsiella pneumoniae subsp. rhinoscleromatis
njp10	Klebsiella pneumonia	Klebsiella pneumoniae subsp. rhinoscleromatis

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RECENT ADVANCES IN MOLECULAR DETECTION OF BACTERIAL FISH PATHOGENS IN BANGLADESH

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Bangladesh is one of the top ranking fish producing country of the world. Fish and shrimp farming play very important role to the economy of Bangladesh. However, incidence of fish diseases is considered as one of the major constrains for fish production of the country. Due to infestation of various diseases, a substantial amount of production and economic losses occurred in different aquaculture facilities every year. The most prevailing bacterial fish diseases recently occurred in different fish farms of the country are motile aeromonad septicaemia, bacterial haemorrhagic septicaemia, tail and fin rot, edwardsiellosis, streptococcal infection, enterococcal infection etc. Proper diagnosis of a disease is very crucial for prevention and control of that disease. In Bangladesh, however, fish disease diagnosis is mostly based on traditional methods which are time consuming and often misleads or fails to identify the disease properly. Nonetheless, recently, several molecular diagnosis methods have been developed for detection of major bacterial fish pathogens. By analyzing 16S rRNA gene sequence homology, Aeromonas hvdrophila, A. veronii, A. bivalbium, Pseudomonas fluorescens, Stenotrophomonas maltophilia, Edwardsiella tarda, Streptococcus agalactiae, S. iniae and Enterococcus faecalis were identified as potential fish pathogens of the county. Among these, A. bivalbium, E. faecalis. S. iniae and S. maltophilia are the first time identified as fish pathogen infecting fishes in Bangladesh. Rapid and specific identification of Aeromonas spp., Edwardsiella spp., Pseudomonas spp., E. faecalis, S. agalactiae and S. iniae was possible through development of specific PCR methods. Development of PCR-RFLP methods makes it possible to successfully identify different species of Aeromonas viz. A. veronii. A. hvdrophila and A. bivalbium and two species of Pseudomonas viz., P. fluorescens and P. putida. Development of simultaneous PCR method facilitates identification of Aeromonas sp. and Edwardsiella sp. simultaneously. Furthermore, development of multiplex-PCR assists us to identify most virulent fish pathogenic A. veronii strains.



Fig. 1. PCR amplification of *Pseudomonas* sp. isolates (1-8).

EMBRYONIC AND LARVAL DEVELOPMENT OF MICRONUTRIENT DENSE SMALL FISH MOLA, AMBLYPHARYNGODON MOL THROUGH INDUCE BREEDING

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Embryonic and larval developments of micronutrient dense small fish mola, *Amblypharyngodon mola* were studied through induced breeding. The experiment was carried out at mini hatchery cum breeding complex, Bangladesh Agricultural University, Mymensingh -2202 during August, 2015. For breeding of mola, pituitary gland (PG) was administrated as inducing agent. Sophisticated camera (Optica Microscope Italy 4083.B3) setting microscope (Biological Microscope G-206) was used for intensive observation of the developmental stages. The

embryonic development of A. mola was found to be very rapid and larva hatched out within 12 h at 26.9±0.3°C. Fertilized eggs were found to be yellowish or golden in color, sticky, demersal, and transparent and 0.8±0.02 mm in length and unfertilized eggs were fade or whitish in color. The first cleavage was occurred within 25 min of post-fertilization. The egg size during the embryonic development was not significantly changed (Fig. 1). The newly hatched larva was 1.9±0.32 mm

in length (Fig. 2). Pectoral fin bud and swim bladder development was initiated at 12 h of post hatching. The larvae started first feeding between 48 and 60 26.82±0.37°C. The detail h at development biological information would be useful to improve the production technology and to assist further researches molecular on biotechnology for the species.



Fig. 1. Embryonic development stages of Amblypharyngodon mola at 27oC - (upper L-R) zygote, cleave, morula, blastula and gastrula and (lower L-R) bud, segmentation, partial harvesting and hatching.



Fig. 1. Larval development of *A. mola* - larva at (L-R) 0h, 6h, 12h, 18h, 24h, 30h, 36h, 42h, 48h and 60h.

GENETIC CHARACTERIZATION OF GOBI FISHES (PERCIFORMES: GOBIIDAE, ELEOTRIDAE) OF BANGLADESH THROUGH DNA BARCODES

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Bangladesh is very rich in fish diversity for its unique geographical location. There are about 266 freshwater fishes in Bangladesh including a number of endemic species. The gobies are ecologically and economically important freshwater fishes under family Gobiidae and Eleotridae. There is a huge taxonomic confusion in the proper identification of freshwater fishes in Bangladesh of which gobies are the less studied group. The present study was conducted to genetically identify six species of gobies (Acentrogobius cyanomos, Awaous guamensis, Butis melanostigma, Eleotris fusca, Glossogobius giuris and Stigmatogobius sadanundio) through DNA barcodes based on Cytochrome oxidase I (COI) gene of mitochondria to reduce the taxonomic ambiguities. Samples of the fishes were collected from four different regions of Bangladesh including the River Jamuna, the Itna haor of Kishoregoni, the Borochora of Cox's Bazar, Shyamnagar of the Sundarbans. Morphometric and meristic analysis of these species were performed alongside the molecular studies. About 500-530 base pair sequences of the COI gene of each species have been amplified through polymerase chain reaction (PCR) and then sequenced which expressed the genetic identity of each goby species. The specific barcode sequences of the selected species identified under the present study can be used to confirm their taxonomic identification combining with the traditional taxonomic study.

SOME ASPECTS OF MORPHOLOGY AND LENGTH-WEIGHT RELATIONSHIP OF THE SMALL INDIGENOUS SPECIES AILIA COILA (HAMILTON, 1822) FROM DHARLA RIVER, KURIGRAM

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Ailia coila was described from the freshwater rivers, mostly from Jamuna, Padma, Brahmaputra, Ganga in the plains of Bangladesh, India, Pakistan, and Nepal. It is a widespread species that has undergone significant decline in its population due to natural and anthropogenic activities. Globally the species is considered as near threatened (NT) and as least concerned (LC) in Bangladesh. By considering the threatened situation the morphology and the length-weight relationship of A. coilla from the Dharla river were investigated. A total of 85 specimen of A. coila ranging from 9.3cm to 13cm in total length and 4.1g to 12.73g body weight were used for the study. The morphometric and meristic data were measured in the laboratory and the lengthweight relationship was determined using the formula w=aL^b. The external morphological features observed; a dorsal profile almost straight or slightly arched, short head, four pairs of barbells, anal fin with 58 to 78 rays, absent of dorsal fin, body colour silvery to dull brown, without any black blotch on caudal base. The study reveals that there is no significant (p>0.05) difference between morphometric characters of collected specimen and the length-weight relationship established for the fish suggested that the fish did not follow the cube law strictly (Figure 1). The equations and the correlation coefficients suggested a significant relation (p<0.01) between the length and weight of Ailia colia. The regression coefficients (b) value was 2.52 that indicated negative allometric growth of the species from the Dharla river. The proper management of the Dharla river is highly required to conserve the indigenous fishes.



Figure 1: The length-weight relationship of the Ailia coila collected from Dharla river

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SEASONAL VARIATION OF HEALTH STATUS OF SOME SMALL ENDANGERED OPEN WATER FISHES OF SURMA AND KONGSA RIVERS

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A study on seasonal variation of health conditionof some small endangered open water fishes like rani (Botia dario), gutum (Lepidocephalichthys guntea), colisa (Colisa fasciata) and tara baim (Macrognathus aculeatus) were carried out through clinical and histological observations from Surma river near Gobindogoni, Sylhet and Kongsa river near Jaria, Netrokona for a period of eight months from September 2014 to April 2015. Fish sampling and water quality parameters (temperature, dissolved oxygen, pH, alkalinity and ammonia) were monitored on monthly basis. Among the water quality parameters, water temperature and alkalinity were found to be at unfavorable level for fish during the colder months i.e., December and January. Different clinical symptoms like rough skin, scale loss, red spots, large deep ulcers, gill rot and dermal lesions were noticed during winter season from both water bodies. Histopathologically, sampled fishes were found to be almost normal during autumn i.e., September and October, In late autumn, minor pathologies were found to be started. Marked pathological changes like necrosis, pyknosis, hemorrhage, hypertrophy, hyperplasia, missing of primary and secondary gill lamellae, vacuums, fat droplets, fungal granuloma and fungal hyphae were observed in fish organs during winter season. However, during the month of mid February, the pathological conditions of fishes were gradually reduced. The study showed that severity of clinical and pathological changes increased during winter season followed by autumn, and comparatively less pathologies or almost normal appearance were found during summer season. Fishes of Kongsa river were more affected than the fishes of Surma river when compared between two water bodies
AN ANALYSIS ON DIVERSITY IN EXOTIC AQUATICPET TRADE: A POTENTIAL THREAT TO FISHERIES RESOURCES OF BANGLADESH

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A study was conducted on 20 shipments and stock-filling patterns of 23 in-house and web-based aquarium shops of Bangladesh from August, 2014 to June, 2016 in quest of species having invasion records elsewhere and to get a view on native species in the hobby. Targeting nine major aquarium fish categories, plants and invertebrates, from a total of 108identified exotic species, 32 of 71 cichlids, all seven catfishes and large characins each, two of three cyprinoids, three of five labyrinth fishes, all four oddballs, both hybrids, three snakeheads, three plants, two crayfishesand one cyprinodontid species were found as potentially hazardous. A total of 19 species of cichlids, two catfishes, three characins, three labyrinth breathers, one hybrid, two cyprinoids, the cyprinodontid and the plants locally bred and have been propagated successfully. Twenty one exotic species were commercially bred by local vendors and marketed as exotic species among which 11 species were cichlids. In the trade, a total of 51 species including 21 cichlids were identified with non-native populations elsewhere in the world. Astronotinae, Cichlasomatinae and Haplochrominae tribe of Pseudocrenilabrinae cichlids, all percoids, all hybrids, one lepisosteid as oddball, two loricariid and one pimelodid catfish had high frequency rate (>80%). Though enlisted characins and snakeheads had low frequency (~40%), large serrasalmids and cynodontids had faced market-entrance and been made popular after June, 2015. One Critically Endangered Haplochromislatifasciatushad been seen as well as the highly demanding Endangered Sahyadriadenisonii (70% frequency). Three plants and two crayfishes were found which were declared as contraband invasives by US, Australia and New Zealand. Three indigenous species were found in the market. Devariodevariowas seen being used as feeder fish and Chela laubucaas as by-catch of the lot whereas Scatophagusargus as a moderately popular pet species (~50%).

SEASONAL VARIATION OF PLANKTON COMMUNITY OF DHEPA RIVER IN DINAJPUR, BANGLADESH

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Seasonal variation of plankton communityof Dhepariverin Dinajpur district was observed from May 2014 to April 2015. Samples were collected fortnightly dividing by four season as summer, autumn, winter and spring from the sub-surface zoneof four sampling sites. Results revealed that majority of plankton community was shared by phytoplankton groups. The abundance of plankton community greatly varied between summer and winter season. A total of 74 genera of plankton have been identified belonging to 7 groups as Chlorophyceae, Bacillariophyceae, Cyanophyceae, Euglenophyceae, Rotifera, Cladocera and Copepoda. The abundance of total plankton was higher (32.33×10³ cell/L) during winter following phytoplankton and summer due to zooplankton. Chlorophyceae appeared to be the dominant group in terms of genera (31 genera). In the early winter season, abundance ofBacillariophyceaewas found higher, on the other hand, in late winter Cyanophyceae was found dominant. Whereas, the seasonal variation of Euglenophyceae wasinsignificant. Moreover, the abundance of all zooplankton groupswas found to decline from summer to autumn. It might be due to the variation of rain fall in different season. However, the water quality of Dhepariver at the study area on the aspects of plankton productivity was better during the winter season compared to other season.

DIVERSITY STATUS OF FISHES OF THE MEGHNA RIVER ADJACENT TO NARSINGDI DISTRICT, BANGLADESH

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The present experiment was conducted on the fish diversity of Meghna River close to Narsingdi district from September 2015 to March 2016. Fish samples were collected from the fishermen for taxonomic study and thereby diversity of fishes was assessed. A total of 71 fish species were identified during the investigation under 23 orders and 28 families. Among 71 fish species; 26 were found belong to Cyprinidae family followed by Bagaridae (5), Schilbeidae (4), Channidae (4), Ambassidae (2), Belontiidae (3), Siluridae (2), Notopteridae (2), Mastacembelidae (2) and others (19). During the study period, among 71 fish species, 7 species were found critically endangered, 15 species were endangered and 12 species were vulnerable and 26 species were not found in threatened position.

HEAVY METALS IN SOME COMMERCIALLY IMPORTANT FISHES OF MEGHNA RIVER ADJACENT TO NARSINGDI DISTRICT, BANGLADESH: HEALTH RISK ASSESSMENT

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The present study was carried out to determine the heavy metals (Cd, Pb, Zn, Al, Cu, Ni, Fe, Mn, Cr, Co) in the muscles of 32 fish species for 3 seasons in Meghna River. The heavy metals were analyzed by Atomic Absorption Spectrophotometer. The estimated concentrations of all metals in the present study were lower than the limits permitted by FAO, WHO, EU, United States Food and Drug Administration (USFDA), US Environment Protection Agency (US/EPA) and England Guidelines except the concentrations of Pb & Zn that were found above the fishes Amblypharyngnodonmola. allowable ranges in different namely Colisalalia. Tetraodoncutcutia, Labeocalbasu, Puntiussarena, Ompokpabda, Ailacoila, Mastacembelus armatus, Glossogobius giuris, Nandus nandus, Tenualosa ilisha, Lepidocephalichthys guntea, Xenentodon cancilaandHeteropneustes fossilis. Significant variation in the concentrations were found in different seasons forPb, Zn, Al, Cu, Ni, Fe, Mn, Cr, Co (p<0.05) except Cd (p>0.05). Multivariate statistical analysis such as principal component analysis and correlation matrix showed significant anthropogenic intrusions of Zn, Al, Cd, Pb, Cu, Ni, Fe, Mn, Cr, Co in fishes. There was significant positive correlation between Cd vs Co (0.733), moderate positive correlation between Fe vs Al (0.568), Ni vsCo (0.482), Mnvs Co (0.395) which indicates that their common origin especially from industrial effluents, municipal wastes and agricultural inputs.



Fig. 1. Graph showing concentrations of heavy metals (mg/kg) for different seasons.

AQUATIC HABITAT SUITABILITY ASSESSMENT IN GAZIPUR, BANGLADESH USING GEO-SPATIAL TECHNOLOGY

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Suitable site selection is a key factor for any fisheries operation planning. The study assessed habitat suitability of beel (a wetland), floodplain and pond using integrated habitat suitability index approach to produce geo-referenced habitat requirement information about the fish of different Upazillas(sub-districts) ofGazipur district, Bangladesh. This study found that the degree or magnitude of habitat suitability in respect of habitat productivity varied with (i) habitat condition including habitat type, spawning ground, water depth and soil pH; (ii) food availability including phytoplankton availability and pollution proximity to agricultural and industrial pollutants. GazipurSadar and KapasiaUpazilas have been identified as the highest habitat suitability for beel and lowest for floodplain fish habitat. In case of KaliakairUpazila, highest suitability was for floodplain and lowest for pond, and in SreepurUpazila highest suitability was detected for pond and lowest for beel.

A NEW SPECIES OF *TRICHODINA* EHRENBERG, 1838 (CILIOPHORA: PERITRICHIDA) FROM THE FRESHWATER FISH OF THE BAIKKA BEEL, MOULVIBAZAR, BANGLADESH

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During surveys of diversity of trichodinid ciliates from freshwater edible fish of the Baikka Beel, Moulvibazar, a new species of the genus *Trichodina* Ehrenberg, 1838 was obtained from the gills of *Tetraodon cutcutia*. The investigation was carried out from January to December 2015. Based on the Klein's dry silver nitrate impregnation technique this new species is characterized by having medium sized body dimension with uniformly impregnated adhesive disc; slim, slightly curved, cudgel-shaped blade with rounded distal margin above tangent point; smoothly curved anterior margin without prominent apex; large interblade space; well developed and thick blade connection; triangular and straight central part with sharply pointed tip and loosely fitted into following denticles; and slightly slanted ray in anterior direction, ending in rounded tip. The taxonomic and morphometric descriptions for the new species were observed along with rate of prevalence, infestation status, and morphometric and meristic data comparison with closely related species.

LIFE HISTORY TRAITS OF BANDED GOURAMI, *Trichogaster fasciata* (BLOCH AND SCHNEIDER, 1801) IN THE PADMA RIVER, NORTHWESTERN BANGLADESH

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The present study describes the life-history traits, including length-frequency distributions (LFD), length-length relationships (LLR), length-weight relationships (LWR), condition factors (K), form factor ($a_{3.0}$) and sexual maturity (L_m) of *Tichogaster fasciata* in the Padma River, northwestern Bangladesh. Sampling was carried out using traditional fishing gears during August 2015 to January 2016. All the lengths including total length (TL) and standard length (SL) were measured to the nearest 0.01 cm using digital slide calipers and total body weight (BW) was measured using an electronic balance with 0.01 g accuracy.

The LWRs was calculated using the expression: $W=aL^b$, where the W is the body BW in g, L the length (TL, SL in cm), and b are the parameters of the regression. Condition factor (K) was calculated using the equation: $K_F = 100 \times (W/L^3)$. A total of 278 specimens were sampled, where TL ranged from 3.3 cm - 9.9 cm. The LFD indicates maximum population stands on 6.00-6.99 TL group (Fig. 1). The allometric coefficient (b)of LWRs indicated negative allometric growth of the species as 'b' value was less than 3.0 (Fig. 2). The LLR was highly significant with r^2 is \geq 0.989. The condition factor (K) showed no significant variations with TL and BW (P > 0.5). The calculated form factor ($a_{3.0}$) was 0.0214 in the Padma River for *T. fasciata* suggesting that, this fish can be classified as relatively fusiform which is characteristic of many riverine fishes. In addition the first sexual was 6.2 cm in TL for *C. fasciata* in the Padma River. The findings of the study would be very effective for fishery biologists, managers and conservationists to initiate early management strategies and regulations for the sustainable conservation of the remaining stocks of this species within the Padma River.



Fig. 1. Length-frequency distribution of the *Trichogaster* fasciata in the Padma River, northwestern Bangladesh.



Fig. 2. Length-weight relationships of *Trichogaster fasciata* in the Padma River, northwestern Bangladesh.

GROWTH, FORM FACTOR, SEXUAL MATURITY AND NATURAL MORTALITY OF FIVE *MYSTUS* SPECIES FROM BANGLADESH

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The present study focuses on the growth pattern (allometric or isometric), form factor $(a_{3.0})$, size at first sexual maturity (L_m) and natural mortality (M_w) of 5 *Mystus* species from Bangladeshi waters. A total of 398 individuals were occasionally collected from the Padma and Rupsha River. The fishes were caught using different types of traditional fishing gears, including gill net (mesh size ranges from 2.0-4.0 cm) and cast net (mesh size varies from 1.5-3.0 cm) during July 2014 to June 2015. Total length (TL) was measured to 0.1 cm, while total body weight (W) was taken to the nearest 0.1 g accuracy.

The length weight relationships (LWRs) were calculated using the equation: $W = a \times L^{b}$. The $a_{3,0}$ of this species was calculated using the equation of Froese (2006) as: $a_{3,0} = 10^{\log a - s(b-3)}$, where *a* and *b* are regression parameters of LWRs and s is the regression slope of *lna vs. b.* The L_m of *Mystus* species was calculated using the equation, $\log (L_m)$ = $-0.1189 + 0.9157^* \log (L_{max})$, by Binohlan andFroese (2009). The M_w for all Mystus spp. was estimated using the model, $M_W = 1.92$ year⁻¹ $^{*}(W)^{-0.25}$ (Peterson and Wroblewski, 1984), where, $^{-1}$ M_W =Natural mortality at mass W, and W = a^*L^b , *a*&*b* are regression parameters of LWR. Based on the allometric coefficient (b) values of LWRs (TL _ vs. BW), Mystus cavasius and M. gulio (b > 3.0) indicatepositive allometric growth. But M. bleekeri, M. tengra and M. vittatus showed negative allometric growth pattern (b<3.0) (Table1). On the basis of calculated form factor all Mystus species indicate elongated in body shaped (Table 1, Growth pattern and form factor of 5 Mystus species from two different habitats in Bangladesh).

Species	Habit	а	b	G	a _{3.0}
	at			Ρ	
Mystus	Padm	0.02	2.5	-A	0.006
bleekeri	а	58	4		1
Mystus	Padm	0.00	3.1	+	0.009
cavasius	а	69	0	Α	4
Mystus	Rups	0.00	3.1	+	0.012
gulio	ha	91	1	Α	8
Mystus	Padm	0.01	2.8	-A	0.008
tengra	а	58	0		5
Mystus	Padm	0.01	2.7	-A	0.008
vittatus	а	69	7		2

Species	Μ	а	b	Lm	95%	Μ
	ax TL				CL of L _m	w
Mystus	13	0.02	2.5	8.	6.6-	1.
bleekeri	.5	58	4	2	10.3	2
Mystus	15	0.00	3.1	9.	7.3-	1.
cavasius	.0	69	0	1	11.4	2
Mystus	17	0.00	3.1	10	8.2-	1.
gulio	.2	91	1	.2	13.0	0
Mystus	11	0.01	2.8	7.	5.8-	1.
tengra	.6	58	0	2	8.9	3
Mystus	12	0.01	2.7	7.	6.1-	1.
vittatus	.3	69	7	6	9.4	3

The size at first sexual maturity was 8.2, 9.1, 10.2, 7.2 and 7.6 cm in TL for *M. bleekeri*, *M. cavasius*, *M. gulio*, *M. tengra* and *M. vittatus*, respectively (Table 2, Size at first sexual maturity and natural mortality of 5 *Mystus* species from two different habitats in Bangladesh). In addition, the M_w was higher in *M. tengra* and *M. vittatus* than other *Mystus* species (Table 2) in the Padma River. The results of this study can be very effective for sustainable management and conservation of *Mystus* species in the Padma and Rupsha River and also in the surrounding ecosystems.

ESTIMATION OF CONDITION FACTOR OF THE CRITICALLY ENDANGERED CATFISH CLUPISOMA GARUA IN THE PADMA RIVER, BANGLADESH THROUGH MULTIPLE FUNCTIONS

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This is the first work which is dealing with multiple condition factors (Allometric, K_{A} ; Fulton's, K_{F} ; Relative condition, K_R ; and Relative weight, W_R) of Clupisoma garua from the Padma River, Bangladesh. Sampling was conducted using different fishing gear (eg. gill net, cast net, seine net) during May 2014 to April 2015. Total length (L) was measured to the nearest 0.01cm & total body weight (W) was taken with 0.01 g accuracy. The K_A was calculated using the equation of Tesch (1968): $K_A = W/L^b$. The K_F was calculated using the equation: $K_F = 100 \times (W/L^3)$. Also, the K_R for each individual was calculated through the equation of Le Cren (1951): $K_R = W/(a \times L^b)$, where a&b are parameters of length-weight relationships. Additionally, the W_R was estimated by the equation given by Froese (2006), as: W_R = $(W/W_{\rm S}) \times 100.$

On the basis of Spearman rank correlation test, the Fulton's condition factor (K_F) was the best fitted index among four types of condition factors in both male and female populations of *C. garua* (Table 1). The K_F ranged from 0.511 to1.713 in males and 0.519 to 2.77 in females and it was significantly different (Mann- Whitney U-test, P < 0.001) between the sexes. The relative weight (W_R) also showed significant variations between males and females (P = 0.1459) during the study. However, the W_R was significantly different from 100 for both sexes (P < 0.001), indicating an imbalance habitat with food availability relative to the presence of products for *C. garua* in the Padme

Deleti	~	80	r volu	OF0/ CL of r	D	0:
Relation	OII	Se	rsvalu	95% CL 017s		3
snip		x	es		values	<u>g</u> .
IL	vs.	M	0.258	0.2823-	P =	*
KA			9	0.3324	0.001	
TL	VS.		-	-0.3972 to -	P<	***
K_F			0.232	0.1549	0.001	
			5			
TL	VS.		0.279	0.2040-3523	P =	*
K_R			8		0.003	
TL	VS.		0.279	0.2037-	P =	*
W_R			6	0.3521	0.003	
BW	VS.		0.352	0.2800-4210	P =	ns
KA			5		0.015	
BW	VS.		-	-1940 to-	P<	***
K⊧			0.115	0.0353	0.001	
,			4			
BW	VS.		0.387	0.3169-	P =	*
K⊳			5	0.4537	0.005	
BW	VS		0.387	0.3116-	P =	*
W	10.		2	0 4535	0 001	
TI	VS	F	0 161	-0.2428 to -	P =	*
K,	<i>v</i> o.	•	5	0.0780	0 001	
TI	1/2		-	-0.3030 to -	D-	***
K_	vo.		0 224	0.3030 10	0.001	
ΝĻ			2	0.1430	0.001	
TL	vs.		0.217	0.1357-	P =	*
K₽			7	0.2968	0.003	
ΤĹ	vs.		0.216	0.1345-	P =	*
WR			6	0.2958	0.004	
BW	VS.		-	-0.2425 to -	P<	***
K,			0.161	0.0778	0.001	
• •			3	010110	0.001	
BW	vs.		-	-0.2048 to -	P<	***
K⊧			0.124	0.0382	0.003	
			0			
BW	vs.		0.316	0.2385-	P =	ns
K₽			6	0.3907	0.035	
BW	vs.		0.315	0.2373-	P =	*
WP			6	0.3897	0.001	
- //			-			

the presence of predators for *C.garua* in the Padma River.

CONSERVATION OF THREATENED SIS WITH CONSIDERATION OF CLIMATE CHANGES IN BANGLADESH

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Bangladesh is rich in fisheries diversity, with approximately 260 species of freshwater fishes among them 140 are classified as small indigenous species (SIS), which are good source of vitamin and minerals; and helps in preventing malnutrition especially to the poor people.In the small indigenous fish species were past, abundant in the rivers, flood plains, beels, canals, and ponds. SIS constitutes a major part of inland capture fisheries and in recent socio-economic studies has demonstrated a crucial role of SIS to the Bangladeshi society. But these SIS are being threatened for various causes including reckless fishing, use of illegal fishing gear, destruction of habitat, reducing ground water level (low rain fall high temperature), siltation, and pollution, Farakka barrage etc. List of some threatened SIS are given in Table 1 (List of some threatened SIS in Bangladesh (Source: IUCN 2000).

No.		
1	Chela laubuca	Kash Khaira
2	Osteobrama cotio	Dhela, Dhipali
3	Rasbora rasbora	Darkina, Darkina
4	Botia dario	Rani, Beti, Botya
5	Botia lohachata	Rani, Putul
6	Batasio tengana	Tengra
7	Ompok Pabda	Modhu pabda,
		Pabda
8	Ompok pabo	Pabda
9	Dermogenys pusillus	Ek Thota
9	Mastacembelus	Baim, Sal Baim
	armatus	
11	Rita rita	Rita
12	Clupisoma garua	Ghaura
13	Eutropiichthys vacha	Bacha
14	Pethia ticto	Tt puti
15	Barbonymus	Sorputi
	gonionotus	
16.	Chanda nama	Chanda
17.	Rhinomugil corsula	Kholla
18.	Mystus gulio	Gulsha tengra
19.	Osteobrama cotio	Dhela
20	Tor tor	Mohashol

Local Name

Also the climate change is principal factors for the threats of SIS. There are significant relationships

of climate changes (temperature and rainfall) with spawning of SIS (Figs. 1 and 2) in Bangladesh.Finally, these threatened SIS would be conserved in Bangladesh and neighbouring countries with the consideration of these above factors and the climate issues.



Fig. 1. Monthly changes of temperatue.



Fig. 2. Monthly changes of rainfall.

ASSESSMENT OF FISH DIVERSITY IN KIRTANKHOLA RIVER: PRESENT STATUS, THREATS AND CONSERVATION PERSPECTIVES

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The River Kirtankhola is situated in the interior coastal region of Southern Bangladesh. It has enriched with fish diversity of different categories which considered as one of the resourceful and potential river in Bangladesh. This river acts as feeding and breeding ground for several migratory (Hilsa) and native (Pangas) fish species including threatened species. The present study was conducted to make a complete list of fishes with their diversity and conservation status in the Kirtankhola River that supports the diverse fisher communities in Bangladesh. Fish samples were collected from four locations of Kirtankhola River namely Lamchori (S₁). Bukhainogor (S₂), Beltola (S₃) and Chair Kowa (S₄) during January to December, 2015. Data was collected from 20 local fishermen and surrounded markets of the study area and analyzed to determine the fish diversity index and their conservation status. Present study revealed that Kirtankhola river represents 29.76% (86 species) species of the country's total fish species belong to 61 genera, 31 families and 14 orders. Among the orders, Cypriniformes (27.91%) was found as dominant order followed by Siluriformes (23.26%), Perciformes (19.77%), Clupeiformes (6.98%), Channiformes (4.65%) and Mastacembeliformes (3.49%); in addition, 4 orders viz., Anguilliformes, Mugiliformes, Osteoglossiformes and Pleuronectiformes were comprised 2.33% each and another 4 orders viz., Beloniformes, Cyprinodontiformes, Synbranchiformes, Tetraodontiformes were contributed 1.16% each. A total 31 red listed species were recorded from studied areas considering 8 critical endangered, 13 endangered and 10 vulnerable species (Fig. 1). The values of Shannon-Wiener index (H), Simpson's dominance index (D), Simpson's index of diversity (1-D), Gibson's evenness (E) and Margalef's index (d) of selected areas are given in Table 1. "H" value showed that the Kirtankhola River is dominated by few species and S₂ area is represented as the migration zone. "d" value showed that S₂ area is the highest species diversity area. According to Diversity index value, S₂ is considered as the rich zone of species diversity followed by S₁, S₃ and S₄. To sustain the expected fish diversity, conservation strategies and active management practice like banning destructive fishing gears and indiscriminate fishing, establishment and management of fish sanctuaries, identification and safeguard of the breeding and nursery grounds should be taken into consideration.

Study area	(H)	(E)	(D)	(1-D)	(d)
S ₁	2.44	0.13	0.15	0.85	7.42
S ₂	2.41	0.13	0.16	0.84	7.57
S ₃	2.18	0.12	0.24	0.76	6.90
S ₄	2.44	0.15	0.16	0.84	6.80



Fig. 1.Fish species under the red list status in the studied areas. [CR= critically endangered, EN= endangered; VU= vulnerable]

IMPACT OF CLIMATIC HAZARDS ON THE JAMUNA RIVER FISHERIES AND COPING AND ADAPTATION STRATEGIES

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The continuous variability of climate and the risk associated with it have a significant impact on the fisheries leading to a global concern for about half a billion fishery-based livelihoods. Though in the context of Bangladesh mounting evidence on the impacts of climate change on fishery-based livelihoods or their socioeconomic conditions are present, the country's inland fisheries sector remains in a negligible corner as compared to the coastal areas which are spotted on the highlight due to its higher vulnerability to climatic hazards. The available research on inland fisheries, particularly river fisheries, has focused mainly on fish production, pollution, fishing gear, fish biodiversity and livelihoods of the fishers. This study assesses the impacts of climate variability and changes on the Jamuna (a transboundary river called Brahmaputra in India) River fishing communities and their coping and adaptation strategies. This study has used primary data collected from Kalitola Ghat and Debdanga fishing communities of the Jamuna River during May, August and December 2015 using semi-structured interviews, oral history interviews, key informant interviews, focus group discussions and impact matrix as well as secondary data. This study has found that both communities are exposed to storms, floods and land erosions which impact on fishery-based livelihood assets, strategies, and outcomes. The impact matrix shows that human and physical capitals are more affected by climate hazards which in turn affect financial capital. Both communities have been responding to these exposures through multiple coping and adaptation strategies. The coping strategies include making dam with soil, putting jute sac on the yard, taking shelter on boat or embankment. making raised platform or 'Kheua' and involving with temporary jobs. While, adaptation strategies include permanent migration, change of livelihood activities and strategies, changing fishing practices and making robust houses. The study shows that migration is the most common adaptation strategy for the fishers which resulted in mostly positive outcomes for the migrants. However, this migration has impacted negatively on the livelihoods of existing fishers in the communities. In sum, the Jamuna river fishing communities have been impacted by several climatic hazards and they have traditionally coped with or adapted to the impacts which are not sufficient to maintain sustainable livelihoods and fisheries. In coming decades, this situation may become worse as predicted by latest scientific research and an enhanced level of response would be needed.

ASSESSMENT OF AQUATIC FAUNAL DIVERSITY IN THE RATARGUL SWAMP FOREST AT SYLHET IN BANGLADESH

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The study was conducted to assess the aquatic faunal diversity in the Ratargul Swamp Forest in Sylhet during the period from November 2014 to October 2015. The study area is located at about 45 km on the north-west of Sylhet city and on the bank of river Goyain. The sampling of aquatic faunal species was done by the quadrate method through Transect procedure. The length of each transect was fixed at 100 m long. Four transects were selected in the swamp such as Transect- 1 (situated behind the forest office and run from west to east direction along the bank of a small channel), Transect-2 (started from west direction and run towards east direction), Transect-3 (started from north and run towards south direction along the bank of a small channel), and Transect-4 (started from a low land in east and was run towards west along the bank of a lake). Each Transect was further divided into five stations as St-1, St-2, St-3, St-4 and St-5. To measure species density within a given area, a 0.25x0.25 m quadrate were taken for the sampling of aquatic fauna and all the specimens within this area, both on the surface to the bottom were collected for further identification and measurement. Species diversity was calculated by using Simpson's Index of Diversity. The identification of species and their taxonomic classification were done with the help of different reference books.

The result showed that a total of 24 species of aquatic fauna belonging to 18 families were identified during the study period, in which 07 crustaceans, 04 mollusks, 12 fishes and 01 annelid. Among them, fishes were the most dominant and abundant groups. The crustaceans, mollusks, fishes and annelid were shown different pattern of density and diversity within the Transects. The density of individuals in Ratargul Swamp Forest varied from station to station within a range of 8 to 40 Ind/m². The lowest Simpson's Index of Diversity was 2.76 in Transect-4, which was situated in the transitional area between forested land and relatively deep lake within the forest. The Leptocarpus potamiscus, Nandus nandus, and Pila globosa were the dominant shrimp, fish and mollusks species in the Transect-4, respectively. The highest Simpson's Index of Diversity was 3.89 in Transect-3, which was situated along the bank of a small channel within the forest. The Nematopalaemon tenuipes, Puntius ticto, and Pila globosa were the dominant shrimp, fish and mollusks species in Transect-3, respectively. The result also showed that highest diversity occurs in the habitat bearinga dense stand of Clinogyne dichotoma (Murta) at the small channel in the middle of the forest, which provides undisturbed shelter for aquatic fauna. The lowest diversity occurs in the habitat situated in the transitional area between forested land and relatively deep lake, which provides insufficient shelter for aquatic fauna. The result concluded that the aquatic environment of the forest was quite stressful with relatively few ecological niches and only a few organisms were really well adapted to that environment. Thus, the biodiversity in the swamp forest needs to develop and restore through proper implementation of existing policy and regulation by the management authority as well as the Department of Forest in Bangladesh.

BOTIA DARIO (HAMILTON, 1822): LOCALLY ENDANGERED SPECIESRECORDED FROM ARIAL BEEL, BANGLADESH

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Bengal loach *Botia dario*, a small indigenous fish, once was available throughout Bangladesh but now the species has become threatened by continuous destruction of its natural aquatic habitat. The study attempts to investigate the natural availability of the species at Arial Beel, a large depression between the Ganges and the Dhaleshwari rivers south of Dhaka. The fish was found confined in some specific area of Arial Beel which was not documented before. A small group of this species has been regularly seen between January and July of 2016. Finally this paper explores the causes for decline of this fish by interviewing local fishermen and elderly people who suggested the area needs protection for conserving this locally endangered species.

POPULATION BIOLOGY OF CORICA SOBORNA IN THE PADMA RIVER, BANGLADESH

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The small Clupeid, *Corica soborna* (Hamilton, 1822) is a high nutritionally valuable food fish and found in Asian countries including Bangladesh, India, Sri-Lanka and Myanmar. This study deals with population parameters of *C. soborna* including length-frequency distribution (LFD), length-weight relationship (LWR), length-length relationship (LLR), condition factors (K), form factor $(a_{3.0})$ and natural mortality (M_w) from the Padma River. A sum of 302 individuals of *C. soborna* was sampled using cast net, square lift net, conical- and box- trap from November 2015 to April 2016.

All lengths including total length (TL), fork length (FL), and standard length (SL) were measured to the nearest 0.1 cm using digital slide calipers, and total body weight (BW) was measured using an electronic balance with 0.01 g accuracy. The LWRs was calculated using the expression: $BW = aL^b$, where the *W* is the BW in g, *L* the total length in cm), *a* and *b* are the parameters of the regression. Condition factor (K) was calculated using the equation: $K_F = 100 \times (W/L^3)$.



Fig. 1. Relationships between In length and In body weight of *Corica soborna* in the Padma River, northwestern Bangladesh.



Fig. 2. Relationships between Total length and natural mortality of *Corica soborna* in the Padma River, northwestern Bangladesh.

The LFD indicates maximum population (54.6%) stands on 3.0-4.0 cm TL group. All LWRs were highly significant with all r^2 values \geq 0.950. All LWRs are given in Fig. 1. Also, all LLRs were extremely significant with r^2 is greater than 0.971. Condition factor (K)showed significant relationship with TL and BW (P <0.001). In addition the calculated $a_{3.0}$ is 0.0056, which indicates the fish is elongated in shape. Also, the natural mortality was calculated as 2.38 and the M_w increases when the fishes were smaller in body size (Fig. 2).

IRRIGATION WATER USE OF HALDA RIVER – AN ECONOMIC ANALYSIS

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Among 40 major rivers of Bangladesh, Halda has gained special interest, especially in recent times, for being the only tidal river in the world that serves as a natural spawning ground for major Indian carps. There is no documented scientific study aiming at economic valuation of the river as a source of irrigation water. Consequently, this study aims at determining the total economic value of the irrigation water use of Halda River. Calculation of total economic worth of irrigation from Halda River was based on data collected from government offices associated with local irrigation. Questionnaire survey during field visits and personal contacts was the basis for contingent valuation method. Total economic value of irrigation water from Halda River stood at 15.7 million and 0.6 million US\$ respectively by direct method and CVM. The study showed that the willingness to pay for irrigation water use of this river is basically a function of the socio-economic factors of the households living in the vicinity of this river. We believe that this research will act as a reliable source of information for the country's decision makers in taking projects and programmes aimed at managing this river for irrigation in a more sustainable manner.

INVESTIGATION OF HEAVY METAL CONTAMINATION IN WATER, FISH AND SEDIMENTS IN THE SHITALAKHYA RIVER AT NARSINGDI OF BANGLADESH

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The study was conducted to investigate the physicochemical parameters and major anions of water as well as the heavy metal concentrations in water, fish and sediments from the Shitalakhya river during the period from January to December 2015. The water samples were collected monthly during the pre-monsoon (Feb. to May), monsoon (Jun. to Sep.) and post-monsoon (Oct. to Jan.) seasons from five sampling stations as St-1 (Saorait Bazar), St-2 (Ghorashal Fertilizer Ind.), St-3 (Jamalpur Bazar), St-4 (Ghorashal Fertighat), and St-5 (Fuleshawri Bazar). The fish (Foli: *Notopterus notopterus*) and sediments samples were collected once in a season from three sampling stations as well as stations St-1, St-3 and St-5. The physicochemical parameters of water samples were analyzed in the laboratory of the Department of Environmental Science and Resource Management (ESRM), Mawlana Bhashani Science and Technology University (MBSTU), Tangail.

The results showed that temperature 19.90 to 31.70 °C varied with season to season, whereas higher level of electrical conductivity (EC) 418 to 1288 µS/cm and total dissolved solids (TDS) 305 to 882 mg/l revealedpresence of higher amountof ionic and dissolved constituentsin river water. The contents of dissolved oxygen (DO) 6.3 to 7.8 mg/l and biochemical oxygen demand (BOD) 1.6 to 3.9 mg/l indicated the lower level of organic waste in the water. The pH 7.1 to 8.1 and alkalinity 106 to 558 mg/l depicted slightly alkaline condition, whereas higher level of hardness 38 to 270 mg/l indicated presence of various salt in water. The nitrite (NO₂) 1.12 to 98.55 mg/l content was much higher than the standard level which might be due to the direct discharge of NO₂ containing compounds from industrial and municipal sources. The higher concentrations of zinc (Zn) 0.300 to 0.970 mg/l was found in all seasons though within the standard level and the cadmium(Cd) 0.0010 to 0.0060 mg/l was found lowest, while the concentrations of mercury (Hg) 0.0010 to 0.0080 mg/l was exceeded the standard level which might be due to the influence of the effluents from paper and pulp, cement and fertilizer industries in water. Of the four studied heavy metals in fish, Zn 15.82 to 35.59 mg/kg was also highest in fish and the others such as lead (Pb), copper (Cu) and chromium(Cr) were below the lower detection limit (0.05 mg/kg). In sediments, the higher concentrations of iron (Fe) 11475.32 to 31184.36 mg/kg was found which indicated highly polluted sediment according to the EPA guideline, and the other metals found in the order of: Zn (42.22 to 99.55 mg/kg)>Cr (11.12 to 57.83 mg/kg)>Cu (7.98 to 53.31 mg/kg)>Pb (7.54 to 22.41 mg/kg)>Cd (0.38 to 0.87 mg/kg).

The study concluded that the Shitalakhya river is highly subjected to anthropogenic disturbances; resulting in metallic pollution to some extent. Thus, proper management initiatives and regular monitoring of water quality along with industrial discharge of effluents should be carried out to maintain the healthy aquatic environment of the Shitalakhya river.

FRAUDULENCE DETECTION IN FISH MARKETING OF BANGLADESH USING DNA BARCODING

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Fraudulence in fish market has emerged as a global problem. According to 'The Consumer Rights Protection Act 2009' consumers' demand is increasing day by day about composition and provenance of processed and unprocessed food products. In Bangladesh, fishes (indigenous and exotic; freshwater and marine) are cultured to a large extent all over the country. Moreover, a large amount of fishes are also landing from inland open water and marine capture fisheries. But still there is a need to produce more fish to fulfill the demand of growing population. The demand of this huge population for fish with limited supply, high profit incentive, an increase in international trade of processed foods and lack of regulation enforcement are leading fisheries business to several fraudulence such as fish species substitution, mislabeling of fish products, capture of endangered species. The lack of morphological features that are traditionally used to identify animal species is a common problem with food products, making authenticity tests impossible without alternative identification methods.

The aim of this study was to identify the level of fraudulence in fish markets of Bangladesh. Ten different species of fish were collected from different supermarkets of Dhaka metropolis examined. CO1 and aene sequence (656 bp long) was amplified using Fish primers (Fish F1, Fish R1) for all the analyzed specimens and then compared with reference sequences from different (GenBank databases and BOLD).The results showed that 8 out of 10 samples were mislabeled, the overall fraudulence was 60%

Sample		Real species as DNA	
ID	Sold as	barcode	Mislabeled
sn1	Sardenella longiceps	Megalaspis cordyla	Yes
mm2	Rastreliger kanagurta	Megalaspis cordyla	Yes
cn3	Pseudapocryptes elongates	Scartelaos gigas	Yes
lg4	Pampus chinensis	Piaractus mesopotamicus	Yes
ma5	Clarius batrachus	Heteropneustes fossilis	Yes
bp6	Clupisoma prateri	Clupisoma prateri	No
cg7	Gudusia chapra	Tenualosa ilisha	Yes
cj8	Gudusia chapra	Tenualosa ilisha	Yes
bj9	Bagarius bagarius	Bagarius bagarius	No
ta10	Tor putitora	Mylopharyngodon piceus	Yes

Table 1. Identification of collected samples using DNA barcoding and compare with the Gene Bank/Bold database

but specifically fraudulence for whole fish was 71.42% and for fillet fish it was 33.33%. These results demonstrate that DNA barcoding is a reliable tool for detecting fish products adulteration in Bangladesh. We recommend its use for control and law enforcement to get rid of product fraudulence.

FISH BIODIVERSITY STATUS OF THE PUNARVABA RIVER OF DINAJPUR WITH SPECIAL **REFERENCE TO AVAILABILITY, THREATS AND CONSERVATION MEASURES**

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The present fish biodiversity status of the Punarbahaba river in Dinajpur district of Bangladesh was investigated to know the availability of fishes, threats on existence and measures for the conservation. Fish samples were collected from Kanchan bridge area of the river (25°37'45.0"N 88°37'06.6"E), where fishermen are involved in fishing throughout the year. The collected fishes were immediately preserved in ice and finally in 7% formalin for the further investigation. The fishes were identified, incase of confusion the morphometric and meristic characteristics were measured and compared with the available literature. The threatened status of fishes were recognized from the red list categories of IUCN Bangladesh (2016). The fishermen involved in fishing at the sampling site were interviewed concerning their views on threats to fishes and A total of 65 species of fishes belongings to 19 families were identified, where river. cypriniformes was the dominant order (48%). Among the identified fishes, 2 were critically endangered (CR), 16 were endangered (EN), 7 were vulnerable (VU), 9 were near threatened (NT), 28 were least concerned (LC) and 3 were data deficent (DD). The massive siltation of river beds, indescriminate catching of fishes by management of Kata fishery, destruction of the riverine ecosystem for native speices by the entrance of exotic fishes are identified as the major threats on the fishes and river. The domestication and seed production of selected fishes in captivity for the restoration could be the effective means for the conservation. The sudden siltation may be due to the impacts of climate change and the upstream river basin development beyond the border of the country. Thus international mitigation measures needed to be taken to protect the fishes of the Punarvaba river and other rivers of Bangladesh from the upcoming challenges of climate change.

IDENTIFICATION OF F1 CROSSBREEDS (PNATIVE CLARIAS BATRACHUS AND EXOTIC radius clarias gariepinus) at its fingerling stage

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Clarias batrachus, locally known as magur, commercially important fish having delicious taste and medicinal properties. The seed production through hypophysation has significantly increased the aquaculture production of this species in Bangladesh. Stimulation of male C. batrachus sometimes failed to release the milt. Therefore, the production of crossbreed by mating C. batrachus (\mathcal{Q}) with C.gariepinus (\mathcal{J}) is practicing in many private hatcheries. The identification of this crossbreed from native C. batrachus at the early stages is very difficult and sometimes not known. Hence, the fish farmers are being exploited by stocking this crossbreed in their cultured pond because of less consumer acceptance. If such situation is going on, the farmer's interest of culturing this species will be reduced and the existence of this highly demanded *C. batrachus* will be in threats. By considering this, a preliminary attempt was taken for the morphological identification of C. batrachus, C. gariepinus and their F1 crossbreed. The crossbred was found to be intermediate between the parents. The head of the crossbreed was grey that was similar to C. batrachus and the body colour was black similar to C. gariepinus. The occipital process shape in C. batrachus was somewhat V shaped and in C. gariepinus it was round shaped. Interestingly, in crossbreed progeny was intermediate between parents. Another distinguishing feature was the presence of strong pectoral spine in C. batrachus and crossbreed, but there was no pectoral spine in the C. gariepinus. The C. batrachus and crossbreed progeny showed very active movement, while C. gariepinus showed slow movement. Further details studies including genetic identification are highly required for the clear identification of this crossbreed, which could be effective for sustainable C. batrachus production in the country.

IMPACTS OF CLIMATE VARIABILITY AND CHANGE ON FISHERIES OF THE PADMA RIVER AND ADAPTATION STRATEGIES

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Global climate change is impacting and will continue to impact on fisheries. It is assumed that the Padma/Ganges river, contributing significantly to the fisheries and fishers livelihoods of Bangladesh and India, is already affected by the climate change. However, there is a lack of evidence on it and the response strategies are unknown. This study assesses the impacts and adaptation strategies of climate variability and change on the Padma river fishers of Manikganj district, Bangladesh. Data have been collected using household interviews, focus group discussions and key informant interviews during July to October, 2015. The higher to lower rank of the climatic shocks based on their level of impacts on fishers livelihoods are as: storm>low rainfall>high temperature>low temperature>riverbank erosion. Storms have damaged fishing equipment and caused increased frequency of physical injury to the fishers which affected their coping and adaptation strategies. Low rainfall in the rainy season and higher temperature in the summer have reduced the water level in the river that results in reduced fish catch. Riverbank erosions have displaced the fishers and forced them to change their livelihood strategies. The duration and intensity of low temperature and dense fog in winter have increased over the years and it hindersfishers fishing activities. This study also found that maladaptation due to unplanned construction of embankment for controlling riverbank erosion has blocked the migration of fish between river and floodplains resulting in reduced fish catch. The fishers' common coping strategies are selling physical productive assets or livestock's, reducing food consumption, employing their school going children, temporary migration, taking loans and taking shelter in the nearby canal. Adaptation strategies include embankment construction, permanent migration, livelihoods diversification, changed in fishing duration, changed in fishing gear and fishing boats, and tree plantation. This study has found that climate variability and change has impacted on the Padma river fishery dependent livelihoods. The fishers' households are responding to these impacts and transformed some coping strategies into adaptation strategies, but these are not sufficient enough to fully address the impacts. This study has unlocked frontiers to develop appropriate policies and strategies for sustainable adaptation or reduce climate change impacts and build resilience for the river fisheries dependent livelihoods.

GROWTH, CONDITION, MATURITY AND MORTALITY OF THE GANGETIC LEAF FISH NANDUS NANDUS IN THE PADMA RIVER, BANGLADESH

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This study describes the growth pattern (allometric or isometric), condition factors (Allometric, K_A ; Fulton's, K_F ; Relative condition, K_R , and Relative weight, W_R), form factor ($a_{3.0}$), first sexual maturity (L_m) and natural mortality (M_w) of Gangetic leaffish, *Nandus nandus* (Hamilton, 1822) from the Padma River (distributory of Ganges), northwestern (NW) Bangladesh. A total 125 individuals of *N. nandus* were caught using different types of traditional fishing gears, including gill net and cast net during July 2014 to June 2015. Total length (TL) was measured to 0.1 cm, and total body weight (W) was taken to the nearest 0.1 g accuracy. The length weight relationship (LWRs) was calculated using the equation: $W = a \times L^b$, where W is the total body weight (g) and L is the total length (cm). The $a_{3.0}$ of this species was calculated using the equation of Froese (2006) as: $a_{3.0} = 10^{\log a \cdot s(b \cdot 3)}$, where a and b are regression parameters of LWRs and s is the regression slope of In a vs. b. The L_m of was calculated using the equation by Binohlan and Froese (2009) and the M_w for this species was estimated using the model of Peterson and Wroblewski (1984).

The allometric coefficient (*b*) for TL *vs.* BW relationship indicates positive allometric growth (*b*>3.0) and for SL *vs.* BW specifies isometric growth (*b*≈3) (Table 1). Among four types of condition factors the Fulton s condition factor was best for assessing the wellbeing of *N. nandus* in the Padma River. The K_F was ranged from 1.258 to 1.336. Also, the Wilcoxon signed rank test point out that the W_R did not show any significant difference from 100 (*p* = 0.325), indicating

Table 1. Growth, form factor, sexual maturity and mortality of Na	andus nandus from the Padma River, Bangladesh
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Total lengtl	h (cm)	а	b	a _{3.0}	L _m	95% CL of <i>L_m</i>	M _w yr⁻¹
Min	Max						
3.0	15.1	0.0080	3.2 2	0.0159	9.1	7.3-11.5	1.33

CL, confidence limit

BARRIERS TO OXBOW LAKE (*BAOR*) FISHERIES MANAGEMENT: CASES FROM SOUTH-WESTERN BANGLADESH

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Oxbow lakes (Baor) are important sources of inland fisheries production covering an area of about 5500 ha in south-west Bangladesh. Some of these baors have been taken under community based fisheries management to enhance the fisheries production. However, several barriers to management are hindering the potential of baors. This study was conducted to identify the limits and barriers to community based fisheries management in 'Jhapabaor' and 'Perkhajura baor' at Monirampur upazila (sub-district) of Jessore district. Both qualitative and quantitative data were collected using face-to-face semi-structured interviews, oral history interviews, focus group discussions and key informant interviews of baor dependent fishers. This study identified a range of climatic, institutional, social and economic barriers. Flood, change in rainfall pattern and siltation are among the most critical climatic barriers which cause pollution, disease outbreak, and damage to fish culture, biodiversity loss and hamper fishers' livelihoods. The baors which are controlled under ministry of land are managed by a real fisherman community. The baor leasing system is an institutional barrier because fishers cannot afford the leasing money as most fishers' income is low. This barrier leads to the inclusion of local powerful and rich non-fisher group in baor management. In addition, social barriers such as restrictions on fishing, poaching, and low level of education of fishers create social conflict resulting in lower financial output. This study concludes that various barriers are hindering the full potential of *baor* fisheries and climatic barriers are the most dominant barriers among these. These barriers can be overcome by approaches like improvement of water drainage system, modification of leasing system, establishment of sanctuaries, etc.

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POPULATION PARAMETERS OF IMPORTANT SPECIES IN SUNDARBANS ECOSYSTEM OF BANGLADESH

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The von Bertalanffy growth model parameters (L^{∞} and K) and mortality coefficients (Z, M and F) were estimated for five fish species caught by fishers in Sundarbans sites of Bangladesh. The specific objectives of this study were to determine the population parameters and assess the exploitation level of the Sundarbans fisheries managed by the co-management approaches. The exploitation ratio (E=F/Z) and gear selectivity (L₅₀) were also estimated for each species.

The growth and exploitation parameters obtained were compared with available estimates to evaluate the consistency of the results with current knowledge about the species in the region. The estimates for $L^{\infty}(26.25 - 55.0 \text{ cm})$ and K (0.90-1.13 year¹) obtained were consistent with those available in literature. Relatively high K (and low L^{∞}) values, typical of short-lived tropical fishes, were obtained for four species. Estimates for Z (2.751 – 4.45) and M (1.078 - 2.18) imply low annual rates of survival and high turnover rates. The estimates for M obtained were consistent with those available in the literature for the 5 species. The exploitation rate was estimated to be between 33 and 62% and the length at first capture was estimated to be a simple parameter which could be used to make a rapid assessment of the status of the stocks. All together study reveals that Sundarbans fishery nearly reached the limit and we have to convince all stakeholders that no additional gears can enter the fishery. Population parameters of five fishes are given in table-1.

Bengali name	Scientific name	L⊡(cm)	к	Phi (ợ')	м	F	E
Tengra	Mystus gulio	26.25	1.0	2.838	1.851	0.90	0.33
Datney	Acanthopagrus latus	35.0	0.90	3.042	1.594	1.046	0.40
Parshey	Liza parsia	27.0	1.3	2.977	2.18	2.270	0.51
Poa	Pama pama	52.5	1.10	3.482	1.624	1.376	0.46
Vetki	Lates calcarifer	55.0	0.60	3.259	1.078	1.722	0.62

Table 1. Growth parameters (L^{∞} , K and Phi (ϕ '), natural mortality (M), fishing mortality (F) and exploitation rate (E) estimated for 5 key species in the SRF wetlands sites

ORGANOHALOGEN RESIDUES OF FISHES FROM DIFFERENT TROPHIC LEVELS IN DIFFERENT SEASONS OF MEGHNA RIVER, BANGLADESH

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Pesticide residue problem is an environmental hazard and becoming serious focus for human health. Fishes are used extensively for environmental monitoring because they uptake contaminants directly from water and food. Generally the ability of the fish to metabolize organochlorines is moderate: thus contaminants load in fish are well reflective of the state of pollution in surrounding environments. In this study, the concentrations of organohalogen pesticide residues DDT and its metabolites DDE. DDD and 2,4-DDT were investigated in different fish species and prawn species of different trophic levels of four different seasons; rainy season (June-September), Autumn (October-November), winter (December- February) from Sonargaon area of Meghna River during rainy-season. and summer (March-Mav) QuEChERS method for extraction, H₂SO₄ for cleaned-up and Gas Chromatograph with Electron Capture Detector (GC-ECD) for analysis were used in the present study. Linearities (r^2) were>0.995 for calibrations. The recoveries were 88.67% - 104.89% (20 ng/g), 70.1% -101.32% (10 ng/g) and 71.64% - 103.83% (5 ng/g). The limit of detection was found 0.0625 ng/g in fish samples. The results are alarming indicating that all the samples contained DDT and its metabolites residues in varying concentrations in all seasons. The concentration of the total DDTs residues in these fish and prawn samples ranged from 2.64-191.14 ng/g in rainy season, 3.88-141.57 ng/g in autumn, 4.21- 543.00 ng/g in winter and 158.43-1660.89 ng/g in summer. The concentrations of total DDTs in all the samples were within the permissible MRL level i.e. for human consumption recommended by FAO-IAEA-WHO. As DDT is a long persistent and bioaccumulative substance in the environment, intake of significant amount of these poisonous elements with human diet is a matter of great health concern.

GROWTH PATTERN AND CONDITION INDEX OF FRESHWATER MUSSEL LAMELLIDENS MARGINALIS (LAMARCK, 1819) FROM NORTHWEST BANGLADESH

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This study describes the growth pattern and condition index of bivalve mollusk Lamellidens marginalis (Lamarck, 1819) inhabiting the freshwater ecosystem at Rajshahi, north-west Bangladesh. Monthly, 30-50 specimens were collected from January 2014 to May 2015. Shell length of the mussel ranged between 3.65 cm and 10.55 cm and body weight ranged from 3.60 g to 124.05 g. The length-breadth and length-width relationships for the entire study period were SB = 0.179 + 0.475L and SW =0.196+ 0.3163L, respectively. The length-total weight, length-wet tissue weight, length-dry tissue weight, length-shell weight, length-dry shell weight relationships were W = 0.1241L2.9066. W = 0.0524L2.7377. W =0.0116L2.7849. W = 0.0533L2.9178 and W = 0.0391L3.0386, respectively. The monthly equilibrium constant values of length-weight relationships were 2.3373 to 3.5011 for length-total weight. The highest condition index was recorded in June (23.35) and lowest in November (10.44). A rapid increase of condition index during April and June and then a sharp decline during June and August could be related to the cycles of gonadal growth and spawning. The higher condition index during summer and winter indicated a better period of commercial exploitation. This study's results will supply valuable information on growth pattern and condition index of L. marginalis and will be useful for fishery managers to impose adequate regulations for sustainable fishery management of this species in the freshwater ecosystem of Bangladesh.

BIOMETRIC INDEX OF STRIPED DWARF CATFISH, *MYSTUS VITTATUS* (Bloch, 1794) FROM THE PADMA RIVER, NORTHWESTRN BANGLADESH

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This study illustrates the biometric index i. e., length-frequency distributions (LFDs), lengthlength relationships (LLR), length-weight relationships (LWR), condition factors (Allometric, K_{A} ; Fulton's, K_{F} ; Relative, K_{R} ; Relative weight, W_{R}), form factor $(a_{3.0})$ and size at first sexual maturity (L_m) of *Mystus vittatus* from the Padma River, northwestern Bangladesh. A total 400 specimens (Male=185 and Female=215) ranging from 5.00-11.80 cm in TL were collected using different traditional fishing gears during July 2014 to June 2015. All the lengths including total length (TL), fork length (FL) and standard length (SL) were measured using digital slide calipers to the nearest 0.01 cm and total body weight (BW) was measured using an electronic balance with 0.01 g accuracy. The LWR was calculated using the expression: W= $a^{*L^{b}}$. The results showed there are no significant differences in the LFDs between sexes (P=0.225) and maximum population found in the length class 6.0-6.99 for male and 7.0-7.99 for female (Figure 1). All the LLRs were highly significant with all r^2 exceeding 0.984. Also, all LWRs were highly significant with all r^2 >0.986. The LWRs are shown in Figure 2. The Fulton's condition factor ($K_{\rm F}$) showed significant variations between the sexes (P<0.001) and $W_{\rm R}$ was significantly different from 100 for both populations (P<0.001), indicating an imbalance habitat with no availability of food, relative to the presence of predators for the M. vittatus in the Padma River. The calculated $a_{3,0}$ was 0.0109 for male and 0.0158 for female populations in the Padma River, suggesting that this fish can be classified as relatively elongate. The L_m was estimated as 6.84 cm and 6.94 cm in TL for male and female, respectively. The results of the study would be an effective tool for fishery biologists and conservationists to initiate early management and regulations for the sustainable conservation of *M. vittatus* within the Padma River ecosystem.



Fig.1. Length-frequency distributions of *Mystus vittatus* in the Padma River, Bangladesh.

PRESENT STATUS OF FISH BIODIVERSITY IN DEKHAR HAOR, BANGLADESH: A CASE STUDY

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The study was conducted to identify the present status of fish biodiversity in Dekhar *Haor* of Sunamganj for a period of 11 months from June 2013 to April 2014. It was done by questionnaire interviews (QI) of fishers, focus group discussions (FGD), key informant interviews (KII) and secondary data collection. During the study period, a total of 84 fish species under 30 families were recorded where 65 species under 23 families were found available in the study area and 19 species disappeared by last 10-15 years. The species availability status was remarked in four categories and obtained as 26 commonly available, 18 moderately available, 21 rarely available and 19 not available species. Among the available species, 9 of carps, 16 of catfishes, 10 of barbs and minnows, 1 of clupeid, 4 of snakeheads, 4 of eels, 11 of perches, 1 of feather back, 3 of loaches and other miscellaneous 6 species including 3 species of prawns were found. The highest abundance of fishes was catfish (24.62%).



Fig. 1. Different types of fish groups recorded during the period of study

Among 54 threatened fish species listed by IUCN Bangladesh, about 37 species were found 10-15 years ago in the *Haor* but only 24 were found during the study period. It is revealed that there has been gradual reduction of fish diversity in the Dekhar *Haor* area that is from the earlier 84 species to present 65 species (22.62% declined). Average fish catch per fisherman per day was also reduced from 8.35 kg to 1.4 kg in the Dekhar *Haor* within 10-15 years. Community based fisheries management, fishing gears maintenance, sanctuary establishment and management, implementation of fish acts and regulations, stocking of fish fingerling in the open waters, dredging of *beels* and raising public awareness can play a great role in conserving fish biodiversity.

MORPHOMETRIC AND MERISTIC TRAITS OF ENDANGERED TICTO BARB PETHIA TICTO FROM THE PADMA RIVER IN NORTHWESTERN BANGLADESH

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The present study describes the morphometric and meristic characteristics including lengthweight relationships (LWRs) and length-length relationships (LLRs) using a total of 13 linear dimensions and meristic traits for various body parts of the endangered ticto barb Pethia ticto (Hamilton, 1822) from the Ganges River, northwestern (NW) Bangladesh. A total of 100 individuals of *P. ticto* were sampled occasionally from the Ganges River during July 2014 to October 2015, using various traditional fishing gears (e.g. cast, gill, and square lift net). Counts of fin rays and scales (including lateral line scale) were made with a magnifying glass. Additionally, a total of 14 different morphometric lengths were measured to 0.1 cm, and whole body weight (BW) was taken to the nearest 0.1 g for each individual. The fin formula of *P. ticto* is: dorsal, D. 10-11 (ii/8-9); pectoral, P₁. 12 (ii/10); pelvic, P₂. 8- 9 (ii/6-7); anal, A. 7-8 (ii/5-6); and caudal, C. 20-24 (iv /16-20), respectively. Minimum



and maximum sizes were 4.9-9.5 cm in total length (TL) and 1.5-12.9 g body weight (BW). All LWRs were highly significant (p < 0.001) with r^2 values ≥ 0.987 . Based on r^2 value, LWR by BW vs. TL was the best fitted model among 14 equations. In addition, the LLRs were also significant with r^2 values ≥ 0.986 . According to r^2 values, LLR by TL vs. FL was the best fitted model among 13 equations. This study would be very effective for species identification and stock assessment in the Ganges River, NW Bangladesh and in surrounding ecosystems.

FISHERIES RESOURCES AND FISHING EFFORTS OF THE ANDHARMANIK RIVER

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The Andharmanik River is a 40 km long coastal river of the Ganges system located in Kalapara Upazila, Patuakhali District, Bangladesh. A baseline fisheries biodiversity assessment and a comprehensive census on fishing crafts (boats) and gears (nets, long-lines, etc.) of the river were conducted under ECOFISH^{BD} (Enhanced Coastal Fisheries in Bangladesh)project in 2014 and 2015, respectively to support the proposed first riverine co-management in this river. Local Ecological Knowledge (LEK) regarding the trends in fish biodiversity was also harvested in 2015 from senior community members. The biodiversity assessment revealed the presence of 94 fish and 5 shrimp species in the river. The fish species belonged to 66 genera and 45 families, of which 5 most important families were Cyprinidae, Clupeidae, Bagridae, Engraulidae and Sciaenidae. Out of the 5 shrimp species, 4 species belonged to Penaeidae family. The LEK indicated about 35 species mostly abundant in the commercial catch of which top 10 species are presented in Table 1. Hilsa, seabass, croakers and shrimps are included amongst the top 10 species (Table 1). The findings also indicated significant declines over time in fish abundance in the Andharmanik River.

Based on the census, a GIS map has been produced indicating the cluster of boats and fish landing centers. A total of 1,550 fishing boats of different size ranges (manual, small, medium and large)were found in and around the river, of which 912 were manually operated and the remaining 638 were motorized. A total of 15 types of major gears were used by those boats, of which top 10 important gears are shown in Table 3. ShinyJal (white gillnet), llishJal (drift gillnet) and BehundiJal (set-bagnet) were used by 29%, 13% and 11% boats, respectively. Out of the top 10 gears, 6 having mesh size about 0.2 cm were illegal and the remaining nets were legal gears (Table 3). Up-todate information on crafts and gears will help the introduction of an effective co-management that will reduce the fishing pressure and the use of illegal harmful gears in the river.

Top 10 Important	%Responded as (n = 88)			
Species	Important	Abundance		
	Species	Declining		
Shrimp (Penaeus sp.)	94	73		
Tengra (Mystus	68	49		
tengara)				
Coral (Lates calcarifer)	66	50		
Poa (<i>Otolithoides</i> sp.)	60	50		
llish (<i>Tenualosa ilisha</i>)	59	56		
Faisha (<i>Setipinna</i> sp.)	55	50		
Taposhi (Polynemus paradiseus)	47	35		
Gulsha (<i>Mystus gulio</i>)	41	34		
Boal (<i>Wallago attu</i>)	40	27		
Gagra (Arius gagora)	39	24		

Table 1. Top 10 important fish speciesin the Andharmanik River.

HEALTH CONDITION OF SOME SMALL INDIGENOUS SPECIES OF OPEN WATER BODIES: A HISTOPATHOLOGICAL STUDY

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Seasonal variation of health status of some small endangered open water fishes like baila (Glossogobius giuris), gutum (Lepidocephalichthys guntea) and kuchia (Monopterus cuchia) was carried out through clinical and histological observations from Noli beel, Kapasia upazila of Gazipur district and Kangsa river near Jaria, Netrokona for a period of twelve months from June 2015 to May 2016. Clinically fish was affected with parasitic infestation. EUS, tail and fin rot, nutritional deformities, red spots, gill rot and patches in lateral and ventral regions, large deep whitish ulcers reached up to deep muscle especially in the winter months. Comparatively fishes were less affected during rainy season followed by autumn and summer seasons in both regions. Parasitological point of view, higher prevalence of parasitic infestation was observed in the fishes of Noli beel and comparatively less infested fishes were observed from Kongsa river. Major pathological changes were observed in external organs likes muscle and aill than internal organs likes liver and kidney. Pathologies in the skin and muscle were epidermis separated from dermis, presence of fungal granuloma, vacuums, hemorrhage and necrosis. Loss of primary and secondary gill lamellae, hypertrophy, hyperplasia, clubbing, primary gill lamellae separated, necrosis, hemorrhages and presence of protozoan cyst, monogenetic tramatodes in the gill. Vacuums, pyknosis, necrosis, hepatocytes, protozoan cyst, scattered debris were observed in liver. Protozoan cyst, degenerated kidney tubules, fat droplets, glomerular nephritis, vacuums, hemorrhage and necrosis were found in especially kidney during winter. Overall, in autumn (September to October) clinically and histologically fishes were almost normal or had mildly affected, however, during late autumn (November) pathological changes were gradually increased. Fishes were found to be more affected in December and January. Whereas, during February to April, the pathological condition of fishes gradually healed up to normal condition except having few vacuums and hemorrhage. Under parasitological, clinical and histopathological observations, fishes of Noli beel were more affected than the fishes of Kangsa river.

INVESTIGATION OF HEAVY METAL CONCENTRATION IN WATER AND FISH FROM BANGSHI RIVER AT MIRZAPUR IN BANGLADESH

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The study was conducted to investigate the heavy metal concentration in water and fish (Tengra: *Mystus vittatus*) from Bangshi river in Mirzapur during the period from July 2015 to September 2015 (wet season) and December 2015 to February 2016 (dry season). Water samples were collected from three different stations: St-1 (Mirzapur municipality), St-2 (Gorai) and St-3 (Ajgana) and Tengra fish samples were collected from St-3 only at the same time. The physicochemical parameters of water samples were analyzed in the laboratory of the Department of Environmental Science and Resource Management (ESRM), Mawlana Bhashani Science and Technology University (MBSTU), Tangail. The concentrations of heavy metals of water and fish samples were analyzed in Soil Laboratory of Bangladesh Institute of Nuclear Agriculture, Mymensingh.

The physicochemical parameters such as temperature, total dissolved solid (TDS), electrical conductivity (EC), dissolved oxygen (DO), biological oxygen demand (BOD), pH and alkalinity of water were varied from 30.4 to 32.9°C, 62 to 142 ppm, 121 to 169µS/cm, 3.5 to 4.9 ppm, 0.7 to 2.9 ppm, 7.64 to 7.84 and 53.3 to 165 ppm, respectively during wet season and 19.3 to 21.1°C, 408 to 561 ppm, 772 to 869µS/cm, 1.9 to 2.8 ppm, 2.6 to 5.6 ppm, 7.76 to 8.47 and 216.6 to 371.2 ppm, respectively during dry season. Some of these physicochemical parameters were found unsuitable for fisheries and irrigation purposes. The values of all parameters except temperature and DO were found higher in dry season compared to that of wet season. The pollution level was found higher in St-2 and St-3 when compared with St-1. In case of heavy metal concentration in water the level of lead (Pb), cadmium (Cd), copper (Cu), manganese (Mn) and zinc (Zn) were ranged from 0.005 to 0.016, 0.0005 to 0.0009, 0.04 to 0.06, 0.78 to 1.39 and 1.30 to 1.94 ppm, respectively in wet season and 0.011 to 0.021, 0.0011 to 0.0019, 0.07 to 0.13, 1.32 to 2.05 and 2.06 to 3.05 ppm, respectively in dry season. The concentration of heavy metals in river water was higher in dry season than that of wet season and was within the permissible level except Mn. In fish (Mystus vittatus), the level of Pb, Cd, Cu, Mn and Zn were 0.21, 0.02, 0.65, 3.45 and 5.81 mg/kg in wet season, and 0.18, 0.023, 0.77, 2.80 and 5.67 mg/kg during dry season, respectively. The concentration of all the heavy metals studied was within the standard limit in fish samples.

The study showed that the water of Bangshi river is not completely safe and is polluted to a certain extent. The present status should not let continue that may get critical in near future. To maintain the sound environment and healthy ecosystem of the river and surrounding areas, proper management and monitoring of water quality of the river is necessary.

RAPID 16S rRNA NEXT GENERATION SEQUENCING OF BACTERIAL COMMUNITY IN THE TAMA RIVER AT SUBURBAN TOKYO, JAPAN

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Identification of genus- or species-level taxonomic profiles and diversities of planktonic microbial communities residing in urban and suburban rivers is essential to design methods of conservation through understanding the ecology. The Tama River is an important urban river in Japan flowing through Tokyo and Kanagawa Prefectures. Since very little information is known on this river, metagenomic approach was used for the first time to identify microbial population and their diversity targeting 16S rRNA gene amplicon using Ion PGM after fractionation of microbes through 5 μ m, 0.8 μ m and 0.2 μ m filters.

The resulting 16S sequences had a total of 1.48 Gb with an average of 2.38 M reads from each filter fraction. Results indicated that a half of the bacterial reads were Proteobacteria, followed bv Bacteroidetes. Actinobacteria Cyanobacteria. and Unlike other freshwater metagenomes, the potential fish pathogen Flavobacterium (Bacteroidetes) was the most numerous genera accounting for 16% of assigned reads). Mycobacterium, also а potential pathogen, was the second largest. Other dominant bacterial genera were thought to be associated with waste water and sludge. Several ecologically important bacterial including those associated with phosphorus cycling, nitrogen fixing, iron oxidizing, degrading polycyclic aromatic hydrocarbons, and biodegradation were detected. The freshwater clade of the SAR11 family

Table 1. Summary of the metagenomic datasets



Fig. 1. Relative abundances of major bacterial divisions in the Tama River 5, 0.8, 0.2 mm filter fractions based on the taxonomic identification.

(LD12 freshwater group) was also detected. This brief analysis revealed previously unknown aspects of bacterial diversity in the Tama River and can serve as a baseline estimate for further routine sampling for biomonitoring.

7th Biennial Fisheries Conference & Research Fair 2016

HAOR FISHERIES MANAGEMENT: PRESENT STATUS, CHALLENGES AND OPPORTUNITIES

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Haors is a bowl shaped floodplain depressions located in the north-eastern regions of Bangladesh covering about 1.99 million ha of area accommodating about 19.37 million people. There are about 373 haors located in the districts Sunamganj, Sylhet, Habiganj, Maulvibazzar, Netrokona, Kishoreganj and Brahmanbaria covers an area of about 858,460 ha which is around 43% of the total area of the haor region.

Haors are unique, in terms of rich ecosystems and biodiversity. Over the years, due to natural and manmade causes, aquatic biodiversity especially fish diversity and other aquatic organisms have been declining sharply. Despite the economic importance of the haors, people in the region are

poorer than in any other part of the country. More than 28% of the total population here lives below the Lower Poverty Line (LPL). Natural disasters are the main reason of poverty, which is aggravated by lack of availability of basic infrastructure and social amenities, inequity in resources acquisition and poor access to natural resources. Haor fisheries are under great stress and their sustainability is in danger due to changing aquatic ecosystem, siltation, unplanned construction of flood control and drainage structure, water drainage, agro-chemical and industrial pollutants, use of destructive fishing gears and climate change effects.

Mass of the people largely depends on the haor fisheries resources for their livelihood. Increase production and protection of fish biodiversity and ecosystem in the haor waterbodies through establishment of fish habitat restoration. sanctuaries. beel nurseries, stocking fish fingerlings, community or household-based pen and cage culture and implementation of fish act are essential. Therefore involvement of all stakeholders of haor areas should be ensured to conserve its natural resources.

Table 1. Haor areas in different districts

District	Total area	Haor area	No. of
	(ha)	(ha)	haors
Sunamganj	367,000	268,531	95
Sylhet	349,000	189,909	105
Habiganj	263,700	109,514	14
Maulvibazaar	279,900	47,602	3
Netrokona	274,400	79,345	52
Kishoreganj	273,100	133,943	97
Brahmanbaria	192,700	29,616	7
Total	1,999,800	858,460	373

Table 2. Haor fish production (kg/ha) during last 5 years

Year	Contribution (%) of total	Production
	fish production	(kg/ha)
2014-15	12.17	388
2013-14	10.30	321
2012-13	8.65	384
2011-12	8.98	352
2010-11	9.70	334

This article reviews the present status of haor waters and attempts to identify the problems and challenges thereby to provide some recommendations in the haor fisheries management and development.

STOCK STRUCTURE ANALYSIS OF MOLA (*AMBLYPHARYNGODON MOLA*) FROM DIFFERENT REGIONS OF BANGLADESH USING MORPHOMETRIC, MERISTIC CHARACTERS ALONG WITH LANDMARK BASED TRUSS NETWORK MEASUREMENTS

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Morphological variations were studied based on morphometric and meristic characters along with landmark based truss network measurement of 514 small indigenous fish mola, *Amblypharyngodon mola* (Cypriniformes: Cyprinidae) collected from nine populations from four regions of Bangladesh during May 2014 - October 2015. Ten morphometric and six meristic characters were analyzed and a truss network was constructed by interconnecting twelve landmark points to form a total of twenty seven distance variables extracted from digital images of samples using Klonk Image Measurement (version 13.2.1.2) software.

All the populations were found to be with low morphometric variability (CV<30%). The morphometric and truss distances were significantly correlated (p<0.01) with total length. Significant differences (p<0.001) were observed in all morphometric and truss measurements and meristic counts except pelvic fin rays among the populations. For morphometric and truss measurements, the first and second discriminant function accounted 53.5% and 16% of total variances among the group variability, respectively. Individual sample of 65.5% were correctly classified into their original population according to canonical discriminant function analysis. Two distinct clusters were found by discriminant function and hierarchical cluster analysis (Fig. 1 and Fig. 2). To identify the mola stock structure, caudal region was identified as the important factor by discriminant function and principle component analysis. The result of the present study would be very helpful to develop improved broodstock in Bangladesh.







Fig. 2. Morphometric similarity among *A. mola* from nine populations as dendrogram using between group linkage method through Squared Euclidean distances.

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IMPACTS OF TEMPORAL AND SPATIAL FISHING BAN ON FISH AND SHELLFISH BIODIVERSITY IN TWO FISH SANCTUARIES IN BANGLADESH

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Fishing ban is a widely practiced fisheries management tool which impacts the fish biodiversity within and beyond the sanctuary areas. The two months total fishing ban in five riverine hilsha sanctuaries in Bangladesh have been reported to increase hilsha production which also may have impact on overall fish and shellfish biodiversity. Present study was carried out to assess the impact of temporal and spatial fishing ban on fisheries (fish and prawn/shrimp) biodiversity in two riverine hilsha sanctuaries. Two fish landing sites were selected at Chandpur and Shariatpur within the sanctuaries in the Padma and Meghna rivers, respectively and two sites were selected outside the sanctuary in the same rivers. Fish and prawn samples caught by different gear were collected from pre-contacted fishers and identified based on morphometric and meristic characteristics. A total of 55 species of fish from 18 families and 6 prawn species of Palaemonidae family were identified from the four sites. The most abundant family of fish was from Clupeidae (59.84%). The species diversity and evenness evaluated by Shannon-Weiner Diversity Index (H) and equitability (E_H) , respectively are presented in Table 1. The overall H value (2.5529) indicates the presence of a wide range of species. In contrast, the individual sites were less diverse. Among the four sites the highest H was found at Chandpur due to the presence of estuarine species, while the lowest was at Maowa. The fish and prawn were more diverse with higher H values (Table 1) within the sanctuaries compared to outside indicating a positive impact of fishing ban on overall fisheries biodiversity. The different species within and outside the sanctuary were moderately evenly distributed as revealed by E_H values (Table 1). The highest evenness value was found 0.3746 at Chandpur and lowest value observed 0.01465 at Shariyatpur. The findings of the present study suggest that the temporal fishing ban has made positive impact on the fish and shellfish biodiversity within the two sanctuary areas. So, temporal fishing ban in riverine fisheries management can be an effective tool to conserve biodiversity.

Sampling sites		Shannon-Weiner biodiversity Index (<i>H</i>)	Shannon's Equitability (<i>E_H</i>)
Within	Chandpur (Meghna river)	1.2741	0.3746
sanctuary	Shariatpur (Padma river)	0.1747	0.0593
Outside	Narayanganj (Meghna river)	0.9006	0.2513
sanctuary	Mawa (Padma river)	0.2035	0.0145

Table 1. Shannon-Weiner biodiversity and equitability indices of fish and shell fish within and outside of two hilsha sanctuaries in Bangladesh
BIOMETRIC INDICES OF MOLA CARPLET (*AMBLYPHARYNGODON MOLA*) IN THE PADMA RIVER, BANGLADESH

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This study illustrates the biometric indices including length-weight relationship (LWR), lengthlength relationship (LLR), condition factor (*K*); and Form factor ($a_{3.0}$), sexual maturity (L_m) and natural mortality of *Amblypharyngodon mola* (Hamilton, 1822) in Padma River, northwestern Bangladesh. A total 308 individuals of *A. mola* were sampled using cast net, square lift net and conical trap during November 2015 to April 2016. All lengths i.e., total length (TL), fork length (FL), and standard length (SL) were measured using digital slide calipers to the nearest 0.01 cm, and total body weight (BW) was measured using an electronic balance with 0.01 g accuracy. The LWR was calculated using the expression: $W=aL^b$, where the *W* is the body weight, *L* the length (TL, FI and SL in cm), *a* and *b* are the parameters of the regression. The condition factor (*K*) was calculated using the equation: $K = 100x (W/L^3)$. The $a_{3.0}$ was deliberated using the equation of Froese (2006) as: $a_{3.0} = 10^{\log a \cdot s(b-3)}$ and L_m of was calculated using the equation by Binohlan and Froese (2009).

All LWRs were highly significant with r^2 values ≥ 0.953 . The relationships of TL vs. BW, FL vs. BW and SL vs. BW are shown in Figure 1. Also the LLRs TL vs. FL, TL vs. SL were extremely significant with r^2 values ≥ 0.973 (Figure 2). The condition factor (*K*) showed significant relationship with TL and BW (P<0.001). The calculated form factor ($a_{3.0}$) was 0.0129 for *A. mola* suggesting that, this fish can be classified as relatively fusiform. The size at first sexual maturity was 5.2 cm in TL (95% CL = 4.2-6.4 cm in TL). In addition, the calculated natural mortality for *A. mola* was 1.85 year⁻¹ in the Padma River. Therefore, the results of this study can be very effective for sustainable management and conservation of this small indigenous species in the Padma River and neighbouring bionetwork.



Fig. 1. Length-weight relationships of *Amblypharyngodon* mola in the Padma River.



Fig. 2. Length-length relationships of *Amblypharyngodon* mola in the Padma River.

PHYSICO-CHEMICAL PARAMETERS AND PLANKTON ABUNDANCE OF THE NATURAL BREEDING GROUND OF KAPTAI LAKE, BANGLADESH

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The physico-chemical parameters and plankton abundance were studied from July 2015 to June 2016 at Kasalong and Barkal breeding channel of Kaptai Lake. Standard methods were used to analyze monthly plankton and water samples collected from aforesaid breeding ground. Mean values and ranges of air temperature, water temperature, dissolved oxygen, CO₂, pH. total hardness and total alkalinity were 24 to 32°C, 18 to 34°C, 5 to 8 mg/L, 2.13 to10 mg/L, 6.5 to 8, 34.2 to 119.7 mg/L and 34.2 to 68.4 mg/L, respectively. In this study, the concentration of total ammonia (NH₃) was nil. During the study period phytoplankton and zooplankton populations recorded from the Kasalong and Barkal channel of Kaptai Lake. The phytoplankton population includes four orders i.e. Chlorophyceae, Cyanophyceae, Bacillariophyceae and Euglenophyceae. In kasalong channel phytoplankton population comprised of Chlorophyceae 44.92%, Cyanophyceae 21.42%, Bacillariophyceae 20.26% and Euglenophyceae 14.31%. In Barkal channel phytoplankton population comprised of Chlorophyceae 48.15%, Cyanophyceae 18.45%, Bacillariophyceae 23.02% and Euglenophyceae 10.38%, respectively. Among the phytoplankton the dominant order in both study areas was Chlorophyceae. The zooplankton population includes three orders i.e. Rotifers, Cladocera, Copepoda. The Zooplankton population in Barkal channel comprised with Rotifers 57.26%, Cladocera 37.51%, Copepoda 9.23%. The Zooplankton population in Kasalong channel comprised with Rotifers 49.91%, Cladocera 42.84%, Copepoda 7.25%. Among the zooplankton the dominant order in both study areas was Rotifers.

Parameters	Natural Breeding Ground of Kaptai Lake				
	Kasalong channel	Barkal channel			
Air temp (⁰ C)	28.3±2.87(24-32)	28.7±2.21(25-31)			
Water temp ([°] C)	26.3±4.57(18-34)	26.8±3.26 (21-32)			
DO (mg/L)	5.9±0.74 (5-7)	6.5±0.97(5-8)			
$CO_2 (mg/L)$	4.34±2.25 (2.13-10)	3.48±0.80 (2.36-5)			
pH	7.2±0.35(6.5-7.5)	7.25±0.42 (6.5-8)			
Total Hardness(mg/L)	54.72±15.71 (34.2-85.5)	78.66±24.45 (51.3-119.7)			
Total alkalinity (mg/L)	41.04±11.96 (34.2-51.3)	46.17±14.08 (34.2-68.4)			
Ammonia (NH₃)	Nil	Nil			

Table 1. Mean values (mean±SD) and ranges of water quality parameter
as obtained from the study areas during the study period

MULTISPECIES FISH PASSAGE BEHAVIOUR IN A VERTICAL SLOT FISHWAY IN LABORATORY SYSTEM

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Fish are confronted to a challenging hydrodynamic environment when they swim upstream vertical slot fishways. Nevertheless, the knowledge of fish behavior in these conditions is limited, particularly for coarse species such as cyprinids. The goal of the present study is to analyze fish swimming behaviour in these artificial environments and to explore its implications in the development of new fishway designs. To this end, a set of experiments has been conducted in an indoor full scale vertical slot fishway model with different sizes (fry, fingerling, juvenile and adult) of cyprinid species Rui (*Labeo rohita*), Catla (*Catla catla*) and Mrigel (*Cirrhinus reba*). Their upstream movements have been recorded with a video camera system and water velocity have measured through ADV (Appoustic Doppler Velocity Meter) and Current Meter. The results emphasize the value of achieving a deeper understanding of fish requirements in these devices and show the potential of the methodology developed to fulfil this objective. The results obtained can contribute to develop robust guidelines for future fishway designs in Bangladesh.

STOCKING DENSITY AND MALE MORPHOTYPES FORMATION OF PRAWN MACROBRACHIUM ROSENBERGII IN PROBIOTIC BASED CULTURE SYSTEM

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Formation of different morphotypes in male galda in culture ponds is a potential drawback in increase of production; the males with blue claws (BC) are bigger than either the orange claw (OC) males or small males (SM). The proportion of these morphotypes in cultured population determines the total production; the larger the proportion of BC males in the stock the more the production and thus it needs to be looked at what trigger the formation of the different morphotypes. With this aim in view the present study was conducted in an on-going experiment based on the impact of two commercial probiotics - Zymetin (a food related probiotics) and Super PS (a soil related probiotics) on the production of galda, stocked in three densities. We tried to see if the sex ratio in stocked galda and the doses of probiotics used in the culture treatment had role in the formation of different morphotypes with consequent net result in production. Three stocking densities tested with the two probiotics in the experiment were - 2 iuveniles $/m^2$ (T₁), 3 juveniles $/m^2$ (T₂) and 4 juveniles $/m^2$ (T₃). The sex ratios obtained in the final production were found to be $1.08:1(T_1)$, $1:1.13(T_2)$ and $1.78:1(T_3)$ (Fig. 1) and proportions of BC, OC and SM males were obtained to be 57%,35% and 8% (T1); 64%, 31% and 5% (T₂) and 25%, 44% and 31% (T₃) (Fig. 2). The highest proportion of BC male (64%) was obtained from T₂ treatment with consequent highest production of 1158kg/ha followed by 57% BC male with total production of 667.87kg/ha in T₁ and 25% BC male with total production of 787.18kg/ha in T₃.Evidently in T₃ the proportion of SM male (31%) led to increase of production than in production obtained in T₁ with next higher proportion of BC male (57%). The results of the experiment suggested that stocking density of 3juveniles/m² with 5g Zymetin (with 20g Mutagen/kg feed) and 15 liter Super PS (with 7.5kg sand /ha/week) was the best in galda production, with slightly more females, leading to higher proportion of BC males.



Fig.1. Percentages of male and female in different stocking densities.



Fig. 2. Proportions of different male morphotypes in different stocking densities.

OPTIMIZATION OF STOCKING DENSITY OF GIANT FRESHWATER PRAWN MACROBRACHIUM ROSENBERGII UNDER PROBIOTICS ADMINISTERED CULTURE

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The study was conducted to find out thesuitable density of prawn (Macrobrachium stocking rosenbergii) by administering probiotics in monoculture svstem. The experiment was conducted in Khulna University Campus during July, 2015 to December, 2015. There were four different stocking densities. viz.. 2.3. 4 and 5 juveniles/m² intreatments T_1 , T_3 T₂, and T₄ respectively with three replications each. Initially feed was applied at 12% of body weight which was gradually reduced to 2%. The daily dose of feed probiotic was 5g/Kg feed mixing with 20g binder and the weekly doze of soil probiotic was 1ppm in first 4 months and 2ppm in last 2months. Sampling was conducted fortnightly to measure the growth performance and water quality parameters. The



initial average weight of prawn juvenile was similar of 3.48 ± 1.15 g,the growth pattern during the culture period was different (Fig. 1). Similarly, after 180 days of culture, the weight were 50.95 ± 0.85 , 45.99 ± 0.71 , 38.29 ± 0.99 and 30.85 ± 1.22 g that were significantly different (p<0.05) among the treatments. Survival rates also varied significantly(Table1). The water quality parameters were varied within the cultivable range. Though, the highest production (1156.97±29.92 kgha⁻¹) was found in T₃, but considering cost benefit T₂could be said best due to sizable grade and higher market price where production was second highest (1136.18±17.61kgha⁻¹).Therefore, the stocking density can be suggested to 3juveniles/m² in the context of present culture related inputs.

Table1. Production performance and benefit of Macrobrachium rosenbergii for six month culture								
Treatments	Stocking	Body	weight (g)	SGR(%)	Survival	Production	Net Profit	FCR
	ha ⁻¹	Initial	Final		rate (%)	kg/ha/crop	per Ha	
T_1	20000	$3.48{\pm}1.40^{a}$	50.95 ± 38.14^{a}	1.49±0.10 ^a	88.43	901.10±15.02	4,05,996.11	1.64
T ₂	30000	$3.48{\pm}1.40^{a}$	45.99±15.66 ^b	1.43±0.11 ^b	82.35	1136.18±17.61	4,34,629.77	1.69
T3	40000	$3.48{\pm}1.40^{a}$	38.29±13.50 ^c	1.33±0.12 ^c	75.54	1156.97±29.92	2,64,045.32	1.85
T4	50000	$3.48{\pm}1.40^{a}$	$30.85{\pm}11.93^{d}$	1.21 ± 0.12^{d}	69.23	1067.87±42.18	45,349.10	2.01

PROBIOTIC INFLUENCE ON PRODUCTION PERFORMANCE OF GIANT FRESHWATER PRAWN *MACROBRACHIUMROSENBERGII* IN EARTHEN POND

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Prawn is one of the important export earning commodities in Bangladesh. The farmers practice prawn farming in traditional system that results less growth, high mortality effecting low production and less economic return. A study was conducted to evaluate probiotics effectof on production performance of freshwater prawn (Macrobrachium rosenbergii) for a period of from July, 2015 to December, 2015 in Khulna, southwest of Bangladesh. The stoking rate was 2 iuveniles/m² with two treatments of (i) control or without probiotics (T_0) and (ii) soil and feed probiotics (T_1) . Six ponds (each 240m²) were used to conduct the field experiment for three replications of



both the treatments. Water and soil quality parameters (Temperature, pH, DO, hardness, alkalinity, un-ionized ammonia, nitrite nitrogen) were measured and found within the acceptable range. The initial average body weight of prawn was $3.48\pm1.4g$ in T₀ and $3.49\pm1.4g$ in T₁. After six months (180 days), at the time of harvesting average individual weight was42.61±14.29g in T₀ and 50.95±16.33g in T₁ (Table 1).The prawn survival rate was found 83.25 and 88.43% in T₀ and T₁ respectively. Significantly higher (P<0.05) growth and survival rate were found in T₁ where two commercial probiotics were used. The estimated total production was709.45±2.58 and 901.10±15.02 kgha⁻¹ in T₀ and T₁ respectively (Table1). This study suggested that probiotics could be used for higher prawn production.

Table 1. Production and Growth Parameters of Macrobrachium rosenbergii for six months								
Treatments	Stocking	Body weight (g)SGR (%)SurvivalProductionFCR						
	ha ⁻¹	Initial	Final		rate (%)	kg/ha/crop		
T ₀	20000	3.48 ± 1.40^{a}	42.61±14.29 ^a	$1.39{\pm}0.002^{a}$	83.25	709.45±2.5	1.71	
T_1	20000	3.49 ± 1.40^{a}	50.95±16.33 ^b	$1.49{\pm}0.009^{b}$	88.43	901.1±15.02	1.64	

ENVIRONMENTAL IMPACT OF SHRIMP FARMING IN BANGLADESH: HABITAT, LANDSCAPE AND BIODIVERSITY

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Aquaculture has become one of the fastest-growing economic subsectors of the Bangladesh economy, providing protein-rich food, source of employment and earning foreign currency. Presently, the sector provides income and livelihood for more than 11% people of the country's 160 million people. Total shrimp production of the country increased from 14,773 ton in 1986 to 128,313 ton in 2014, almost 8.7 times increase over the last 28 years. Area under shrimp farming has increased from 115,051 ha in 1986 to 276,495 ha in 2014. The country earned about US\$ 535 million in 2013-14 through the export of 47,635 tons of frozen shrimp. However, in parallel with the contribution of the shrimp sector to the local and national economy, it is anticipated that shrimp aquaculture might have caused some negative impact on the local ecosystem. This may include some deterioration of soil and water quality, depletion of mangrove forest, decrease in population of local species of fish and shellfish, intrusion of saline water, water pollution and change of local hydrology. There have also been some socioeconomic consequences on the livelihood patterns of people living in the coastal areas and migration. Other impacts may include deterioration of drinking water quality, loss of land for grazing for livestock and changes in the cropping patterns, with an impact especially on landless agricultural labourers. Social and environmental sustainability may have been overlooked during the expansion of shrimp farming. Losses due to disease, which are still a periodic problem for the sector, are a major indicator of an unsustainable system. At this stage, a paradigm shift is needed away from current shrimp farming practices to a more holistic and integrated approach. Some modification and improvements have been made in recent years - these should be extended. At the same time, incentives are needed for appropriate investment, to improve the physical infrastructure of ghers (ponds), and adopt new management methods; this is an important role of government- without a guiding policy on the development of the shrimp sector, private businessmen are likely to move ahead in an unplanned or unregulated way. To support this process, research is needed to better understand the effects of hydrology on biotic processes and of the biota on hydrology in an altered scenario caused by shrimp farming. Alternative and innovative culture systems must be identified as they form pathways to make shrimp aquaculture production sustainable. The benefit for the poor must be ensured through understanding and identifying right ways to address the practical constraints under which the poorer and less organized shrimp producers operate. Access to interest free or credit with minimal interest through institutional reform could help transform shrimp farming sector particularly for the poor or marginal shrimp famers and PL harvesters and traders. This will also prevent mal-adaptation, and tend to diversify livelihood strategies as well as reduce the cost of farming. Institutional reform can also improve enforcement laws and acts on fish diversity conservation, fish feed and hatchery. Enforcement of regulations and provision of insurance would increase safety of the shrimp farmers. Finally, building shrimp farmer's human capital will underpin the creation of alternative livelihood activities.

ABUNDANCE OF PHYTOPLANKTON IN FRESHWATER PRAWN *MACROBRACHIUM ROSENBERGII* FARMING WITH DIFFERENT CARBON AND NITROGEN RATIOS IN BIOFLOC SYSTEM

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A study was conducted, in nine experimental ponds (each 240m²) of Fisheries and Marine Resource Technology Discipline at Khulna University campus from September to December 2015,to estimate the abundance and diversity of phytoplankton in biofloc based freshwater prawn (*Macrobrachium rosenbergii*) pond with three C/N ratios 10:1 (T₁), 15:1 (T₂) and 20:1 (T₃).Each treatment was replicated three times. Plankton samples were collected fortnightly. Plankton samples were collected by conical shaped monofilament nylon plankton net (50µ mesh size) through passing 20L water sample and Lugol's solution was used for preservation. Different physico-chemical parameters of water were measured during study period. The phytoplankton abundance was influenced by biofloc treatment as it controls water quality. The abundance of phytoplankton cells were18270±16.27, 19010±78.14 and 20650±166.45cells/L in T₁ , T₂ and T₃respectively. Significantly highest number phytoplankton was found in T₃ and lowest in T₁ (Table 1, p < 0.05)).

Five groups of phytoplankton were identified in all the three treatments. Phytoplankton composition in T_1 was Chlorophyta 10660±32, Cyanophyta3050±30, Bacillariophyta 2470±37,

Euglenophyta

2470±37, 1530±23 and
 Table 1. Monthly abundance of phytoplankton (cells/L) in different treatment

treatment					
Treat		Mor	Average		
ment	Sep.	Oct.	Nov.	Dec.	Avelage
T ₁	18320 ^a	18313 ^a	18000 ^a	18440 ^a	18270±16.27
T ₂	20180 ^b	19240 ^b	18150 ^b	18480 ^b	19012±78.14
T ₃	22060 ^c	22540 ^c	18770 ^c	19240 ^c	20652±166.45

Chrysophyta560±15 cells/L;in T₂ was Chlorophyta 11490±58, Cyanophyta 3010±39, Bacillariophyta 2432±30, Euglenophyta 1410±29 and Chrysophyta 670±26 cells/L and in T₃ was Chlorophyta 12310±39, Cyanophyta 3422±18, Bacillariophyta 2270±39, Euglenophyta 1450±47 and Chrysophyta 1200±73 cells/L. The ANOVA test result showed that, abundance of Chlorophyta was significantly (P \square 0.05) higher than the other groups in every treatment. The outcome of the present study will help the farmers in successful farm management maintaining suitable water quality parameters in prawn (*Macrobrachium rosenbergii*) culture regarding phytoplankton production in biofloc culture system.

OPTIMIZATION OF CARBON NITROGEN RATIO INBIOFLOC BASED PRAWN (MACROBRACHIUMROSENBERGII) FARMING SYSTEM

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Freshwater giant prawn (*Macrobrachium rosenbergii*) farming is currently one of the crux sectors of the national economy in Bangladesh, with its diverse contributions such as food production, employment opportunity and valuable foreign currency earnings. As a sub-tropical country, Bangladesh has a vast water bodies and suitable ecological condition for the culture of freshwater prawn. The average prawn production in Bangladesh is still remained very low(300-600kg/ha/year),compared to other neighboring countries. Biofloc Technology (BFT) is a new approach toward management of mostly intensive shrimp culture ponds.

A study was conducted, in the experimental ponds (each $240m^2$) of Fisheries and Marine Resource Technology Discipline at Khulna University campus, to optimize the C/N ratio for higher production of prawn. Four treatments namely control (T₁), C/N ratio 10:1 (T₂), 15:1 (T₃) and 20:1 (T₄). Ponds were dried and prepared following standard aquaculture method.

Table1. Production performance of prawn (Macrobrachium rosenbergii) in different Carbon nitrogen ratio

				0	
Treat	Stocking	Initial wt.	Final ind.	Survival	Production
ment	Density	(g)	Avg wt	(%)	(Kg/ha.)
		-	(g)		
T ₁	2/m ²	3.48±1.4	39.5±8.5 ^ª	86.34	681.22
		3.48±1.4	41.3±7.4 ^a		
T_2	2/m ²		b	88.85	733.01
		3.48±1.4	46.9±6.5 [°]		
T ₃	2/m ²		d	92.65	868.13
T_4	2/m ²	3.48±1.4	43.4±8.2 ^b	91.42	792.61

Juvenile prawn were stocked in pre-prepared grow-out ponds at a density of 2juveniles/m² where initial average weight was3.48±1.42g. Prawn were fed with prepared feed containing 32% protein two times a day at the rate of 10~3% of their total body weight in all four treatments. To maintain C/N ratio maize flour was used as carbon source. Regular sampling was done measuring prawn length-weight, water quality, total heterotrophic bacteria etc. After 180 days of culture, significantly highest growth (46.9±6.5 g) was found in T₃ where C/N ratio was 15:1(Table 1, P \square 0.05).Survival rate (92.65%) and production (868.13kg/ha) were also higher in T₃ compared to other treatments. The lowest production of 681.22kg/ha was yielded in T₁ (without bifloc). The result indicates that C/N=15:1 could be suggested in biofloc based prawn culture system.

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CO-CULTURE-INDUCIBLE PROBIOTIC ACTIVITY OF *LACTOBACILLUS* ISOLATES AGAINST SHRIMP PATHOGENS

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The use of traditional chemotherapeutic agents has been questioned for disease management in aquaculture systems, due to the emergence of multiple drug-resistant (MDR) bacteria and enduring residual effects in the environments. Probiotics – the friendly bacteria with a host of benefits that work by competitive exclusion of pathogenic bacteria can be a suitable alternative. Here, the antagonistic activities of probiotic bacteria, *Lactobacillus* spp., isolated from curds were tested against four different MDR shrimp pathogens: *Enterobacter cloacae, Klebsiella pneumoniae, Enterococcus casseliflavus* and *Exiguobacterium profundum*, previously reported from diseased post-larvae.

The co-culture experiments composed of a single probiotic bacterium and a single pathogen revealed that three *Lactobacillus* isolates were found to produce bactericidal activity against all four pathogenic isolates within 24 hours of incubation at 37°C, and this inhibition was due to the potential secretion of antimicrobial substances released from *Lactobacillus* spp., rather than the

lowering of pH of the growth medium. However, this activity was not observed when the cell-free supernatant of *Lactobacillus* was used under the same set of conditions, indicating that the effect was an inductive one, rather than constitutive.

A 16S rDNA sequencing analysis revealed that these probiotic bacteria were closely related to *Lactobacillus delbrueckii* subsp. *indicus*, *L. plantarum* and *L. fermentum*. Dose-dependent co-culture





assay revealed that the optimum combination of probiotic to pathogen fell in between 1,000:1 to 100:1 for a bactericidal effect. Further characterization of the probiotic activity will help ensure a better preventive approach to control prawn mortality, and thereby strengthen the aquaculture sector economically.

FACTORS THAT INFLUENCE THE PRODUCTION OF TIGER SHRIMP (*PENAEUS MONODOM*) AT BAGERHAT, BANGLADESH

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This study was conducted to identify the factors which influence the production of *Penaeus monodon* in nine shrimp farms of Fakirhat, Mongla and Rampal Upazila under Bagerhat district. Data were collected from 200 shrimp farms from 2012-2013 of above mentioned regions. Previously practiced farms were selected for this experiment with close observation. Most of the farmers are practicing improved extensive culture system. Now a days shrimp culture pattern has been changed especially in stocking density in comparison to it's initial farming practices. Most of them are culturing shrimp with other crustaceans species like Giant freshwater prawn (*Macrobrachium rosenbergii*), Horinacingri (*Metapenaeus monoceros*),Chaka Cingri along with some fin fishes (Tilapia, Banghna, Khorsula, Bhetki etc) . We observed that production of Tiger shrimp depends upon various factors like inadequate water exchange, salinity fluctuation, accessing polluted water, feeding, disease outbreaks, soil condition, water depth, variable stocking density, stocking pattern, lack of good quality post larvae, predation and many other social factors like poaching, rumor etc. The farmers changes his culture approaches with his previous experiences.

PLANKTON VARIABILITY IN PROBIOTIC TREATED ANDNON-TREATED PRAWN (*MACROBRACHIUM ROSENBERGII*) CULTURE SYSTEM MAINTAINING CARBON AND NITROGEN RATIO 15:1

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The present study was designed with an aim to understand the abundance and diversity of plankton in fresh water prawn (*Macrobrachium rosenbergii*) culture system without probiotics (T₁) and with probiotics (T₂) maintaining carbon and nitrogen ratio of 15:1. The study was carried out in the experimental pond complex of Fisheries and Marine Resource Technology Discipline, Khulna University from November to December, 2015, using stocking density 2 juveniles/m².Six ponds (each 240 m²) were selected under two treatments with three replications. Phytoplankton samples were collected with50 µm plankton net and preserved in Lugol's solution. Zooplankton were collected with 90 µm net and preserved in 5% buffered formalin. Qualitative and quantitative estimations of plankton were done, using a Sedgewick–Rafter (S–R) cell, following the standard procedures. Abundance of Chlorophyta, Bacillariophyta, Cyanophyta, Chrysophyta, and Euglenophyta groups were found higher in T₁ where probiotics were not used. Among the five groups the Chlorophyta(4.19×10⁴ells/L) was highest in number following the Bacillariophyta(2.80×10⁴cells/L).

Abundance of zooplankton Cladocera, Copepoda, Rotifera, Ostracoda, and Crustacean larvae was higher in probiotic treated pond. In both treatments Copepoda was higher(Fig. 1) among five groups and abundance was little bit higher in T_2 (615 cells/L) than $T_1(532 \text{ cells/L})$. The output of the study can be concluded that probiotics can be very well utilized for the prawn culture ponds to



control phytoplankton bloom with increasing zooplankton production.

EFFECTS OF AEGLE MARMELOS LEAVES EXTRACT AGAINST WHITE SPOT SYNDROME VIRUS (WSSV) INFECTION IN SHRIMP PENAEUS MONODON

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The shrimp industry is one of the significant contributors in the economy of Bangladesh. Viral diseases in aquaculture pose as an important limiting factor. In recent years, the infection caused by White Spot Syndrome Virus (WSSV) leads to a great deal of economic loss in Penaeus monodon culture sites. Mass mortality due to the manifestation of WSSV diseases in southern part of Bangladesh is very common. For the present study, shrimps were collected from the WSSV affected ghers in Satkhira Sadar upazila. Satkhira and Rampal upazila. Bagerhat. Two ghers were selected from each district and samples from each gher were randomly collected and examined for the presence of WSSV by the most powerful technique of Polymerase Chain Reaction (PCR), using two different pairs of primers yielding amplicons of 298 bp and 941 bp. The primer pairs used in this study are designated as 146 F2-R2 (941 bp), I,K 3-4 (298 bp). The methanol extract of A. marmelos (locally known as 'Bael' or 'Bell') was experimentally checked for the antiviral activity against WSSV infection in our study. The results revealed that this extract has potential antiviral activity against the viruses of WSSV. Two different concentrations (100mg/kg of body weight and 150mg/kg of body weight) of methanol extracts were tested against WSSV in P. monodon. At the concentration of 100bmg/kg of body weight, the extract showed partial anti-viral effect in shrimp having a mortality of 35% at the end of the experiment after post administration. WSSV-specific band was found from day 5 in our experiment. On the other hand, at the concentration of 150mg/kg of body weight, the extract showed strong anti-viral effect in shrimp as there was no manifestation of WSSV symptoms, no mortality occurred and no positive band was found at the end of the experiment as well. Though A. marmelos is conveniently available throughout our country, it would be a viable and environment friendly option to minimize the hazardous economic loss due to disease in aquaculture sector in Bangladesh...

DEVELOPMENT OF A MULTIPLEX PCR PROTOCOL USING NOVEL PRIMER FOR RAPID DETECTION OF WHITE SPOT SYNDROM VIRUS IN SHRIMP

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The high cost for white spot syndrome virus (WSSV), causative agent for white spot disease in shrimp, testing can be attributed to the fact that all PCR testing laboratories in Bangladesh employ the use of patented kits imported from overseas countries instead of locally available bulk reagents. The open-access database together with bioinformatics tools can be conveniently used to access and design new primers from WSSV genome that can be tested with locally available reagents to develop a cost-effective protocol for WSSV screening. Therefore, a multiplex PCR-based protocol was developed using a novel set of primer for rapid and routine screening of white spot syndrome virus (WSSV) in shrimp PL, juvenile and brood.

An outer primer pair (VP466 F/R)and an inner primer pair (VP466 Nested F/R) were newly designed from WSSV genome sequence that encodes for structural protein corresponding to 760 and 416 bp respectively, where an another set of primer, internal control (host)corresponding to 441 bp, was also retrieved from shrimp ribosomal gene. To develop the protocol, DNA was extracted from virus affected shrimp using 1% SDS-based genomic DNA extraction buffer and the selected primers were amplified separately to test their efficacy. Once completed, multiplexing was done in a factorial design using the WSSV-specific primer and shrimp-specific primer in a single tube by single step PCR. The most suitable primer combination was optimized for the PCR protocol on the basis of reproducibility and resolution. In addition, a positive control was developed for the protocol to verify negative amplification results by cloning a target DNA fragment of WSSV genome into a pMD20-T vector and transformed it into Escherichia coli JM109 competent cells which were finally plated on LB plates for incubation and the recombinant plasmids were isolated and electrophoresed on a 1.5% agarose gel to screen for the insert DNA. The new multiplex PCR-based protocol under the study minimized the possibility of cross-contamination, increased the sensitivity and specificity, reduced operational time and was30-35 times cost effective for WSSV detection with shrimp as internal host. The protocol along with the positive control can be a replacement of 'all-in-one' costly imported kit for the rapid and routine screening of white spot disease in shrimp.



OPTIMIZATION OF DNA EXTRACTION PROTOCOL FOR RAPID DETECTION OF WSSV IN SHRIMP USING NON-PATENTED BULK REAGENTS

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White spot syndrom virus (WSSV) is by far the most devastating pathogen threatening the shrimp industry in Bangladesh. Stocking of PCR-screened virus free post larvae (PL) is a prerequisite to combat against the virus. However, costing of a single shrimp sample for WSSV detection remains substantially high in our country because of employing imported kit instead of locally available reagents. Therefore, acost effective shrimp genomic DNA extraction protocol was developed in terms of reagent composition, stability and reproducibility of results that focused on development and fine tuning a PCR protocol for WSSV screening under existing field condition, which can be conveniently adopted by the farmers.

The genomic DNA extraction protocol was optimized with six protocols using three commercial kits and three formulations based on sodium dodecyl sulphate (SDS) based DNA extraction buffer exclusive of any proprietary commercial kit but instead, relying on non-patented available bulk reagents. We compared the efficacy of 'all-in-one' commercial extraction solutions from suppliers like Invitrogen (PureLink spin colum kit), Invitrogen (DNAzol) and Genereach (IQ 2000 WSSV kit) with the optimized 1% SDS-based DNA extraction buffer. The six genomic DNA extraction protocols showed considerable amount and purity of DNA. The purity (ratio of A_{260nm} and A_{280nm}) of the DNAs ranged from 1.70 to 1.86 whereas the concentration ranged from 752 to 1023 µg/ml. DNA extracted from all six protocols resulted in amplification of expected PCR products after optimization of thermal cycling parameters for individual primer pairs specific to both shrimp and WSSV. In comparison with commercial kit based extraction protocols, SDS based DNA extraction protocols tested for this study took considerably less time to accomplish the task with comparable results in terms of resolution and reproducibility. We concluded that DNA extraction buffer containing 1% SDS and other locally available reagents was the best, considering the time, cost and manipulation involved and the PCR results achieved.

Protocol Name	Source	Total steps	Time taken for completion	Concentration (µg/ml)	Purity (A ₂₆₀ /A ₂₈₀)
Pure Link Genomic Extraction Kit	Kit; Invitrogen, USA	11	3 h	752	1.86
DNAzol kit	Kit; Invitrogen, USA	05	1 h	1023	1.77
IQ2000 WSSV Kit	Kit; GeneReach, Taiwan	05	1 h	643	1.70
DNA extraction Buffer-1 (DEB-1)	Non-kit using non patented bulk reagents	05	1 h	820	1.66
DNA extraction Buffer-2 (DEB-2)	Non-kit using non patented bulk reagents	05	1 h	870	1.71
DNA extraction Buffer-3 (DEB-3)	Non-kit using non patented bulk reagents	06	2.5 h	948	1.80

Table 1: Results of the compared protocols to investigate the efficacy for shrimp DNA extraction

ANTIVIRAL POTENTIAL OF *MOMORDICA CHARANTIA* LEAVES EXTRACT AGAINST WHITE SPOT SYNDROME VIRUS (WSSV) OF BLACK TIGER SHRIMP *Penaeus monodon*

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White spot syndrome virus (WSSV), the most contagious pathogen that causes mass mortality, leading to a huge economic loss to the shrimp industry especially black tiger shrimp in many countries including Bangladesh. The huge outbreak and lack of effective therapeutic or prophylactic measures have aggravated the situation, necessitating the development of antiviral agents. With this aim in view, the antiviral activity in the methanol extract of *Momordica charantia* (the bitter gourd, locally called 'korola') in *Penaeus monodon* was evaluated. Many attempts have been made toward the identification and finding solution to this problem. For the detection of WSSV, samples were collected from Rampal upazilla and Satkhira Sadar upazilla had been selected. The samples from each gher were randomly collected and examined for the presence of WSSV by Polymerase Chain Reaction (PCR) using 146 F2-R2 (941 bp) primers and conformed of WSSV infection. Methanolic extract of *M. charantia* was injected in shrimp at a concentration of 100 mg/kg and 150 mg/kg of body weight shrimp showed no mortality, no

external signs during the study period. The presence of WSSV was examined by PCR using 146 F2-R2 (941 bp) primers and a nested PCR using I,K 3-4 (298) primers but no evidence of WSSV was found. The overall results suggested that the methanol extract from *M. charantia* could protect *P. monodon* from white spot syndrome virus infection and it might be used as an effective, cheaper and eco-friendly antiviral agent to combat the WSSV in shrimp culture.



STUDY ON WATER AND SOIL QUALITY PARAMETERS OF SHRIMP AND PRAWN FARMING IN THE SOUTHWEST REGION OF BANGLADESH

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Water and soil quality parameters play a vital role for sustainable shrimp and prawn production which together is the leading exportable seafood product in Bangladesh contributing to a significant amount of foreign currency earnings. However, this sector is often negatively criticized by the consumers of importing countries for farm (locally called *gher* in Bengali) environment. In this context, an investigation was carried out to assess water and soil quality parameters of shrimp and prawn farms in southwest Bangladesh. This study was conducted at Dumuria and Paickgacha Upazila of Khulna district during dry and wet season in 2012.

The data were collected from nine shrimp and prawn farms and they were categorized in three different groups (as treatments) including 3 prawn (T_1) , 3 shrimp & prawn (T_2) and 3 shrimp farms (T_3) . Water temperature, dissolved oxygen, pH, ammonia, nitrate, nitrite, alkalinity, salinity, total phosphorous and total hardness were measured using portable advanced HACH water quality test kit in both dry and wet season. Farm soil (sediment) quality parameters including pH, organic carbon, total nitrogen and available phosphorus were measured in the laboratory in wet season. It was found that most of the water quality parameters were in suitable range in both seasons for prawn, shrimp & prawn and shrimp farming. However, the ammonia content was 0.009 to 0.45 ppm and 0.2 to 0.6 ppm in shrimp farm during dry and wet season, respectively, which was higher than the other category of farms. The higher ammonia content in shrimp farm might be due to the decomposition of aquatic weeds, organic matter, uneaten feed etc. creating stress to shrimp. Different co-relationships were found between the water quality parameters in all the farming systems in the both seasons. In terms of soil quality parameters such as pH, organic carbon and total nitrogen, there was no significant difference between the farm categories. However, available phosphorous content was significantly higher in shrimp & prawn farm. Phosphorous content was found negatively correlated with pH and organic carbon content of farm sediment (soil). From the present study, it could be argued that ammonia is the main problem for shrimp farms that may cause severe disease outbreak which need to be addressed from the view point of research and development towards sustainable seafood production in Bangladesh.

KETNOTE PAPER

CURRENT CHALLENGES AND FUTURE PROSPECTS OF AQUACULTURE IN BANGLADESH

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Historically we have long experienced amateur aquaculture in rural areas of Bangladesh, largely with three or more different species of carps fish like rohu, catla, mrigal and a few Chinese carps. The affluent residents and owners of rural lands usually maintain comparatively large size ponds for such cultivation. Commercial aquaculture started developing slowly within the country during post-independence era. At present, according to the Department of Fisheries (2014-2015) Bangladesh is producing 2.06 million metric ton fish through aguaculture, which accounts almost 56% of total fish production of the country. The farmed fish primarily consisted of carps, pangas, tilapia and some catfish, though more species are being slowly introduced as of now. According to the DoF, to date, 7,94,361 ha of land is under aquaculture. Production per ha from aquaculture is stated to be about 2.6 MT fish. The department also states that we have achieved 5% annual growth in the last 5 years, in terms of yield. At the same time total area under aquaculture also continues to expand. This horizontal expansion is our main challenge as we know, land is a limited resource in this nation, keeping in mind that there are other crops such as, rice along with overall ecological impacts of unplanned fish farming. During 1976 -2010, about 1 million ha land came under fish farming. On the other hand, as it is assumed by 2040, the natural habitat of marine fish will be depleted because of climate change, over fishing and other anthropogenic factors. Therefore, this is the high time to rethink the importance of aquaculture as the main source that has to provide our protein needs in a sustainable way. The World has long been relying on aquaculture as a main source of animal protein. New technological innovations along with some existing ones be required to save our land and at the same time increase our fish production vertically. Presently main challenges are arising from the farmers' lack of knowledge of water chemistry and fish feed - and their relations with quality fish seed, day to day management practices and overall fish health. Most of the fish farmers are not well-aware of the long term impact on water chemistry and aquatic ecology. Nor are they aware of the impact of using fish feed with health hazards such as poultry waste along with the use of different banned steroids, meat and bone meal many of these ingredients have potential to pose severe threats to the human health ...

Other countries have already introduced technology for aquaculture which we are yet to consider, such as RAS system (Re-circulating Aquaculture System). As RAS has been rapidly expanding in a number of fish producing countries, it is expected that, by 2030, 40 % of total famed fish will be grown in RAS. Currently it represents 4.5% of aquacultured product globally. The present aquaculture yield is about 10 kg per dec (60 m³ if pond depth is 1.5 m) whereas using RAS technology, we can achieve 50-60 kg per m³. Many of the farmed fish of Bangladesh particularly pabda, gulsha, pangas, shing, magur along with koi, sarpunti etc. can easily and profitably be cultured using RAS.

EFFECT OF GAS REMOVAL CHEMICAL (G.R. PLUS) ON GROWTH AND HEALTH CONDITION OF THAI SARPUNTI (*PUNTIUS GONIONOTUS*)

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The present study was conducted to observe the efficacy of G.R. plus on the growth and health condition of Thai sarpunti for a period of 90 days from 25 July to 22 October, 2014 in eight mini research ponds located in the northern side of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. There were four treatments each with two replications. Out of four treatments T_1 (3 fish/m²) and T_2 (5 fish/m²) were treated by G.R. Plus aqua-drug and T_3 (3 fish/m²) and T_4 (5 fish/m²) were considered as control. Formulated feed (Mega feed) was supplied by spreading method manually twice a day and fed at the rate of 15-3% body weight of fish during the experimental period. G.R. Plus was applied at the rate of 12 ml/decimal/0.9 m depth of water at 10 days interval. Fish sampling were done at 10 days interval. Water quality parameters such as temperature, pH, ammonia, alkalinity, hardness, dissolved oxygen and nitrite were estimated at ten days interval. During the study period, pH values were ranged from 7.3 to 8.0, 7.3 to 8.5, 7.1 to 7.4 and 7.1 to 7.3, ammonia values, 0.01 to 0.015 mg/l, 0.01 to 0.015 mg/l, 0.01 to 0.07 mg/l and 0.01 to 0.06 mg/l, alkalinity values, 90 to 155 mg/l, 110 to 155 mg/l, 75 to 115 mg/l and 80 to 120 mg/l, hardness values, 52.0 to 70.5 mg/l, 57.5 to 70.5 mg/l, 42.5 to 57.5 mg/l and 37.5 to 55.0 mg/l, dissolved oxygen values, 5.95 to 6.65 mg/l, 5.95 to 6.75 mg/l, 5.70 to 6.05 mg/l and 5.75 to 6.15 mg/l and the nitrite values, 0.01 to 0.015 mg/l, 0.01 to 0.015 mg/l, 0.01 to 0.06 mg/l and 0.01 to 0.06 mg/l in T1, T2, T3 and T4 respectively. Water quality parameters in treated ponds were better than those of control ponds. Initial weight of fish was 0.78 g in all treatments. The results of the present study showed that mean weight gain were 73.33 ± 0.16 g, 66.71 ± 0.38 g, 39.58 ± 1.29 g and 30.62 ± 0.17 g, average daily weight gain were 0.81g, 0.74g, 0.44g and 0.34g, SGR were 5.06%, 4.96%, 4.38% and 4.11%, FCR were 1.43, 1.41, 1.40 and 1.41, survival rates were 94.58%, 90.50%, 80.41% and 75.25% and fish production were 2080.74 ± 7.21 kg/ha/90 days, 3018 ± 2.69 kg/ha/90 days, 954.87 ± 5.80 kg/ha/90 days and 1152.08 \pm 2.94 kg/ha/90 days in T₁, T₂, T₃ and T₄ respectively. In the present study, Thai sarpunti showed higher production in treated treatments than control treatments. Clinically G.R. Plus treated fish were more healthy than control ones. Histopathologically, liver sections were normal in treated treatments except some vacuums (T_1 and T_2). Liver sections of T_3 and T_4 (control treatments) exhibited vacuums, necrosis, hemorrhage and hepatopancreatic degeneration. Kidney sections of treated and control treatments exhibited vacuums and tubular degenerations. Based on the results, G.R.Plus could be recommended to use in aquaculture at farmers' level.

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MEASURING VULNERABILITY OF AQUACULTURE TO CLIMATE VARIABILITY AND CHANGE IN 64 DISTRICTS OF BANGLADESH

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Climate induced vulnerability varies locally in terms of aquaculture practice, fish production and livelihood of fish farmers in Bangladesh even though no study has been conducted to measure the district level vulnerability of aquaculture to climate change in Bangladesh. The present study measured the level of aquaculture vulnerability to climate variability and change in 64 districts of Bangladesh using composite vulnerability index approach and GIS. A total of 21 climatic, environmental and socio-economic indicators have been used to reflect the three components of vulnerability: exposure, sensitivity, and adaptive capacity. The results of the study reveal that 12 districts namely Gaibandha, Lakshmipur, Rangpur, Dinaipur, Kurigram, Thakurgaon, Nilphamari, Lalmonirhat, Panchagarh, Sunamganj, Satkhira, and Shariatpur have very high vulnerability in which 8 districts fall in the North-western region of Bangladesh. These very highly vulnerable districts are very highly exposed to climatic variability and change with moderate sensitivity and low to moderate adaptive capacity. Four districts namely Dhaka, Chittagong, Mymensingh and Comilla have the lowest level of vulnerability in aquaculture because of very high adaptive capacity. This study can provide an important basis for national planners and policy makers to build effective planning and develop district wise adaptation strategies to minimize the risk of aquaculture sector to climate variability and change.

GROWTH AND PRODUCTION PERFORMANCE OF CARP POLYCULTURE IN HILLY CREEKS OF KAPTAI LAKE, BANGLADESH

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The experiment was carried out for evaluating growth and production performance of carp polyculture in hilly creeks of Kaptai Lake for a period of seven months from November 2015 to June 2016. The study sites were selected in three upazilas viz., Sadar (T_1), Naniarchar (T_2) and Longodu (T₃) under Rangamati Hill District, Bangladesh. Stocking density of the experiment was 80 fish per decimal (rohu 30, catla 30, mrigal 20) under treatment-1, 70 fish per decimal (rohu 25, catla 25, mrigal 20) under treatment-2 and 60 fish per decimal (rohu 25, catla 20, mrigal 15) under tratment-3 respectively. The average initial length and weight of the fingerlings of rohu, catla and mrigal were 7.00, 7.37 and 7.2 cm and 18.43, 24.9 and 21.6 g respectively. During the study period, the range of water temperature 21±2.1 to 24±1.4°C, transparency 0.3±0.11 to 0.5±0.3 m, dissolved oxygen 4±0.62 to 7±0.54 mg/l, pH 6±1.34 to7±1.5, total alkalinity 45±3.5 to 81±4.6 mg/l, CO₂ 7.7±1.32 to 9±1.2 mg/l and total hardness 46±3.1 to 73±3.2 mg/l were within the productive range and more or less similar in all the creeks under three treatments. The study revealed that, catla was found to have comparatively highest weight 650±22.24g with a SGR of 1.54 in Longodu (T₃) creek. Conversely, Naniarchar (T₂) creeks were reported with highest weight 435 \pm 25.12g for rohu and sadar creeks (T₁) was found to be conducive to mrigal with a higher weight of 406±22.32g respectively. In general, growth performance of catla was comparatively higher than rohu and mrigal. Among the three treatments, T₃ was the best stocking density considering the highest growth of the catla in the creeks.

	Stocking density/dec	Species	Initial		After 210 days			
Treatment			length (cm)	Weight (g)	length (cm)	Weight (g)	 SGR (%day) at 210 days 	
		Rohu	7±1.15	18.5±1.41	20±1.34	412±20.59	1.47	
l ₁ (Sadar)	80	Catla	7.2±0.67	24.2±0.67	22±2.17	465±16.08	1.40	
(Oddar)	00	Mrigal	7.2±0.52	20.2±2.61	18±0.87	406±22.32	1.42	
–		Rohu	7±0.45	18.3±3.50	21±0.86	435±25.12	1.50	
l ₂ (Nanjarchar)	70	Catla	7.5±0.67	25.3±2.05	23±1.05	445±21.32	1.36	
(Maniarchar)	70	Mrigal	7.2±0.81	23.2±3.42	22±3.32	415±20.34	1.37	
		Rohu	7.2±0.84	18.5±2.32	22±1.34	460±25.34	1.53	
T ₃ (Longodu)	60	Catla	7.4±0.68	25.2±2.34	24±1.35	650±22.24	1.54	
		Mrigal	7.2±0.65	21.4±2.42	21±2.66	455±23.45	1.45	

Table 1. Growth performance of carp fishes in different creeks of Kaptai Lake

IMPACT OF PROBIOTICS ON THE GROWTH AND PRODUCTION OF TILAPIA (OREOCHROMIS NILOTICUS) IN FRESHWATER

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The present study was conducted to ascertain the impact of probiotics on the growth and production of tilapia (Oreochromis niloticus) for 120 days from 15 July to 12 November 2015. There were four treatments such as T_1 (super biotic probiotics), T_2 (biozyme probiotics), T_3 (zymetin probiotics) and T_4 (control) having three replicates with a size of 1.5 m³ (1.5m x 1m x 1m) each cages. Pond was cleaned manually and limed @ 250 kg/ha of CaO. It was then fertilized with urea and TSP @ 25 kg and 37.5 kg/ha, respectively. After few days of fertilization, 12 cages made of nylon net, nylon twine and bamboo were set up in the pond. Cages were stocked with nursed male tilapia fry at a density of 35/m² with average size of 3.0 g. Tilapia of all the cages were fed with Mega floating feed @ 5-10 % of total biomass at three times daily. Feed was supplemented with probiotics @ 0.5 g/kg of feed. Water quality conditions such as temperature, transparency, dissolved oxygen, pH, total alkalinity, nitrate and ammonia were within the suitable range for tilapia growth and did not cause any stress. Growth of tilapia was recorded at fifteen days intervals and feed was adjusted accordingly. Higher net growth of tilapia was found in T_3 (272.78 g) followed by T_2 (242.56 g), T_1 (222.76 g) and T_4 (199.35 g). The lowest food conversion ratio (FCR) was obtained in T_3 (1.01) than that of T_4 (1.38), T_1 (1.23) and T_2 (1.14). Significantly (p<0.05) highest gross production (8.82 kg/m²) was achieved from T_3 compared to T₂ (7.78 kg/m²), T₁ (7.23 kg/m²) and T₄ (6.35 kg/m²). There was no significant (p>0.05) difference in production between T_1 (7.23 kg/m²) and T_2 (7.78 kg/m²). The highest net profit (Tk. 401.5/m²) was found in T₃ than that of T₂ (Tk. 281.6/m²), T₁ (Tk. 211.6/m²) and T₄ (Tk. 119.0/m²). The growth and production of tilapia of this study was very much higher than the production of tilapia reported from earthen freshwater and brackish water bodies. Therefore, from the results of the study it may be concluded that probiotics may be suggested to apply in aquaculture for boost up fish production and can also contribute to national production to a significant level.

GROWTH PERFORMANCE OF MONOSEX TILAPIA (*OREOCHROMIS NILOTICUS*) UNDER DIFFERENT STOCKING DENSITIES IN CAGES IN THE *HAOR* AREAS, BANGLADESH

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Experiment was conducted from May 2015 to August 2015 to optimize the stocking density of monosex tilapia (O. niloticus) in the cages in haor water at Karimgani, Kishoregani district. Twelve cages were used having submerged volume of 29.5 m³. The experiment was assigned into a completely randomized design, having four treatments of stocking densities with three replications. Four stocking densities, denominated as treatments T1, T2, T3 and T4 were 23,73. 30.51, 37.29 and 44.07 fries m⁻³, respectively. Fish were fed daily twice in the morning and evening with commercial floating crumbled feed at a declining rate of 10% down to 3% of estimated average body weight. The survival rate ranged from 91.39 - 99 % in different stocking densities. Biomass gain was increased gradually from T1- T4 with increasing the stocking density. There was a decrease in trend of FABW, ABWG and MDBWG with the increase of stocking density. FB and BG were positively correlated with densities from T1 to T4. FCR was also significantly correlated with the stocking densities (p<0.05) in all treatments. On the other hand, FABWG, MDBWG and SGR were negatively correlated with the stocking density. The SGR of fish decreased but FCR increased with increasing stocking density (p<0.05). The significantly (P<0.05) higher fish production (kg m⁻³) was found in T3 (533.15 kg) compared to other treatments. The cages with 37.29 fries. m⁻³ (T3) showed significantly better (p<0.05) growth, yield and survival rate, which could be recommended to adopt in cages in haor waters. However, further trials are suggested to optimize the stocking density for better production performance and profit.

PRODUCTION ENHANCEMENT OF MONOSEX TILAPIA (*OREOCHROMIS NILOTICUS*) RAISED IN FIBRE GLASS TANKS, WITH DL-METHIONINE SUPPLEMENTATION

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Two feeding trial were conducted to investigate the effects of increasing levels of an important essential amino acid, DL-methionine (DLMA), supplementation on the replacement of fish meal (FM) with soybean meal (SBM) in two protein diets (28 % and 32 %) for Nile tilapia (Oreochromis niloticus). Fish were fed for 60 days a consecutive replacement of fish meal with soybean meal diets supplemented with graded levels of DLMA (Diet 2 to Diet 4). Contrast in dietary DLMA, concentration was created by supplementing with 1 (Diet2), 2 (Diet3) and 4 (Diet4) g kg⁻¹ DLMA for both protein level diets. At 28 % protein level, 7 % of FM was gradually decreased (7, 5, 3, 0%) and replaced by soybean meal (40, 42, 44 and 47.3 %). At 32 % protein level, 8 % of FM was gradually decreased (8, 6, 4, 0%) and replaced by soybean meal of 50, 52, 54 and 57.5 %, respectively. For soybean meal, with gradually increasing DLMA, in diets containing 28 % crude protein had no significant (P>0.05) difference on final body weight gain among the diets. For soybean meal, with gradually increasing DLMA, in diets containing 32 % crude protein diets had significant (P>0.05) difference on final body weight gain only in diet 4. Moreover, the effects of supplementing SBM-based diet with graded levels of DLMA indicated that a dietary DLMA of 4 g kg⁻¹ diet (as fed) was required to reach maximum significant (P<0.05) weight gain for 32 % protein diets and non-significant (P>0.05) in 28 % protein diets. The FCR was negatively correlated with FBWG, SGR and PER in both 28 % and 32 % crude protein diets. Interestingly, PER values in 32% protein diets, regardless of higher dietary crude protein content, were lower than 28% protein diets. Supplementation of SBM based diet with graded levels of DLMA proved an effective strategy in reducing FM content in practical diets for Nile tilapia. Data also indicated that adjustment of dietary formulas according to currently observed DLMA dietary concentrations would probably limit maximum growth potential of Nile tilapia as well as reduce the cost of production.

EFFECTS OF STOCKING DENSITY ON GROWTH PERFORMANCE OF CAGE REARED CLIMBING PERCH (ANABAS TESTUDINEUS) OF HIGH YIELDING VIETNAMESE STRAIN

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Vietnamese climbing perch (Anabas testudineus, Bloch), locally known as Vietnam koi, (5.36 ± 0.20 cm; 20.4 ± 1.14 g) were cultured for 90 days from May 2015 to July 2015 in floating net cages at four stocking densities (33.89, 50.85, 67.79 and 84.75 fish m⁻³) each with three replicates in haor waters. Fish were fed daily twice in the morning and evening with commercial floating crumbled feed at a declining rate of 10% to 3% of estimated average body weight. The survival rate ranged from 63.35 - 72.33 % in different stocking densities. Biomass gain was increased gradually from T1- T3 with increasing stocking density, but decreased in T4, though density increased. There was a decrease in trend of FABW, ABWG and MDBWG with increasing stocking density. FB and BG were positively correlated, but FABWG, MDBWG and SGR were negatively correlated, with the increased stocking densities. The SGR of fish decreased with increasing stocking density. Conversely, the FCR increased with increasing stocking density. Highest production and profit were observed at cages stocked with 67.79 fish m⁻³ stocking density (T3). The cage with 67.79 fishes m⁻³ (T3) showed significantly better (p < 0.05) growth, yield and survival rate which could be recommended to adopt in haor cages. However, more trials are suggested to optimize the stocking density for better survival rate, production performance and profit.

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A SUSTAINABLE AQUACULTURE METHOD ON PRODUCTION OF CUCHIA (MONOPTERUS CUCHIA) IN BANGLADESH

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The study was conducted in sadar, Gopalgonj, Bharhatta, Netrokona and Nalitabari, Sherpur to establish a new technology on a sustainable aquaculture method of cuchia (Monopterus cuchia). Production potential of M. cuchia in semi-intensive monoculture systems was assessed at a stocking density of 44.0/sq.m (1200), 54.0/sq.m (1500) and 64.0/sq.m (1800), in the treatment T_1 T_2 and T_3 for a period of 180 days. Nine small ponds(ditch) with an area of 300.0 sq.ft were selected for the experiment accommodating three replications for each treatment. The fish were fed with dhani pona, fish meal, earth warm, small apple snail and muscle of snail. Initial weight of the fingerling was 100 ± 0.66 g was stocked in all treatments. In treatment T₁, the highest average net growth was 402.45±2.44g/180 days and average daily gain, survival rate; specific growth rate and FCR were 1.96±0.002g, 96.22±1.14, 3.44±0.01 and 2.86±0.04, respectively. Poor growth performance of *M. cuchia* was observed in treatment T_{3} , where stocking density was higher (44.0/sq.m). The mean differences of gross yield among different treatment were significant (p<0.05). The results of this study indicated that treatment T_1 showed significantly superior growth, yield (464.42±8.06 kg/180 days/27.88 sg.m) and economic return compared to treatment T_2 and treatment T_3 . It is advocated that *M. cuchia* semi-intensive sustainable aquaculture technology is a good proposition to save the fish from extinction and introduce a viable sustainable cuchia culture in the field level and change socio-economic status of the rural people.



Fig 1. Growth performance of M. cuchia

UNDERSTANDING FISHERY EXIT AND ENTRY IN CHITTAGONG COAST OF BANGLADESH

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Fishing is one of the most important traditional livelihood activities of the coastal communities which plays a significant role in the socioeconomic condition of small-scale fishers in Chittagong and considered as a major source of income through small-scale fishing in Bangladesh. The present study was conducted on the root level of coastal fishermen community of Kumira ghat and Halishahar sea beach area to understand the drivers that are responsible for exit and entry into fishery. The empirical analysis shows that main drivers which cause push to fishers to leave fishery are poverty cycle, bodily insecurity with illiteracy and pulled out to leave the fishing profession. Fishers' poverty is a complex issues and a wide array of causal factors are responsible for the complexity of poverty in fisheries. Fishermen are threatened by low productivity of fisheries resources, low income, increasing fishing operation cost, frequent natural disasters, bouts of diseases, large household's size, heavy debt bondage, sea piracy and other activities of illegal elements both in sea and on land. Lack of financial assets, fishing gears and crafts, inaccessibility to market and formal credit institution, changes in technology and competition, seasonality in fishing, conservation measures, remoteness of living areas, lack of education and awareness, mobility, lack of social security, low political voice also marginalize the fishing communities. Different livelihood crisis drivers are shown in dimensions such as inside to inside, inside to outside, outside to outside which lead to livelihood failure and profitable drivers discuss in outside to inside in result. Pollution of ship-breaking and industrial effluent discharge by different canals in Kumira area is most vulnerable and sluice gate of the canal brings more grief in their livelihood for Kumira fishers. The monthly income per fishermen of both study area was comparatively much lower from the national per capita income. On the whole life the fishermen are in risk and they have no refreshment and no different taste of life. Therefore poverty alleviation in fisheries community can improve their livelihood and appropriate steps should be taken such as proper use of effluent plant to reduce industrial pollution and reduce ship breaking pollution. Government should give loan for them at low interest rate and create alternative job opportunities in off season or ban season, government should also ensure basic education and health service for fishing community, to mitigate the risk of piracy and invasion emphasized on coast guard activities. Last of all, as fisher community is so much assiduous, government should utilize their potential combining with alternative income generating profession which will improve their livelihoods and nation will be benefited.

LIVE FISH TRANSPORT AND MARKETING IN RAJSHAHI REGION: AN ATTEMPT TO DELIVER FISH AS SAFE FOOD

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Fish - a perishable commodity requires special attention to transport and marketing to keep it fresh. Fish traders are sometimes found to add harmful chemicals or additives to extends shelf life of fish making it unsafe for consumption. Some grow-out fish farmers of Rajshahi region use to produce large size carps *viz.*, *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala* etc. and developed live fish transportation system and marketing techniques by their own initiatives. Innovative fish farmers from Paba, Mohanpur, Tanore, Durgapur, Puthia and Baghmara upazila of Rajshahi district and Sadar, Boraigram and Gurudashpur upazila of Natore district are the pioneers. As far as safe food is concerned, live fish transport and marketing can play an important role. An investigation on live fish transport and market their live fish mainly in Dhaka, Sirajganj, Rangpur, Bogra and Sylhet. There were two period of peaks marketing in a year. First in May-June and the second peak was found in September-October. In peak season, nearly 25-35MT of live fish is transported from Rajshahi and marketed daily where Dhaka fish market receives around 50% of the total supply.

Main technique considered by the farmers is to produce large size major carps and market them live. For the large size carp production, overwintered large sized yearling rared from good quality hatchling are stocked with low density (7500-700/ha) (table-1). Yearly 5.5-6.5MT/ha fish is produced. Fish is harvested twice or thrice a year. Supplementary feed is regularly supplied along with natural feed to ensure expected growth. For live transport prior conditioning is essential. Then truck or pick-up van is used for carry. A small artificial pond is made using polyethelene on the floor of the truck or pick-up van with fresh tube-wel water. To reduce transportation sensitivity glucose and saline are added with water. Small wood particles and coal are also used as water cleaner. In the afternoon these trucks are prepared and the journey starts from the evening. If prior conditioning is done 650-700kg fish can be loaded in a truck (3.0m×2.5m×1.0m) otherwise only 450-600kg fish is usually loaded for transport.

SI.	Species	Weight (kg)	Nos.			
01	Rui	0.5-1.0	280-300			
02	Catla	1.0-2.0	60-75			
03	Mrigal	0.25-0.30	140-150			
04	Silver carp	0.25-0.30	60-75			
05	Bighead carp	0.25-0.30	140-150			
06	Common carp	0.25-0.30	60-80			
07	Black Carp	0.25-0.30	05-10			
08	Grass carp	0.25-0.30	05-10			
	Total:		750-850			
Table 4 Otenhing density of fish an exist in name						

Table 1. Stocking density of fish species in pond.

It is revealed from the study that at least 20-25% more sell price can be achieved from live fish marketing. Supply of safe food for human consumption which is a burning issue of time also can be ensured by this means. The study also suggests that facility of fresh water supply for water exchange and support from law and order agencies along in the journey way are the crucial factors for the success of this business.

AN ASSESSMENT TO THE ABUNDANCE OF *PENAEUS MONODON* POST LARVAE (PL) AND TO QUANTIFY THE DAMAGE OF DIFFERENT AQUATIC FAUNA DURING COLLECTION OF *P. MONODON* PL IN MONGLA TIDAL RIVER

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The study was conducted in Mongla tidal river (Rampal) of Bagerhat district from November 2014 to October 2015 to assess the abundance of black tiger shrimp (Penaeus monodon) post larvae (PL) and to quantify the damage of different aquatic fauna during collection of P. monodon PL. Observation was also made on the distribution of aquatic organisms with the variation of water quality parameters and season. Insignificant variation in water temperature, pH, salinity and hardness was found but salinity and hardness showed great fluctuation during the study period. Regression analysis shows that the abundance of P. monodon PL was significantly (p>0.05) related to water temperature, pH, salinity and hardness. It was found that about 401 other shrimp larvae, 382 fin fishes and 1717 other macrozooplankton were killed during the period of collection for only one PL of P. monodon. During the survey period around 0.16 million man days/year were estimated to be involved in shrimp PL collection activities and on average 6.3 million of P. monodon PL were collected annually from the studied area. It was also calculated from the present study that about 29,874 million of other shrimp species, fin fishes and macrozooplankton were destroyed annually by the shrimp seed harvesting process in Mongla river. Therefore, the results obtained from the study imply that present seed collection practice caused severe damage of other valuable aquatic fauna, which is directly affected the biodiversity of tidal waters, natural productivity, improvement of mother stock and environment friendly coastal and marine water.

POTENTIAL OF IRON NANOPARTICLES TO INCREASE GROWTH AND DEVELOPMENT OF THAI SARPUNTI (*BARBONYMUS GONIONOTUS*)

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Recently nanotechnology is used as production of more effective fish feed for aquaculture species and improving of the physical, chemical and nutritional quality of feed. This study was conducted the first time in Bangladesh to determine the potentiality of iron nanoparticles for enhancing growth and biochemical composition of Thai sarputi, Barbonymus gonionotus. Two experiments were conducted for this purpose. One was synthesis of iron nanoparticles. Another was effect of different doses nanoparticles enriched diet on the muscle composition, hematological characteristics, and growth performance of Thai sarputi. An agoustic method has been considered to prepare iron nanoparticles in water by reducing their ionic salts such as FeCl₃ in presence of surfactant (PVP) under oil bath heating for several minutes. In this experiment six concentration levels of Fe nanoparticles were added to fish feed such as control (0.0 µg), T1 (2.12 µg), T2 (5.2 µg), T3 (7.28 µg), T4 (9.36 µg) and T5 (11.44 µg). In fish muscle, crude protein and lipid content was highest in T3 (28.95±0.64 and 7.35±0.49 %) and lowest was found in T_5 (23.50±0.75 and 2.77±0.10 %). The value of all serum parameters (RBC, WBC, Haemoglobin, globulin and iron) were relatively high in T1, T2, T3, T4 and T5 than control treatment. All growth parameters (weight gain, specific growth rate and final weight) were relatively high in T3 than other treatments. Growth performance of fish was decreased in T4 and T5 (where high concentration levels of Fe nanoparticles were applied) than control treatment, it may be due to toxic effect of high concentration of Fe naonoparticles in that treatments. In this experiment, it was found that T3 (7.28 µg) is the best concentration of Fe nanoparticles for fish feed that give better growth and development of Thai sarputi.

WATER QUALITY AND PLANKTON COMPOSITION IN FED MOLA (AMBLYPHARYNGODON MOLA) POND STOCKED AT DIFFERENT DENSITY

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An experiment was conducted to study the water quality and plankton composition in fed mola (Amblypharyngodon mola) pond stocked at different density during the period of 09 July to 09 October, 2011, at the Field Laboratory complex, Faculty of Fisheries, BAU, Mymensingh, Bangladesh. There were three treatments, each with three replications. Nine earthen ponds were used with an average depth of 1.5 m. Selected ponds were followed by proper management system including removal of unwanted species, liming, fertilization and feeding. Ponds of three treatments T_1 , T_2 and T_3 were stocked with mola at the density of 145,000; 73,000 and 36,500 individual ha-1, respectively. Feeds were supplied twice daily for mola and feeding rates were 10% of body weight at the start of study (up to 15 days), and reduced to 8% after this till the last month. Water quality parameters such as water temperature, transparency, total alkalinity, pH and dissolved oxygen were measured weekly. Nitrate-nitrogen, nitritenitrogen, ammonia-nitrogen, phosphate-phosphorus and chlorophyll-a of the ponds water were measured monthly. Plankton samples were collected once in a month. Water quality parameters (except transparency, chlorophyll-a) did not vary significantly (P>0.05) among the treatments. The lowest PO₄-P and chlorophyll-a concentration were observed in treatment T₁ where 145,000 individual ha⁻¹ of mola was stocked. A total of 38 genera of phytoplankton and 13 genera of zooplankton were identified of which Chlorophyceae (20 genera) in phytoplankton population and Crustacea (9 genera) in zooplankton population were dominant. The mean value of total plankton population (x10³ cells L⁻¹) were 158.42±53.33, 191.17±62.24 and 240.17 \pm 93.37 in T₁, T₂ and T₃ treatments, respectively and contributing to the production according to their availability and abundance within the treatment.

EFFECTS OF ACHYRANTHES ASPERA TO THE IMMUNITY OF ROHU (LABEO ROHITA) AGAINST PSEUDOMONAS FLUORESCENS

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The study evaluated the efficacy of dietary doses of *Achyranthes aspera* extract on immunological parameters and disease resistance against *Pseudomonas fluorescens* infection in Indian Major Carp, Rohu, *Labeo rohita* (average weight 28.1±1.2 g). Fishes were fed with four different doses of herbal diet containing 0%, 2%, 4% and 6% of *A. aspera* extract. Among the doses 6% *A. aspera* showed highest significant responses in phagocytic activity, specific and non-specific immune responses on week 4 compared to control diet whereas the changes did not manifest on first week. In addition, the 6% *A. aspera* resulted in lowest mortality (20%) indicating highest protection from *Pseudomonas fluorescens* infection than 0%, 2% and 4% *A. aspera* diets that resulted 73.33%, 46.67% and 33.33% mortalities, respectively. The results suggested that the dietary supplementation of *Achyranthes aspera* extract acted as immunostimulants, reduced mortality and increased disease resistance in *Labeo rohita* against *Pseudomonas fluorescens* infection.

GROWTH PERFORMANCE AND FATTY ACID PROFILE OF NILE TILAPIA (OREOCHROMIS NILOTICUS) FED WITH DIFFERENT PHYTOPLANKTON

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To estimate the effects of different phytoplankton on growth performance and fatty acids composition of Nile tilapia (Oreochromis niloticus) an experiment was conducted for twenty four weeks in four small concrete ponds. Treatment-1 was fed with commercial feed as Control. Treatment-2 was fed with Spirulina, Treatment-3 was fed with Chlorella & Treatment-4 was fed with mixed feed of phytoplanktons (Chlorella, Spirulina, Azolla and Pistia) and wheat bran, Moringa oleifera was used as supplementary feed. It can be stated that the growth performance of Nile tilapia could be improved by feeding Chlorella and Spirulina with supplementary feed wheat bran and Moringa oleifera on the basis of Condition factor. The findings of the investigation showed that Condition factor found in treatment T3 with Chlorella (1.73±0.02) was significantly higher than that of T1 control (1.56±0.02) at 24 weeks culture period. Specific growth rate of treatment-4 with mixed feed (2.00±0.10) was significantly higher than treatment-3 with Chlorella (1.13±0.05) after 24 weeks of rearing. So the growth performance of Nile tilapia was found to be the highest with Chlorella and lowest with commercial feed that was used as control among four treatments. Use of different phytoplanktons such as Spirulina, Chlorella and Azolla influence the fatty acid profiles of Nile tilapia. Findings also showed that the amount of Eicosapentaenoic acid in treatment-3 fed with Chlorella (1.83±0.22) was highly significant than other treatments. The highest amount of Docosahexaenoic acid (DHA) was found in treatment-1 fed with commercial feed (2.70±0.53%) and lowest in treatment-2 with Spirulina (0.06±0.02%). Among 19 unsaturated fatty acid, highest concentration of PUFAs were measured from treatment T3 (42.55±3.46%) fed with Chlorella. The findings of this research suggest that raising Nile tilapia with Chlorella and Spirulina in ponds might be helpful for better growth and improvement of fatty acid composition.

ASSESSMENT OF POND PRODUCTIVITY FOR CARP FISH SPECIES IN RAJSHAHI

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The present study was undertaken to assessment of pond productivity for carp fish species in 28 experimental ponds, located at Rajshahi district, Bangladesh for the period of one year. Various physiochemical parameters involved to water quality were monitored fortnightly and the mean values of physiochemical parameters of water in the experimental ponds during the culture period were 28.82±0.09, 71.19±1.53, 6.81±0.32, 3.09±0.28, 7.28±0.33, 0.41±0.04 and 70.87±1.05 for Temperature (⁰C), Transparency (cm), Dissolved oxygen (mg/l), Carbon dioxide (mg/l), pH, Toxic ammonia (mg/l) and Alkanity (mg/l), respectively. Total 11 fish species named Hypophthalmichthys molitrix, Aristichthys nobilis, Catla catla, Labeo rohita, Cirrhinus mrigala, Cyprinus carpio var specularis, Cyprinus carpio var communis, Barbonemus gonionotus, Oreochromis niloticus, Ctenopharyngodon idellus and Labeo bata were cultured in the study ponds. Among the species middle layer species Labeo rohita were inputted in the highest amount 6425.6±407.0 Kg and the Gross production was 19251.8±612.9 Kg and net production was 12826.2±497.7 Kg of that were comparatively higher than other cultured species. Most of the investments were incurred in lease value TK. 2061210± 69597 of the ponds, fingerling TK. 1827817± 91969 and feeding TK. 1263357± 38485 purposes. 32.7% investment used for lease value, 29% for fingerlings purchase and 20% for feeding purposes. The gross fish production were 3574.28±1559.3 Kg/ha (14.47±6.3 Kg/decimal) and gross income were 486479±221975 TK/ha in the study. Physical water productivity of study ponds were 2587.1 Kg/ ha and economical productivity of the study ponds were 218324 TK/ha.

INTEGRATED FLOATING CAGE AQUAGEOPONICS SYSTEM (IFCAS): A CLIMATE ADAPTIVE INNOVATIVE SOLUTION FOR CO-PRODUCTION OF FISH AND VEGETABLE IN SALINE PRONE AREAS OF BANGLADESH

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Aiming to develop a viable business model of integrated floating cage aquageoponics system (IFCAS) for salinity affected people in coastal Bangladesh, 35 cages were installed in ponds and canals within polder based aquatic system of Satkhira district with 30 participants in three business groups designated as Micro (MI), Small (SM) and Medium (ME) business options. In business modeling, there were different combinations between aquageoponics larger cages (9) M³) and non-aquageoponics smaller cages (1 M³). The MI group started the enterprise with five larger aquageoponics cages and five smaller cages, the SM group had five larger cages and ten small cages and the ME group had only ten aquageoponics larger cages with no small cages. Mono sex tilapia was stocked (12 July 2016) in first cycle at 200 m⁻³ and with mega grower floating feed applied at 3% bw twice a day. Total 120 sponge gourds (*dhundul*) and bottle gourd (lao) saplings were planted in 40 tubs floated with 20 larger cages (12 July, 2016). Initial mean weight of fish was 5.5 g, 6.5 g and 5.6 g in MI, SM, ME business group, respectively which reached to a mean individual fish weight of 78 g, 109 g and 89 g after 80 days where total investment for three groups was \$218.77, \$287.47 (extra for crab protection \$200) and \$444.97, respectively. After 80 days of operation, fishes and vegetables were at partial harvesting stage. It was found that SM group having highest investment shown better fish production than other two groups. Canals could be more suitable sites than ponds though there was a challenge of protecting from crab which could damage nets if not protected by extra bamboo fence. However, smaller unit of such business can be viable in ponds too having scarcity of suitable canal sites. The growth rate of fish was apparently better in canals than in the ponds. Shared group management had positive effects on the business with individual accountability for cages. Bottle gourd performed better than sponge gourd. Production of both vegetables was better in medium business group (ME). Around average 8.5 kg of vegetables produced so far per aquageoponics cage within 80 days. The new experiences of farmers have been shared through local Union Council based digital centers and centrally from Krishi Call Centre, Dhaka. Main challenges were - finding suitable canal site, security issues, facing carb attack and managing water quality during jute retting in canals. The first trial is expected to end by mid-November, 2016 followed by the 2nd cycle between November, 2016 and February 2017.

STUDY ON COMPARISON OF PRODUCTION PERFORMANCE AND ECONOMICS OF DIFFERENT CARP POLYCULTURE SYSTEMS IN GANGNI UPAZILA OF MEHERPUR, BANGLADESH

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The study was conducted to evaluate the comparison of production performance and economics of different carp polyculture systems in Gangni upazila under Meherpur district from July to November 2015. PRA tools such as questionnaire based interview and cross check interview were used for primary data collection and secondary information were used to assess the performances of aquaculture activities. Forty pond fish farmers were purposively selected, among which 7 (18.0%), 17 (42.0%), 3 (8.0%), 7 (18.0%) and 6 (15.0%) farmers were engaged with carp-mola, carp-tilapia, carp-koi, carp-shing polyculture and carp fattening, respectively. Only 28.0% fish farmers took aquaculture as their primary occupation. On the other hand, 57.0% fish farmers were involved in agriculture, 8% business, 3.0% service holder and 5.0% student. Only 23% farmers had small ponds (5-15 decimal), 35% medium ponds (16-25 decimal) and 40% farmers had large ponds (above 25 decimal). The minimum water depths of 23% ponds were within 0.5-1.0 m, 53% ponds were within 1.00-1.5 m, 17% ponds were within 1.6-2.0 m and 7% ponds were up to 2.0 m. From the survey, it was found that 14 (35.0%) of the farmers applied supplementary/homemade feed prepared with rice-bran and mustard oil cake, 17 (43.0%) farmers used commercial feed and 9(22.0%) farmers were depended on natural feed. Average fish production was observed 6274 kg/ha/yr. The highest average fish production was 7904 kg/ha/yr and net income was BDT 2,42,060 ha/yr come from carp-tilapia polyculture system, whereas lowest average fish production was 5187 kg/ha/yr and net income BDT 1,66,478 came from carp-koi polyculture system. From the present study, it is clear that the average production of carp-tilapia polyculture was higher and financial benefit came from the same technology was also higher. Therefore, it is revealed that carp-tilapia polyculture was better than other polyculture systems.
POTENTIALITY OF SPROUTED WHEATGRASS POWDER AS FISH MEAL ALTERNATIVE FOR STINGING CATFISH FRY NURSING

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Wheatgrass is one of the green foods that are valued by health-conscious individuals as a natural sources of nutrients. The wheatgrass juice contains 70% chlorophyll and a good source of potassium, dietary fiber, a range of vitamins and minerals, pantothenic acid and protein. It plays important roles in poultry, dairy and human health due to it's unique amino acid profile. So, the present experiment was conducted to see the potentiality of sprouted young wheatgrass powder as an alternative of fishmeal in stinging catfish fry feed as protein supplements. The disease free and good quality wheat was used for sprouting through special method. The wheat was washed, soaked overnight, kept 24 hours in a cotton bag in the dark, spread in a tray on sand and kept for four days in the dark and another four days in light for sprouting. The sprouted young wheatgrass then cut, boiled and blanched before drying and make powder. The feed was formulated replacing fish meal with wheatgrass powder of 100, 75, 50, 25 and 0%, respectively, which indicated as treatment T1, T2, T3, T4 and T5 as a control. The proximate composition analysis showed that protein level in the fish meal, wheatgrass powder, T1, T2, T3, T4 and control feeds were 58, 20, 32.55, 35.35, 32.90, 33.60 and 36.75%, respectively. The fry rearing was conducted for sixty days with two replications each at a density of 10 fish/20 liter water feeding the formulated feeds. Data analysis showed that there were no significant differences of fish growth in all the treatments in terms of length and weight gain. The survivality was 100% with all the treatments except T2 where it was 90%. The proximate analysis of whole fish showed that the protein range was 13.69(±0.75) to 17.04(±0.98) and significantly higher (p<0.05) protein was found in T2 17.04(±0.98) than the control. Considering the feed cost and overall performances, the better result was obtained with T3 where 50:50 wheatgrass powder and fish meal was used. Therefore, it can be concluded that, the inclusion of wheatgrass powder in stinging catfish fry rearing feed will abate the feed cost in hatchery and nursery and increase the profitability.



Fig.1. Weight increase in stinging catfish feeding wheatgrass powder based feeds



Fig. 2. Sprouting wheatgrass in lab condition.

Bangladesh Fisheries Research Forum (BFRF)

FIRST RECORD OF SEED PRODUCTION OF SWAMP MUD EEL (*MONOPTERUS CUCHIA*) IN CAPTIVITY BY ENVIRONMENT MANIPULATION

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In-situ seed production and introduction in aquaculture are considered as the most important tool for conservation of any threatened fish species. We are working to develop fry production technique of the threatened swamp mud eel (Monopterus cuchia) for several years, and become succeeded recently. During the study period, we have collected traditional knowledge on breeding and feeding behavior of swamp mud eel from the tribal 'Garo' communities in the greater Mymensingh region, who are traditionally involved in cuchia harvesting. Different reproductive biological parameters i.e. coloration, behavior, GSI, fecundity and histological study of gonads has been studied. The wild brood cuchia has been reared in hapas and cisterns for six months to make them captive population. About two months before the breeding season, brood fishes were stocked in environmentally manipulated six breeding pits for natural propagation in captivity. Area of each breeding pits were 9.5 m² and three stocking densities were used for this natural breeding and fry production trial, viz., 2, 3, and 4 fishes/m² (T1, T2 and T3, respectively) where duplicate replications were used per treatment. Male to female ratio was maintained at 1:1 in each treatment. The average weight of stocked broods was >220 g. Broods were fed with small fishes, boiled pest of chicken viscera and earth worm at 3-5% body weight. Water depth of each breeding pit was maintained at 30 - 40 cm. During the end of the month of May, fertilized eggs and fry of cuchia were observed in the nests in all treatments. Swamp eel fries were then collected from the nests and transferred to previously prepared nursing facilities. A total of 5,530 fry were collected from the 6 breeding pits of three treatments composing an area of 57 m². Among the treatments, T3 (4 brood/m²) showed highest fry production (116.6 fries/m²) and the lowest production was found in T1 (2 brood/m²). The success of this research is the first ever report of artificial propagation of swamp mud eel in captive condition by environment manipulation.

HEALTH STATUS OF A CATFISH (*MYSTUS VITTATUS*) FROM THREE FISH MARKETS OF MYMENSINGH, BANGLADESH

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Diseases were investigated through clinical and histopathological observation in a catfish (*Mystus vittatus*) from three fish market of Mymensingh for a period of six months. Clinically, it was observed that fishes were more affected having scale loss, red spots, deep dermal ulcer in the months of December and January observed in Sankipara Railway Crossing and Gollpukurpar markets. Almost normal appearances were noticed during October to November and also February to March from the three fish markets. Histopathologically, marked necrosis, pyknosis, haemorrhage and fungal granuloma were observed in skin and muscle. Gills of fishes from Sankipara Railway Crossing and Gollpukurpar markets were found monogenetic trematode, hypertrophy, clubbing and pyknosis in December and January. Fungal granuloma, necrosis, haemorrhage and vacuoles were found in the kidney of fishes from Gollpukurpar market. Liver of examined fishes had no pathogen having less pathological signs compared to other organs. The investigated species *Mystus vittatus* were found more affected in Gollpukurpar and Sankipara Railway Crossing market than observed in K-R market. From overall observation fishes were severely affected by EUS and dactylogyrosis during the months of December and January from Sankipara Railway Crossing market and Gollpukurpar market.

ACUTE TOXICITY OF TWO HEAVY METALS ON LABORATORY CULTURED TUBIFICID WORMS

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The aquatic oligochaete, tubificid worms are popular live feed for fish and also an ideal indicator of aquatic environmental health. The ability of these worms to grow on polluted sediment and water makes them readily available to bioaccumulate heavy metals which are serious threat to ecosystem functioning. The study was conducted to estimate the 96 h median lethal concentration (LC_{50}) of two metals [Cadmium (Cd), Chromium (Cr)] in tubificid worms. Toxicity of metals was evaluated in a water only exposure experiment using tubificid worms collected from local market. The 96h LC_{50} of Cr^{6+} and Cd^{2+} were 0.284µmol/land 0.1766µmol/l, respectively. The warms also suffered from morphological damage including mucous secretion, autotomy in the hind part of the body. Frequency of morphological damage increased in a concentration and duration dependent manner. The results indicate that Cd is more toxic than Cr to tubificid worms. The findings of the work can be used in ecological risk assessment and in the determination of safe disposal level of cadmium in aquatic ecosystem.

HEALTH CONDITION OF SOME INDIGENOUS SPECIES OF OPEN WATER BODIES: A HISTOPATHOLOGICAL STUDY

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Seasonal variation of health status of some small endangered open water fishes like baila (Glossogobius giuris), gutum (Lepidocephalichthys guntea) and kuchia (Monopterus cuchia) was carried out through clinical and histological observations from Noli beel, Kapasia upazila of Gazipur district and Kongsa river near Jaria. Netrokona for a period of twelve months from June 2015 to May 2016. Clinically fishes were affected with parasitic infestation, EUS, tail and fin rot, nutritional deformities, red spots, gill rot and patches in lateral and ventral regions, large deep whitish ulcers reached up to deep muscle especially in the winter months. Comparatively fishes were less affected during rainy season followed by autumn and summer seasons in both the regions. Parasitological point of view, higher prevalence of parasitic infestation was observed in the fishes of Noli beel and comparatively less infested fishes were observed from Kongsa river. Major pathological changes were observed in external organs likes muscle and gill than internal organs likes liver and kidney. Pathologies in the skin and muscle were epidermis separated from dermis, presence of fungal granuloma, vacuums, hemorrhage and necrosis. Loss of primary and secondary gill lamellae, hypertrophy, hyperplasia, clubbing, primary gill lamellae separated, necrosis, hemorrhages and presence of protozoan cyst, monogenetic trematodes in the gill. Vacuums, pyknosis, necrosis, hepatocytes, protozoan cyst, scattered debris were observed in liver. Protozoan cyst, degenerated kidney tubules, fat droplets, glomerular nephritis, vacuums, hemorrhage and necrosis were found in especially kidney during winter. Overall, in autumn (September to October) clinically and histologically fishes were almost normal or had mildly affected, however, during late autumn (November) pathological changes were gradually increased. Fishes were found to be more affected in December and January. Whereas, during February to April, the pathological condition of fishes gradually healed up to normal condition except having few vacuums and hemorrhage. Under parasitological, clinical and histopathological observations, fishes of Noli beel were more affected than the fishes of Kongsa river.

DEVELOPMENT AND INTRODUCE AQUAPONIC SYSTEMS FOR FISH AND VEGETABLES PRODUCTION THROUGH DECEIVING AQUACULTURE WASTE WATER

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Population pressure creates stress on natural resources, food security and sustainability in the world. Huge demand of food grain and protein driven farmers to boost up production. To maximize food production from the limited land resources, farmers intensified water, feed and chemicals use that depleted underground water, creates air and water pollution and hazards on environment as well as on human health. The attempt was made to develop and introduce aquaponic systems for fish and vegetables production through deceiving aquaculture waste water. The aquaponic systems such as media based system for taro, tomato, ladies finger, papaya, mint, cucumber, nutrient film technique for water spinach, lettuce, mint, deep water culture for lettuce and tomato and vertiponics for strawberry, tomato, lettuce and mint were used to see the effectiveness of nutrient trapping and vegetable grown in lab and field conditions round the year. Tilapia, pangus, common carp and walking and Asian catfishes were the experimental fishes in all the systems for their hardy and air breathing nature. Fishes fed pellet feed twice daily at 3-5% of their body weight. Fish waste water was irrigated with a mini pump to the systems where denitrifying bacteria convert the wastes into nutrients for the vegetables and made the water clean for fish before return to the fish tank again. Nutrients deficiency was handled with molasses; dried egg shell and banana peel powder prepared at home. Fish production was50-135 tons/ha/yr. Vegetables produced were organic and tastier than the conventional field grown crops and production performances were better than the control. The tomato and ladies finger production cycle in aquaponic system was longer and less disease prone than the control. The experiments showed that nutrient recycling can reduce chemical fertilizer and pesticide use in the country and handle environmental pollution more effectively. The system can utilize unused rooftop, balcony and barren land and generates income by producing organic marketable goods. The waste water recycle can reduce underground and surface water use and wastes converting into biomass could become a profitable business in the country.





Fish and strawberry production in aquaponic system in the Department of Aquaculture, Bangladesh Agricultural University, Mymensingh.

FISH AND VEGETABLE CULTURE IN THE BACKYARD: INTEGRATION OF HYDROPONICS WITH AQUACULTURE

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The farmers' are struggling to keep pace of food production with ever increasing population having the problems of climate change, environmental degradation, shortage of water and decreasing cultivable land resources. Therefore, we need to search for a climate smart technology, which can handle adverse climatic condition, deal with the environmental pollution and maintain steady food production to feed the people in the country. Aquaponics is such an innovative technique that can integrate aquaculture and hydroponic system to produce fish and soil less vegetables in a symbiotic relationship. To assess the aquaponic system's potential the experiment was conducted to produce strawberry and lettuce in T1 and T2 treatments in a vertical aquaponic system. Twelve 4.5 feet long PVC pipes filled with coconut coir that hold 15 strawberry saplings each as T1 and four 3 feet long and 1 feet diameter sponge pipes which hold 36 lettuce each in T2 treatment. Fifty Tilapia (Oreochromis niloticus) and 28 Asian catfish (Clarias batrachus) were reared in a 750 liter water tank. The fishes were fed twice daily with commercial floating feed containing 30% protein at the rate of 5% in 1st month, followed by 3% in 2nd month and 2% in 3rd and 4th month of fish body weight. The fish tank waste water was irrigated through the pipes which then return to the fish tank again and reduce water use drastically. The various water quality parameters were measured weekly and monthly interval basis. The fish sampling was done at monthly interval and the strawberry and lettuce were harvested and recorded. The nutrients flow in the effluent water was lower than in influent because major portions were utilized by the plants through the roots. The mean length and weight gain of tilapia was $3.98 (\pm 0.73)$ cm and $32.71 (\pm 9.43)$ g, while in magur $3.77 (\pm 2.83)$ cm and 6.42 (± 1.45) g, respectively. The specific growth rate (SGR) was 0.27(±0.21) and 0.40(±0.19), feed conversion ratio (FCR) was 1.89 and 1.45 and survival rate was 90 and 92% for tilapia and magur, respectively. The production of tilapia was 53.53 while magur was 5.25 tons/ha/110 days. The production of strawberry and lettuce was 40 and 96.87 tons/ha/110 days. Therefore, it can be concluded that the vertical aquaponic system is capable of producing strawberry and lettuce at the rooftop and balcony that is environmental friendly, water saving and suitable to replicate in urban and peri urban areas.

Sampling dates	water Sources	Nitrite (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	lron (mg/l)	
21-01-15	Inlet	0.6	10	1	0.75	
	Outlet	0.6	10	2	0.75	
20-02-15	Inlet	0.4	8	3	0	
	Outlet	0.1	8	3	0	
22-03-15	Inlet	0.1	5	1	0	
	Outlet	0	2	1	0	
Mean		0.3(±0.26)	7.16(±3.12)	1.83(±0.98)	0.25(±0.38)	
Level of significance		NS	**	NS	NS	

Table 1. Shows the nutrient extraction from the inlet water by the plants in aquaponic system

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EFFECT OF MIXED FEEDING SCHEDULE ON THE GROWTH OF CLARIAS BATRACHUS IN RAJSHAHI AREA

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A study was conducted to determine the effect of mixed feeding schedule on the growth of Clarias batrachus using indigenous feed ingredients (30.3% protein) for a period of 180 days from 1st July to 30th December, 2013. Ponds were divided into four treatments viz. T₁, T₂, T₃ and T₄ each having three replicates. The feeding regimes in different treatment under mixed feeding schedule were T_1 = normal feeding (twice a day), T_2 = fed every alternative day (twice a day), T_3 = two days feeding (once a day) followed by two days fasting and T_4 = one day normal feeding (twice a day) followed by two days fasting. The water quality parameters recorded in different treatments during the experimental period were found within the productive ranges and there was no significant difference (P<0.05) among the treatment. The fish were initially fed with 6% of body weight at first 3 months and the rate was gradually decreased at 4% of body weight at last 3 months. The growth performance of fish as mean final weight, mean weight gain, mean length gain, SGR, ADG were significantly (p<0.05) different among different treatment. The highest growth was recorded in T_1 where partial compensatory growth recorded in T_2 and lowest was recorded in T₃ and T₄. The lowest FCR value i.e. the best (305±0.24) was recorded in T₁ and highest i.e. the worst value (4.22±0.90) was recorded in T₄ and the best PER value was 0.89±0.8 in T₁ and lowest was 0.59±0.51 in T₄, respectively which were significantly different (P<0.05) among treatment. The survival rate (%) of fishes varied between 89.00±0.57 to 91.00±0.57 which were not significantly (p<0.05) different among the treatments. Among the treatments the highest yield in terms of kg/ha/180 days was recorded in T₁ (4243.86±93.30) which was significantly higher than other treatments. The highest net profit was calculated 1787967±273.18 Tk/ha in T₁ and T₂ 1736820±324.81 Tk/ha which was lower than T₁ but significantly higher than T₃ and T₄, respectively. The highest feed cost was calculated in terms of Tk/ha in T₁= 965306±314.54 which was 60% of the total cost where in T₂= 482653±241.28 was half of T_1 feed cost which was 42% of the total cost and the lowest was recorded in T_4 = 321768±130.69 that was 60% of the total cost. The best cost benefit ratio (CBR) was recorded in T₂ (1:1.54) with alternate day feeding (twice a day) due to saving of feed cost because of mixed feeding schedule applied than that of other treatments.

BIOLOGICAL CONSIDERATIONS IN HATCHERY MANAGEMENT: A CASE STUDY IN HATCHERIES OF JESSORE, BANGLADESH

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Hatchery produced seeds have been the mainstay of supply of seed for aquaculture of the Indian major carps as well as indigenous and exotic species. There are now 964 hatcheries in this country and a very big array of people are engaged in hatchery management and seed production. The genetic quality of the seed produced often cannot be maintained. Jessore came out as one of the prominent area of hatchery production of fish seed in the country. To assay the problems lay for the biological considerations of broodfish and hatchery management, the present study was undertaken from July to November, 2015. Questionnaire survey and personal interviews were carried out to collect data on the detail management of hatchery and broods. The range of water areas of the 10 hatcheries surveyed was obtained at 297 to 2310 decimal; the pond number similarly was found to range from 4 to 17. Highest seed production was found in Ma Fatema Fish Hatchery (9000 kg/year) having the production capacity of 14000 kg/year and the lowest production was in Anan Fish Hatchery (733 kg/year) having the production capacity of 8000 kg/year. Brood fishes were mainly collected from Government brood bank and Worldfish as well as used from their own stock. Hatchery owners did not maintain the pedigree of breeders thus relatedness in the brood was common leading to inbreeding. Stocking size ranged from 10-20 kg/decimal. The yearly exchange rate of brood fish was varied from hatchery to hatchery which was 20 to 40% in different hatcheries. Mean fertilization rate was found to range between 80 to 96.67 % for rohu and 76.67 to 96.67 % for Catla; the mean hatching rates in the same hatcheries were ranged between 57.78 and 88.89 % for rohu and 56.67 to 83.33 % for Catla. The weight of the breeders used in spawning in the hatcheries

studied was ranged from 3.25 to 8.5 kg female and 2.5 to 5.24 kg male for catla; in rohu the range was 1.79 to 4.17 kg for female and 1.73 to 3 kg for male. Highest Ne was found at 92.12 in Rupali fish hatchery whose average inbreeding percentage (F) was 0.54 for rohu.



Fig.: The relationship between effective breeding number $(N_{\rm e})$ and average inbreeding (F) among the hatchery population of Rohu and Catla

For the same species, the lowest N_e was 10.11 with average inbreeding percentage being 4.95 in Matri fish hatchery. Highest N_e for catla was 21.91 with corresponding inbreeding percentage 2.28 in Rita fish hatchery. The lowest N_e was only 2 with corresponding inbreeding percentage 25 in Haque fish hatchery. For assurance of quality seed production of the two species the standard of management of hatchery and broods has to be improved with regard to both non-genetic and genetic aspects and for that the government has to strengthen its training and extension services.

EFFECTS OF AERATION ON GROWTH PERFORMANCE OF TILAPIA IN INTENSIVE AQUACULTURE SYSTEM IN EARTHEN PONDS

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Intensive aquaculture relies on technology to raise fish in artificial tanks or ponds at very high densities. This type of system requires higher level of dissolved oxygen for uninterrupted growth of fish. Now-a-days intensive aquaculture is being promoted in Bangladesh with Tilapia, Pangasius and other indigenous catfishes. However, there is a scarcity of empirical evidences of the effects of oxygen supply on intensive tilapia pond in Bangladesh. An experiment was conducted to assess the growth and production of tilapia in six (6) earthen ponds at BAU campus, Mymensingh for 90 days. Two treatments, Treatment 1 with 3 aerated ponds; and Treatment 2 with 3 non-aerated ponds were designed with similar stocking density (300/decimal) of tilapia. During the culture period, powder feed was given at a rate of 15% for 1st month, and pellet fed was given at the rate of 10% and 5% of the body weight of tilapia for 2nd and 3rd month, respectively. Oxygen supply was ensured by air compressor at 12 hours interval daily. Fish growth, pond water and soil quality parameters were sampled and assessed at 15 days interval. The sampling data generated from various sources were entered into the Excel spreadsheet. The treatment differences were tested at various sampling stages by Independent Sample T-Test applying statistical software SPSS (Version 16.00).

The external oxygen supply through aeration increased oxygen level significantly (P<0.05) in the ponds of T_1 (6.33 ppm, 6.93 ppm) compared to T_2 (4.67 ppm, 5.53 ppm) at the oxygen sampling stages of 1 and 11. The higher level of oxygen had remarkable impacts on individual growth in length and weight of tilapia at different sampling stages (Figure 1). Particularly, in the sampling stage of 3, 4 and 5, the growth of Tilapia in aerated ponds was significantly (P<0.05) higher than that of non-aerated ponds. Other water quality parameters such as temperature, pH, nitrite, ammonia in the Treatment 1 were within the better range compared to



Fig. 1. Growth (g) of tilapia in T_1 (aerated) and T_2 (non-aerated) ponds at different sampling stages.

Treatment 2. These all suggest that aeration to intensive Tilapia culture ponds can increase the growth and production of fish even though by following similar stocking density and feeding regime. The introduction of aeration in aquaculture in Bangladesh could be brought under action research for building awareness among the farmers.

ENHANCED RESILIENCE OF HILSA FISHING COMMUNITIES IN BANGLADESH

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Coastal fishers recognize that sanctuary areas and the enforcement of fishing ban periods have contributed to increased hilsa availability and production, but perceive the livelihood support given by the government during ban periods as inadequate. This is a major reason for non-compliance with existing conservation rules and norms. In order to reduce dependence on hilsa fishing Enhanced Coastal Fisheries in Bangladesh (ECOFISH^{Bd)} supports alternative livelihoods for 20,000 marginalized and extremely poor fisher households who suffer substantial economic hardship due to lost income as a result of the imposed fishing ban periods. A cross-sectional study amongst 248 households directly dependent on hilsa fishing revealed that almost two-thirds of the interviewed households did not have any income source at all during ban periods. Only 35% reported receiving government support in the form of rice. Only 12% reported to be suffering from hunger during ban periods, but dietary diversity among fisher households was very low. Households borrowed food (71%) or took loans (57%) to cope with food scarcity.

ECOFISH^{BD} to date provided training and input support for aquaculture, small livestock and homestead gardening to more than 8,500 hilsa fishing households. These households increased and diversified their food intake, whilst generating alternative income during fishing ban periods (Table 1; Fig. 1). More than 1,800 fisherwomen are engaged in community savings groups andre-invest their income toavoid loans provided by external micro-credit providers on unfavorable repayment terms. Attitudes and perceptions of these households are now noticeably changing in favor of biodiversity conservation and improved compliance with fishing ban periods.

Pond culture	Prod (Kg)	Sold (Kg)	Cons (Kg)	Cost (BDT)	Value (BDT)
Baseline	47.0		5.0	3,591	5,895
End-line	67.5	23.6	43.8	6,072	8,526

Table 1. Results of homestead pond aquaculture in 11 communities under ECOFISH^{BD}



Fig. 1. Consumption and sales of ECOFISH^{BD} supported vegetable production

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SOCIOECONOMIC CONDITIONS OF FISHERFOLK: INSIGHT FROM THE JAMUNA RIVER FISHING COMMUNITIES, BANGLADESH

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In a developing country like Bangladesh, fisherfolk are often marginalized and poverty engulfs them hardly. This study assesses the socio-economic status of the two Jamuna River fishing communities- Kalitola Ghat and Debdanga in Bogra district. Semi-structured interviews, key informant interviews and focus group discussions were used to collect data from the two fishing communities during May, August and December 2015. The data were collected on different livelihood assets such as human capital (education, health and occupation), physical capital (ownership of house, transport, fishery equipment, sanitary facilities etc.), natural capital (ownership of agricultural land and water based asset), financial capital (bank account, savings, jewelry, livestock, poultry and income) and social capital. Further a cluster analysis has been done using data on income per day, working hour, years of involvement in fishing, ownership of fishing material, diversification of job etc. in each community to explore the intra-community inequality. Around 17.2% fisherfolk of Kalitola Ghat are illiterate and 51% can only write their names while percentage of having primary education in Debdanga is relatively high (31%). However, women education is considerably lower (around 54.3% are totally illiterate and 45.7%, who have experience to go to school, hardly remember anything) in both villages. In Debdanga almost 100% fisherfolk are traditional and their income levels are higher (per day income 350-850tk) than the fisherfolk of Kalitola Ghat but they have no other skill or land based assets to earn from a different source. The per household income of Kalitola Ghat fishing community is 100-800 Tk/day which are lower than that of Debdanga fishing community. About 54% fisherfolk of Kalitola Ghat have diverted their jobs from farming to fishing and due to this they have less experience and less fishing equipment which cause less income. This diversion has also created pressure on existing fisherfolk who are solely dependent on fishing. Based on income in each community three types of clusters are found: high income fisherfolk (11,250 Tk/month in Kalitola Ghat and 13,950 Tk/month in Debdanga), medium income fisherfolk (9,825 Tk/month in Kalitola Ghat and 10,152 Tk/month in Debdanga) and low income fisherfolk (3,720 Tk/month in Kalitola Ghat and 7,275 Tk/month in Debdanga). Although, fisherfolk of Kalitola Ghat sometimes do another part time activities such as farming, bottle selling and day laboring etc., some of them possess agricultural land (22%). Almost every fisherfolk of both villages has to get loan from NGOs during non-fishing period.

UNDERSTANDING THE LIVELIHOOD CHARACTERISTICS OF THE MIGRATORY AND NON-MIGRATORY FISHERS OF THE PADMA RIVER, BANGLADESH

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The Padma is the second longest and one of the trans-boundary rivers of Bangladesh that contributes significantly to the fisheries and supports the fishers' livelihoods. The present investigation was carried out to assess the livelihood characteristics of the migratory and nonmigratory fishers of this river. Data were collected using household interviews, focus group discussions, and key informant interviews during July to October, 2015. All migratory fishers were full-time fishers whereas non-migratory includes full time (88.89%), part-time and occasional (11.11%) fishers. Most of the fishers belonged to the age group of 31 to 40 years represented by 47.37% migratory and 35.18% non-migratory fishers. More than half (58.90%) of the both types of fishers had no education. The Padma river fisheries were dominated by Hindus (93.15%), however, the involvements of Muslim fishers in fishing activities are increasing in the study area. Half of the non-migratory and 42% of migratory fishers had 5-7 family members followed by 43% and 37% had less then five family members respectively. Average annual incomes of both migratory (58%) and non-migratory (65%) fishers were ranged from Tk.30 to 60 thousand whereas 26% migratory and 5% non-migratory fishers had average annual incomes above Tk. 60,000. The results indicate that the livelihood conditions of the migratory fishers are better compared to those of the non-migratory fishers.

FISHERIES CO-MANAGEMENT: KEY LESSONS DRAWN FROM PAST EXPERIENCE AND ECOFISH^{BD} PROJECT

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This paper is aimed to propose a co-management structure for Hilsa fishery management in the sanctuary areas of the Padma-Meghna River systems based on lessons learned through extensive field activities, hosting several workshops and reviews of several project reports on community-based fisheries management (CBFM) in Bangladesh. The information so far received is classified according to structure of natural resource management arrangements in different projects and nature of decision-making arrangements between government and resource users (mostly fishers). The results indicate that CBFM approaches in Bangladesh varied in response to the objectives of improving natural production, fish abundance, biodiversity as well as the nature of community involved. On the basis of information a number of observations are made concerning the determination of the type of co-managements already in place and how Hilsa sanctuary-based co-management initiatives in the Padma-Meghna River systems in Bangladesh can be developed through USAID funded Enhanced Coastal Fisheries in Bangladesh (ECOFISH^{BD}) project, which is jointly implemented by WorldFish and Department of Fisheries. These include the development capabilities of users groups through formation of village level Hilsa Conservation Groups (HCGs), Fishers Women Community Savings Groups (CSGs), livelihood supports in terms of on-farm and non-farm options,

formation of landing Center Groups (HGGs), promotion of dialogue among different stakeholders, developing connectivity between government fishing departments communities, and supporting the capabilities of the DoF and law enforcing agencies for enhancing compliance, and addressing the socio-political culture that prevails in the Southwest regions. This study will support development of co-management frame-work to build scientific basis for Hilsa co-management through involvement government departments, river fishers and The relevant stakeholders. proposed framework of eco-management structures presented below (Fig. 1), which may, if implemented, facilitate the sustainable Hilsa management and conservation in the Padma-Meghna River systems. Hilsa Ghat Group (HGG)



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IMPROVEMENT OF LIVELIHOOD AND ADAPTATION TECHNIQUES OF FISHER COMMUNITY THROUGH THE ASSISTANCE RECEIVED UNDER CLIMATE PROGRAMS IN NOAKHALI AND LAKSHMIPUR, BANGLADESH

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The study was conducted to assess the improvement of livelihood and adaptation techniques of fisher community through the assistance received under climate programs in Subarnachar and Hatiya Upazila of Noakhali and Ramgati Upazila of Lakshmipur districts. Primary data were collected through household survey using PRA tools such as Focus Group Discussion (FGD) and Cross check Interviews (CI) with key informants. Different organizations were found to work on the climate change adaptation in the study area and provided VGF, training, tree plantation, building strong house, life saving equipment, buoy, and financial support to a very limited number of fishermen. Fishermen who got assistance from those programs, among 47% of them replied as they had a improved life in respect to the past whereas 24%, 18% and 11% had moderately improved, slightly improved and no change in life condition respectively. It was observed by the fishermen that the frequency and intensity of natural calamities like cyclone. storm flood and river bank erosion were increased in the recent days. Although these all are life threatening events but unusual salinity intrusion due to sea level rise and scarcity of potable water severely affected their daily life. To cope with the climatic events different local adaptive methods like bolli, angle, high elevation house, low roof and pull rope for strengthening the house was observed. Tree plantation along the coast line, establishment of embankment to reduce river erosion, training for alternative way of livelihood, financial support, construction of more cyclone shelter, provision of life saving equipment, awareness building program on the climate change mitigation measures were recommended by the fishermen as the way of improvement and building resilient livelihood condition in respect to the climate vulnerabilities.

ENHANCING FISHER WOMEN'S INVOLVEMENT IN HILSA FISHERIES CONSERVATION IN BANGLADESH

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Approximately 0.45 million fishers directly depend on Hilsa fishing for their livelihood, another 2.5 million people are indirectly dependent on Hilsa fisheries value chain. Women's participation in Hilsa fisheries value chain in Bangladesh is largely invisible. They are assumed either not to fish in the coastal waters, or not to participate directly in the fishing as this is considered mostly men's work. However, women can play an important role in Hilsa fisheries value chain and thus, can contribute to the decision making in sustainable fisheries management. In an effort to improve resilience of the Meghna River system and the communities reliant on Hilsa fishery, a USAID funded "Enhanced Coastal Fisheries in Bangladesh (ECOFISHBD)" initiative has been jointly implemented by WorldFish and Department of Fisheries (DoF), Bangladesh. Gender equity and women empowerment have been considered as important inbuilt component in the ECOFISHBD project. It is believed that women's involvement and leadership can have a positive role on natural resource management, and on reducing gender-discriminatory norms and practices that negatively affect their lives and livelihoods. At the community level both women and men should be included in decision making that matters to their improved livelihoods as well as establishing fisheries co-management through engagement of fishers and different stakeholders. To increase resilience and social cohesion, ECOFISHBD addresses gender mainstreaming in all its activities. The project targets 100,000 fishers family members (around 50% women), who will be benefitted directly from the project. Also, 200 Fishers' Women Community Savings Groups (CSG) will be formed over the five years in different villages scattered throughout six Hilsa fish sanctuaries. CSG consist of active participation of women to ensure gender equitable systems and structures, higher participation and leadership of women in community-led initiatives as well as women's economic empowerment. Fishers' women has been provided with different on-farm and non-farm alternative income generating activities (AIGAs) to support the households during the fishing ban period and thus to influence the compliance of the management plan of the Government of Bangladesh.

INVOLVEMENT OF CHILD LABOUR IN HILSA FISHING AND ITS SUSTAINABILITY

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About 2% of the country's total population is involved in the hilsa fishery either directly or indirectly for their living. In capture fisheries, using child labour in substitution for adult labour reduce costs- as a result of poor profitability. As a consequence of overfishing further exacerbates unsustainable resource utilization. Due to high economic value, many fishermen are engaged with the Hilsa fishing but forgetting sustainable Hilsa production, the fishing level should be reduced by 25% of the existing fishing level. The hilsa fishermen in the coastal area become more poor then before during the hilsa ban period. They starve with this worst situation. There are also lack of alternative jobs. Peoples are compelled to do illegal fishing during no catch period. Thus scarcity of food and absence of daily necessary in common feature to them. Poor fishermen were unable to hire other fishermen and boats. Children are used by armed groups and criminal gangs because they are vulnerable and can often be manipulated more easily than adults. They also tend to constitute cheap labor and they often lack legal accountability. Fishermen involve their children during fish catching because they need a helping hand they have no extra money to hire an extra fisherman. Fishermen take their children in the river whose ages are below 17. During Expedition in the river the children are just accused and fined. They got sympathy from the polices and other officers. That is the reason why children are getting involved in Hilsa fishing. Various age groups including children (under the age of 17), are employed in fishing related activities including fishing, processing and marketing. About 45% fishermen age between among 5 to18 years age, followed by 19 to 35 years group (39%), and 35 to 70 years group were about 16%. Majority of the fishers were children in the coastal area. A good number of children were engaged in fishing. Among respondent 55% children were involved in fishing. Most of the children lost their parents due to illness or occupational accident died. About 13% children had no family. They were found to be residing in the boats with other fishermen or in land at aratdar and mohajon's house. Lack of proper hygienic sanitation children suffered from various diseases. In Bangladesh, suffer from a chronic lack of well-planned management and governance initiatives. For the effective management and conservation of Hilsa fishery it is important to know the Governance of Hilsa fishing. So, that the optimum exploitation and effective management of Hilsa stock can be ensured. For the effective management and conservation of Hilsa fishery it is important to know the policy of fishing management. Child labor policy issues in Bangladesh are not properly maintained in the fisheries sector. So, it is a fundamental factor, to mention the child labor issues in the fisheries policy.

WOMEN AND CHILD LABOUR GOVERNANCE ISSUES IN COASTAL HILSA FISHING VILLAGES OF BANGLADESH

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This study critically examines the Hilsa fish governance among the coastal rural fishermen villages of Bangladesh. The motivation for and objectives of this study is to gain better understanding the role of women and children fishers perspective in the hilsa fish governance and it's regulation. Both qualitative and quantitative tools were used along with the participatory techniques that including focus group discussions, key informant interviews, participant observations and longitudinal case studies at household and field levels. Following a comparative case study approach, the field research was starting from September 2015 to April 2016 along the Meghna river basin of Bhola district of Bangladesh. The depletion of hilsa resources in the Bangladesh is ostensibly the reason attributed to this 'hiring' of children as workers, as they were the source of cheap labor. Besides insufficient availability of adult fishermen during hilsa peak period (fishing season) and non-peak period child labor become demandable. As a result overfishing, illegal fishing persists. Women can be empowered by giving training programs which will focus on the root causes of labor abuses and impart illiteracy, skills development and abilities needed to resolve this mistreatment. In order to address the violation hilsa fishing governance, we need to understand what the issues are and how child labor can be stopped and women's participation can be socially acceptable way. In Bangladesh, suffer from a chronic lack of well-planned management and governance initiatives. For the effective management and conservation of Hilsa fishery it is important to know the Governance of Hilsa fishing. So, that the optimum exploitation and effective management of Hilsa stock can be ensured.

GOVERNANCE OF HILSA SHAD (*TENUALOSA ILISHA*) FISHING DURING SPAWNING AND JATKA BAN PERIOD: COMPARED TO NON-BAN PERIOD

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The Hilsa shad, Tenualosa ilisha, is an important migratory species in the Indo-Pak subcontinent and the Persian Gulf region, especially in Bangladesh and India. The present study on the governance of Hilsa shad fishing during spawning and Jatka ban period, compared to non-ban period was conducted between August 2015 to February 2016. The information was collected by adopting various participatory methods such as through personal interviewing with a well structured questionnaire, Focus Group Discussion (FGD) and Crosscheck Interviews (CI) with Key Informants (KI). The study revealed that about 70% fishermen are male, 6% fishermen are female and about 24% children are engaged in fishing. Most of the fishermen are illiterate, about 88% and 75% female fishers are illiterate. Though the girls are educated but the boys are mostly illiterate. Only about 5% fishers have both boat and net but the others do not have. Though annual income of the fisherman varies between BDT 30,000 to 150,000 but about 40% fishermen earns only BDT 30,000 per year. Considering the value chain of Hilsa, Aratdar, Paiker and Dadondar plays a major role in price and livelihoods of the poor fishers. Ban period is almost effective and the production is increased due to banning on Hilsa. Though Arats, ice plants were fully closed but hotels and restaurants serve Hilsa during ban period. Mainly illegal fishing was done at night time. Actually the fishermen are bound to do illegal fishing for their poor livelihood conditions. The study shows the moderate effectiveness of good governance for Hilsa in Bangladesh.

IMPACT OF BANNING PERIOD ON THE LIVELIHOOD OF THE HILSA FISHERMEN OF LOWER MEGHNA RIVER, BANGLADESH

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The present study was carried out to determine the impacts of banning period on the hilsa fishermen of lower Meghna River basin. Seventy one fishermen were included in this study; almost all of them were involved in fishing either professional or occasional. It was found that 42% fishermen were belonged to the age group of 19-40, 34% fishermen were in the age group of 40-50 and about 24% children were involved in hilsa fishing. Fishers community was represented by 93% Muslims and 7% Hindus. About 6% women are engaged in hilsa fishing. Regarding the educational level, fishermen aged more than 50 were 100% illiterate. But less than 50 years, 60% fishermen were illiterate, 32% were educated up to primary level and 8% were educated only secondary level. It was found that about 91% fishermen have no fishing assets but about 5% have both nets and boats. All the fishermen have their own house but only 7% have their own agricultural land. About 62% have tin shed house, 33% have kacha house and 5% have half building. Average annual income of majority (40%) earns below BDT 30,000 and only 7% earns above BDT 1,50,000. About 50% fishermen were engaged with net making, 30% were engaged in illegal fishing and 10% work as day laborer. About 87% fishermen took loan from local mohajans or NGOs during ban period. About 60% fishermen got subsidies from government but 40% did not get. Almost 20% fishers improved their status due to VGF but majority (80%) of the fishers could not improved. Therefore, it is necessary to make proper management plan and its implementation to improve the livelihood of fishermen during banning period of lower Meghna River Basin area.

SOME TECHNICAL AND BUSINESS CONSTRAINTS IN CARP NURSERY OPERATION IN CHANCHRA, JESSORE, BANGLADESH

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The present investigation was based on the survey of the existing problems of carp nursery operation in Chanchra area, Jessore district during June 2015 to December 2015. A total of 30 nursery operators were interviewed using a structured questionnaire. The objective of the study was to understand the existing nursery operation and trading systems and to find out the technical problems involved. The rearing of carp spawn was the critical stage of successful aquaculture. Some technical problems and constraints were found that hindered the development of carp nursery operation and trading. The most vital problem of carp nursery in the study area was the lack of technical knowledge (30%) relating to feeding, liming and fertilization, density of stocking, handling and transportation, water quality monitoring and prestocking management cause outbreak of diseases leading to high mortality of fish seed. Disease was one of the major constraints (15%) for intensification of carp nursery, and might sometimes eventually be a limiting factor to the economic success of the nursery operation. The next most important problem of the nursery operator commonly faced with was high lease value of the nursery ponds (12%). The other problems were lack of capital and credit facilities (10%). lack of facilities of using modern scientific equipment (8%), high price of various inputs (5%), unexpected market competition (8%), multiple ownership (5%), water quality problem (3%), manpower problem (3%), poor record keeping system (2%), and social problem (2%). The government and the private sector should come forward for large scale training and dissemination of technologies for successful nursery operation and trading.

ESTABLISHMENT OF WOMEN LED MOLA-CARP DEMONSTRATION POND IN DIFFERENT REGIONS OF BANGLADESH

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A project "Implement market development interventions to mainstream Women's Economic Empowerment (WEE) in the Farmed Fish and Vegetable Sectors" has been co-facilitating by Consiglieri Private Limited (CPL) and implemented by KATALYST since March, 2016. Under this project, fish culture was one of the encouraging activities to empower women. High market valued small indigenous fish species (SIS) mola, Amblypharyngodon mola was selected for this project. Demonstration method was followed for the culture of mola along with carp polyculture. Some appropriate criteria for establishment of mola-carp demonstration pond were set before the selection of demo ponds and these are women or household involvement, perennial or seasonal pond, pond size between 15 and 40 decimal, eagerness and enthusiasm to culture mola, social acceptance and voice, carp farming experience, preference to road side or good accessed pond and different communities. Demo farmers were selected from the fish farming training groups conducted by this WEE project. A total of 31 mola-carp demo ponds were selected from six Districts from three regions of Bangladesh (Northeast- Rangpur, Kurigram and Nilphamari; Southwest - Jessore and Narail and North middle- Mymensingh). Mola broodfish 0.25 kg decimal⁻¹ was provided to each farmer. In addition, lime 1.5 kg decimal⁻¹, Urea 2 kg decimal⁻¹, TSP 2 kg decimal⁻¹ and nursery feed (powder form) 7.5 kg decimal⁻¹ were provided to farmers as a partial support for this practice. Necessary technical consultancy has been providing to the farmers. A signboard was displayed for each demo pond. All the communications and agreements were conducted with women for the selected households.

Mola have already bred in most of the demo ponds and farmers have started to sell mola as seed to other farmers. Harvesting of mola at a regular interval will enhance the regular cash return, which will not only increase the income but also reduce the investment cost of fish farming. Farmers can get mola for their regular household consumption without reducing the stock into pond as mola is a prolific breeder. The output of this project will enhance the women empowerment through economic and nutrition benefits and play a key role to establish broodstock of mola in different regions of Bangladesh along with gender mainstreaming.



Fig. 1. A women farmer showing the mola offspring from their mola-carp demo pond

IMPACTS OF NATIONAL AGRICULTURAL TECHNOLOGY PROJECT (NATP) ON GROWTH AND PRODUCTION OF TILAPIA DEMONSTRATION PACKAGE IN BANGLADESH

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There are a number projects implementing demonstration of different culture packages in Bangladesh, however effectiveness of the tool was scarcely assessed. An on farm trial was conducted to assess water quality parameters, growth performances and length-weight relationship of similar demonstration package in NATP and non-NATP area. Six demo ponds of tilapia were selected from Muktagachha (T₁) and Gauripur (T₂) under Mymensingh district and three ponds of same culture package were selected from Ulipur (T₃) under Kurigram district. Water quality parameters and length and weight of fish of selected ponds were sampled regularly. To study the various physicochemical parameters, *i.e.*, water temperature, water transparency, dissolved oxygen (DO), pH, NH₃, NH₄⁺ and PO₄, water samples from nine ponds were collected and analyzed. Similarly, length and weight gain, percent length-weight relationship of three treatments were calculated. Most of the water quality parameters found to be within the optimum range for aquaculture. There were no significant differences for water quality parameters between NATP and non-NATP ponds found though higher fish productivity was obtained by NATP farmers.

MARKETING CHANNEL AND SEASONAL PRICE VARIATION OF FISHES IN DINAJPUR, BANGLADESH

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A study was conducted in three fish markets (Bahadur Bazar, Rail Bazaar and Farm hut) of Dinajpur district to identify different marketing channels and seasonal price variation of fishes. A total of 55 fish retailers and 20 *aratdars* were interviewed for obtaining pertinent data from July 2014 to June 2015. Four types of marketing channel were identified in the study area. These channels were (a) fish farmer - local *paiker - aratdar* - retailer - consumers, (b) fish farmer-*aratdar* - retailer- consumer, (c) fish farmer - retailer- consumer, and (d) marine resources - agent - *aratdar* - retailer - consumer. The highest price of fish was observed during summer (March to June) season followed by winter (November to February). Comparatively higher fish supply was recorded in winter season than summer season. Different problems in market and marketing channels were also reported from this study. Such as poor infrastructures, lack of clean water supply and sanitation facilities, adequate drainage and ice facilities, political rest, and adequate storage facilities etc. However, well developed transportation system, and corporation among different stakeholders should be improved for smooth marketing of fishes in this area.

IDENTIFICATION OF CORAL ASSOCIATED FISH USING MORPHOMERISTICS AND MOLECULAR APPROACH FROM THE BAY OF BENGAL, BANGLADESH

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Coral reef supports diverse fish communities, although coral-associated fish has not been widely documented globally as well as Bangladesh. The present study was conducted to identify coral associated fish by morphomeristics and DNA Barcoding approach from June, 2015 to September, 2016. Mostly dead and few live fish specimens were collected from fishermen of St. Martin's Island, Cox's Bazar during seven visits. Collection specimens were preserved in cool box till transfer to laboratory at Dhaka further study. Morphomeristic study included 95 morphometric characters and 12 meristic characters. Morphomeristic study identified 67 species, 41 genera, 32 families and 08 orders (Perciformes, Tetraodontiformes, Aulopiformes, Siluriformes. Bervciformes. Scorpaeniformes. Pleuronectiformes and Anauilliformes). Perciformes was dominant among 08 orders, which belongs 23 families, 30 genera and 54 species. The barcoding gene, mitochondrial cytochrome c oxidase I (COI) gene was sequenced first time in Bangladesh for identification of coral associated fish specimens which confirmed 14 species of 5 genera and 5 families.

LIVELIHOOD CHALLENGES OF MARINE FISHERS IN ANDHRA PRADESH, INDIA

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Andhra Pradesh, India is a fisheries prominent state contributing 10% of total fish and shrimp production in the Country with 974 Km long coastline. Though fishing is a major source of livelihood for large population along the coast in the state, there is an acute shortage of effective and remunerative employment in the sector as the income is not fixed. For various other reasons, the marine fisheries sector in the past two decades has been discouraging especially for the traditional fisher folk. In general, socio economic backwardness largely prevails among the fishermen communities in this state.

The small-scale fishing communities in the state are vulnerable to a wide range of factors affecting their livelihoods. Their traditional livelihoods of fishing, fish processing and trade face serious problems for various reasons like declines in access to, and availability of the fish resources, increasing competition both at the fishing grounds and at the market place, over-capitalization of the fishing and post-harvest activities, and rapidly changing macro-economic conditions that often involve undermining the traditional mechanisms that support and protect their livelihoods. Since the fishers are fully occupied with fishing activities, their migration to other fields of work is rather difficult. In addition, the traditional fishers also face complex interplay of a number of factors such as low profitability, poor access to credit services, inadequate infrastructure facilities, destruction of fish habitats and sensitive coast ecosystem due to rapid industrialization and exploitation which ultimately affect their performance and involvement in the sector. Therefore, it is very important to examine various livelihoods challenges faced by the traditional fishers in the Andhra Pradesh and suggest suitable strategies for improving their livelihood status.

GENETIC DIVERSITY AND POPULATION STRUCTURE OF *TENUALOSA ILISHA* IN THE BAY OF BENGAL AND THE PERSIAN GULF

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A total of 130 individuals of hilsa shad (Tenualosa ilisha) were collected from four sites located in Bangladesh (Chandpur, CP & Cox's Bazar, XP), India (Ichapur, IP) and Kuwait (KP). Partial sequences of mtDNA control region (D-loop) were analyzed to assess the genetic diversity, population genetic structure and historical demography of hilsa in the Bay of Bengal (BoB) and Persian Gulf. In D-loop region, 456 polymorphic sites and 86 haplotypes were found. Nucleotide diversities (π) were low (0.091-0.105) whereas the haplotype diversities (h) were high (0.96 -0.99) for all the populations except KP ($\pi = 0.654$, h= 0.84) indicating that the populations of BOB has undergone population expansion after bottleneck and the Persian Gulf population is in demographic equilibrium. Pair wise estimates of the conventional F_{ST} (0.002, P> 0.05) and Exact P (0.24) value suggested population panmixia between XP and CP i.e. populations of Bangladesh. Persian Gulf (KP) population showed genetic structure compared to each of the BoB populations. Phylogenetic analysis of D-loop haplotypes revealed a separate monophyletic clade for Persian Gulf population with 99% bootstrap value. However, the phylogeny of COI barcode region of randomly selected 61 samples from all of the four populations did not show any separate cluster for KP population. In historical demography analysis, neutrality test statistics (Tajima's D and Fu's F_s values) suggested that only the BoB populations have undergone demographic expansion. Mismatch distribution analysis revealed that the expansion of the BoB populations started during middle to early Pleistocene approximately from 0.58 to 1.17 million years ago. This study will help to establish appropriate fishery management and conservation strategy for this species in its distribution area.

DNA BARCODING REVEALS THAT MUD CRAB IN SUNDARBANS, BANGLADESH IS SCYLLA OLIVACEA (BRACHYURA: PORTUNIDAE), NOT S. SERRATA

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Mud crab is a commercially important coastal species of mangrove ecosystem, having high demand and price in the international market. There has been considerable confusion on the identification and the taxonomic nomenclature of the species in the genus *Scylla* found in

Sundarbans mangrove forest area. In most of the literatures of Bangladesh, the mud crab species was mentioned as S. serrata. Few authors assumed that the species might be Scylla olivacea based on traditional morphometry. To resolve this confusion present study was designed to identify and confirm mud crab species the of Sundarbans by analysing mitochondrial COI gene sequences as DNA barcoding. Morphological study positively showed the mud crab species matched with Scylla olivacea rather than Scylla serrata. The comprised sequences 05 haplotypes (GenBank Accession Numbers KX959992-KX959996). NCBI Blast search showed that COI sequences of the present study were minimum 99% identical with previously



Fig. 1. Phylogenetic tree constructed for Sundarbans' *S. olivacea* and reference sequences based on the COI gene.

reported sequences of *Scylla olivacea*. The COI phylogenies constructed using neighbour joining and maximum likelihood methods produced identical topology (Fig. 1). All the COI sequences of the present study formed a monophyletic group with the sequences reported in NCBI from other regions of the world with high (99 or 100) bootstrap support. COI phylogeny showed that all mud crab samples collected in this study were *S. olivacea*, not *S. serrata* or other *Scylla* species (i.e. *S. paramamosain* and *S. tranquebarica*).

NUTRITIONAL EVALUATION OF SOME SEAWEEDS FROM THE BAY OF BENGAL IN CONTRAST TO INLAND FISHES OF BANGLADESH

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Seaweeds have become a very versatile product widely used for food or food supplement in many countries. However, the seaweed industry in Bangladesh is at its initial stage, people in Bangladesh are still not aware of the potentials of seaweed. In contrast, fisheries and aquaculture are the traditional heritage of livelihood of Bangladesh. This present study was initiated to create a nutritional valuation of edible seaweeds of Bangladesh coast in order to popularize its consumption and utilization. Comparisons to corresponding and comparative nutrient values of commonly consumed inland small indigenous fish species were also made. Eight edible seaweeds and seven small fishes were analyzed to determine its proximate and mineral compositions. The proximate composition and micro-nutrient properties of selected seaweeds (Caulerpa racemosa, Enteromorpha intestinalis, Padina tetrastromatica, Sargassum oligocystum, Hypnea musciformis, Hypnea sp. and Jania rubens) were investigated. The protein content was the most abundant components (5.7 to 22.31 g/100 g) and varied among seaweeds with highest in edible red sea weed Hypnea sp. Total dietary fiber (4.1 to 6.8 g/100 g) and ash (3.96 to 27.95 g/100 g) were the other abundant components in seaweeds studied while their lipid content values were low (0.3 to 2.65 g/100 g). The mineral composition (Ca, K, Na, Fe and Zn) showed higher Ca (2,288.9 mg/100 g), K (98 mg/100 g) and Na (161 mg/100 g) values in red seaweed J. rubens, and was followed by S. oligocystum with Ca (228 mg/100 g), K (61 mg/100 g), Na (144 mg/100 g) and Fe (21 mg/100 g) values. The concentration of Zn (0.1 to 0.8 mg/100g) was at low level, indicating no sign of bioaccumulation of heavy metals. Inclusion of sea weed in food salad proved enrichment of food item with micro-nutrients. When comparing to small indigenous fish species (Amblypharongodon mola, Puntius sophore, Heteropneustes fossilis, Mystus bleekeri, Gudusia chapra, Corica soborna and Glossogobius giuris), the proximate composition was higher in seaweeds. Among minerals, Ca ranged from 476 to 1,093 mg/100 g, K from 134 to 300, Na from 38 to 57, Fe from 2.2 to 7.6 and Zn from 2.1 to 3.2 mg/100 g. This illustrates the diversity of micro-nutrient content of small fish species and in particular the rich nutrient composition of seaweed species in comparison to market price, which should guide policy makers and programmes to improve food and nutrition security in Bangladesh.

COMMUNITY ECOLOGY OF CRAB LARVAE IN THE RIVERS OF SUNDARBANS MANGROVE FOREST, BANGLADESH

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The Sundarbans mangrove forms an ideal ecosystem including fishes, shrimps, crabs and also support livelihood to local coastal communities. The composition, density and distribution pattern of crab larvae along with other shell- and finfish larvae in the rivers of Sundarbans with different salinity zones were investigated. Megalopa of crabs were most numerous, making up to 25.6% of the total shellfish catch. The commercial important mud crab species *Scylla* spp. were observed frequently with maximum abundance observed during winter from November to February. No significant seasonal or lunar variation in abundance of crab larvae was observed, although major annual peak in monsoon was recorded. The results have important implications for the development of a sustainable mud crab aquaculture based on collection of juvenile crab from Sundarbans.

SEAWEED CULTURE IN DIFFERENT LOCATIONS OF BAY OF BENGAL COAST, BANGLADESH

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Present study purveyed with successful cultivation of red algae *Hypnea* sp. in selected areas of Bay of Bengal coast, Bangladesh with an improvement of further elegancy to contribute on assumed blue economy. *Hypnea* sp. was cultured in 3 locations i.e. Saint Martin, Innani and Bakkhali for a period of 60 days in 4 x 4m coir rope net attached with bamboo pole. Partial harvesting on cultured species conducted at 15 days with maximum yield (19.31±0.27 kg fresh wt.) obtained from Saint Martin, Teknaf and the minimum (4.24±0.07 kg fresh wt.) was from Innani, Ukhia. Highest daily growth rate of $3.21\pm0.01\%$ day⁻¹ was also found in Saint Martin. Total biomass of *Hypnea* sp. (11.05±0.10 kg fresh wt.m⁻²) was highest in Saint Martin and lowest (7.82±0.04 kg fresh wt.m⁻²) recorded from Innani. Total biomass production in Saint Martin significantly higher than Bakkhali (p=0.002) and Innani (p=0.001), which descending as: Saint Martin > Bakkhali> Innani. Growth rate of seaweed had a significant correlation with PO₄-P (p<0.05) but don't have any significant correlation with NO₃-N. Water salinity had a significant positive correlation with pH (p<0.01), DO (p<0.05) and temperature (p<0.01) during the cultured period. Present study revealed suitable locations of seaweed culture in Bangladesh coast which will add a new dimension to develop sustainable seaweeds mariculture prospect in Bangladesh.



Fig. 1. Bar diagram Shows the biomass production (Kg m^{-2}) of *Hypnea* sp. on 60 days of culture period in 3 ulture sites. Bars with different letter are significantly different from each other (Paired sample t-test).

Bangladesh Fisheries Research Forum (BFRF)

PREVALENCE AND INTENSITY OF PARASITES WITH HISTOPARHOLOGICAL STUDY OF INFECTED ORGANS IN CROAKERS FROM COASTAL BANGLADESH

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Croakers are one of the most desirable and highly priced food fishes in the coastal belt of Bangladesh that inhabit in marine, brackish and freshwater. The present study was conducted to determine the prevalence and intensity of parasites infestation and to investigate the diseases caused by parasitic infection in croaker fish. A total of 30 fishes were collected from coast of Bay of Bengal (St. Martin's Island, Cox's Bazar, and Patharghata) at monthly intervals from October, 2015 to September, 2016. On arrival at the laboratory, the fishes were identified, grouped in sex and their total lengths and total weights were measured to determine the prevalence and intensity.

A total of 448 individual parasites were collected, and 9 of them were identified which belongs to 4 main groups of Crustaceans (3 species), Pentastomid (1 species), Nematodes (4 species) and Acanthocephalan (1 species). The prevalence and intensity of parasites was higher in female 55% and 35 compare to male that was 50% and 20. Furthermore, the prevalence and intensity of parasites was higher in large sized fishes which was 66.66% and 38.4 and lowest in medium sized fishes that was 37.5% and 8.66. On the other hand, in histopathological investigations, the most important alterations in various organs of fish were hemorrhage, necrosis, light fatty droplets, edema, vacuolar degenerations, villi missing, haemosiderotic nodules, dilation of glomerulus capillaries etc. Due to the parasitic infestation, various histopathological abnormalities will create different types of diseases which could be a harm to our sea fish resources in the Bay of Bengal.

NURSERY REARING OF SEEDS OF MUD CRAB (SCYLLA SP.) IN EARTHEN POND

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Crablets of mud crab, *Scylla* sp. were reared for a period of six weeks in earthen pond to determine the effect of different supplemental feeds on their survival and growth. The feeds donated as diet-1 (commercial crab pellet feed), diet-2 (commercial shrimp pellet feed) and diet-3 (trash fish) were used to determine their efficiency in nylon net hapa in earthen pond. A stocking density of 12 crablets/m² hapa was maintained. It was observed that crablets fed diets-1 and 2 had similar body weight gain and daily growth rate, but were significantly different (p<0.05) from crablet fed diet-3(trash fish). Crablets fed diet-3 (trash fish) resulted significantly higher (p<0.05) survival rate of 58.33 ± 7.4 , whereas diet-1 resulted significant lower survival rate of $33.33\pm5.9\%$.

RELATIONSHIP BETWEEN LINEAR DIMENSIONS OF SCALES IN FOUR MULLET SPECIES (MUGILIDAE) FROM THE KARACHI COAST, PAKISTAN

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Present investigation was based on linear regression relationship between six parameters of scale including scale length (TLS), scale width (WDS), number of ctenii found in horizontal (HRS) and vertical rows (VRS) on scale, total radii counts (RDS), vertical distance between focus and outer posterior edge of scale (Rs) for four commercially important mugilid species (i.e. *Liza melinoptera, L. macrolepis, Valamugil speigleri* and *Mugil cephalus*) collected from Karachi coast of Pakistan. The obtained results revealed that the most correlations between scale length (TLS) and width (WDS) with the selected scale parameters (HRS, VRS & Rs) were found to be weak (r < 0.50) and highly significant at 5% level (t-test; p<0.05). Thus, present study adopted to focus the implication of some useful scale characters that could be used as valuable alternative tools in observing the systematic relationship between different genera or species or geographical variants of family Mugilidae.

(-)		Caudal scales N = 36					Transverse scales N = 40					Lateral line scales					
												N = 48					
X	Y	a	b	ſ	p	CT	a	b	ſ	p	CT	8	b	ſ	p	CT	
TLS	WDS	0.11	0.86	0.75	0.0*	*	2.1	0.7	0.82	0.0*	*	1.36	0.7	0.64	0.04	Q	
TLS	RDS	4.92	0.80	0.29	0.2 33	*	3.1	0.6	0.31	0.0*	*	-0.48	1.1	0.47	0.0*	*	
TLS	Rs	0.07	0.33	0.57	0.0 ²	Ŷ	-0.6	0.5	0.69	0.01	Q	0.08	0.4	0.55	0.0 ⁴	Q.	
WDS	RDS	4.17	1.08	0.35	0.0 ¹	*	4.2	0.5	0.21	0.255	2	0.98	0.9	0.48	0.01	2	
WDS	Rs	0.44	0.28	0.57	0.0 ²	\$	-0.4	0.4	0.56	0.01	<u>्र</u>	1.05	0.2	0.43	0.04	2	

Table 1. Regression parameters of caudal, transverse and lateral line Cycloid type scales of *Mugil cephalus*

Note: N, number of scale samples examined; CT, correlation type; p, probability values; ^a shows relationship significant when $p \le 0.05$; NS: non-significant relationship when p > 0.05; * shows the strong correlation (when $r \ge 0.70$), \Leftrightarrow shows moderate correlation when r = 0.51-0.69, \blacklozenge represent weak correlation when $r \le 50$, – shows negative correlation.



BLUE ECONOMY: NEW HORIZON FOR ECONOMIC DEVELOPMENT OF BANGLADESH

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Ocean resources based blue economy became buzzword for sustainable development particularly in drafting the post-2015 development goals of Bangladesh. Blue economy issue has gained further momentum after the settlement of maritime boundary delimitation dispute with Myanmar and India. Based on secondary literature and expert interviews, the present study assesses the potential of blue economy and its constraints in Bangladesh context. The result indicates that Bangladesh has a number of emerging sectors that can be employed for enhancing blue economy. The potential sectors include food and livelihood, energy (eg. wind, wave, tidal, thermal and biomass sources), maritime trade and shipping, tourism, human resource development and services, mariculture coastal protection/greening coastal belts that can progressively contribute to growth, development and poverty alleviation in Bangladesh. To utilize these potentials, there are also several challenges. Skilled manpower and development of technology is essentially required. Political instability can be another barrier. Moreover, security of maritime boundary is much more needed. Invest in human resource capacity building in diverse fields of marine economic activities as well as mobilization of investment for different sectors of blue economy should be a policy focus. Finally, the study submits that in the plight of becoming a middle income country, blue economy based on marine resources should act as driver for sustainable development that denotes development not only for today but for future in Bangladesh too.

EXPLORING THE OPTIMUM TEMPERATURE AND DIET FOR GROWTH AND GASTRIC EMPTYING TIME OF JUVENILE MALABAR BLOOD SNAPPER (*LUTJANUS MALABARICUS*)

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In this study, we analyzed the effects of water temperature and diets on the growth and gastric emptying period of juvenile Malabar blood snapper (Lutjanus malabaricus) over a period of 30day. Fishes were collected from the local hatcheries of Pulau Ketam, Selandor, Peninsular Malaysia and the experiment was conducted in a laboratory using flow-through sea water system. The fish were subjected to four different temperatures (22, 26, 30, and 34 °C) and two diets (formulated pellet and shrimp). The fish were fed twice a day. Body weight gain, food consumption, food conversion ratio, food consumption efficiency, specific growth rate, relative growth rate, daily growth rate, and gastric emptying period were significantly influenced by temperature and diet (p<0.05). The best FCR was with the shrimp group recorded at 30°C (1.33±0.08). The highest growth rate was observed in the shrimp group at 30°C (3.97±0.57%) day⁻¹), and the lowest was observed in the formulated diet group at 22 °C (1.63 \pm 0.29% day⁻¹). No significant difference was observed between the groups subjected to temperatures of 26 and 30°C. Similarly, the lowest gastric emptying period was detected in the shrimp group at 30°C (16 h), where the proportion of meal residues in the stomach decreased from 100% to less than 8% after 12 h of starvation. A significantly longer gastric emptying period was observed in the formulated diet group at 22°C (28 h). Overall, the best results were observed on shrimp group subjected to a 30°C temperature. The data obtained from this study suggest that a shrimp diet fed on L. malabaricus at 30°C will optimize the commercial production and condition for the culture of Lutianus malabaricus.
PRODUCTION OF HEALTH BENEFICIAL FOOD EMULSIFIER BY ENZYMATIC PARTIAL HYDROLYSIS OF PHOSPHOLIPIDS OBTAINED FROM THE HEAD OF AUTUMN CHUM SALMON

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Phospholipids and their partial hydrolysates, namely lysophospholipids (lyso-PL) have been widely used in food, pharmaceutical, and cosmetic products as highly efficient emulsifiers. Phospholipids from egg and soybean have found many applications in food products. Purification of egg lecithin is too costly, therefore, soy lecithin and its' enzymatic derivatives have been widely used as natural emulsifiers in the food industry. Dominant fatty acid component of soy lecithin is mostly linoleic acid and excess intake of this fatty acid may aggravate various kinds of diseases. Therefore, DHA containing lyso-PL derived from marine resources could be used as substitute to alleviate excess intake of soy lecithin. Moreover, it has strong emulsifying properties and health beneficial functions. The present study was conducted to produce docosahexaenoic acid (DHA) containing lyso-PL by enzymatic modification of phospholipids obtained from the head of autumn chum salmon (*Oncorhynchus keta*).

The head of salmon was soaked into hot water (60-70 °C) to denature protein. Cartilage and other portions were separated by a rotary separator. Then total lipid was extracted using ethanol. Two different types of phospholipids were assessed, which were obtained by Sep-Pak Vac silica cartridges and acetone precipitation method. Enzymatic partial hydrolysis was carried out with immobilized phospholipase A₁ (PLA₁) and Lipozyme RM IM. Emulsifying properties of the obtained lyso-PL was also evaluated. Results showed that increase in DHA into the lyso-PL was much higher in the silica separated phospholipids than acetone precipitated phospholipids. DHA content of lyso-PL was increased from 23.1% to 40.6% and 42.6%, after 8 h of partial hydrolysis reactions with Lipozyme RM IM and immobilized PLA₁, respectively, when silica separated phospholipids was used as substrate. The yield of lyso-PL was comparatively higher in the Lipozyme RM IM than immobilized PLA₁. Considering about the LPC content and yield of lyso-PL, silica separated phospholipids and immobilized PLA₁ could be used to produce lyso-PL. Surface tension values of lyso-PL and purified lysophosphatidylcholine (LPC) were reduced to 30.0 mN/m and 30.5 mN/m at a concentration of 100 mg/L and 5 mg/L, respectively. Hydrophilic-lipophilic balance of lyso-PL and LPC were 6.0 and 9.4, respectively. Based on the emulsifying properties, lyso-PL derived from the phospholipids of the head of autumn chum salmon could be used as health beneficial emulsifier in the food industry as a novel source.

STUDY ON SARDINE USING MORPHOMETRIC AND DNA BARCODING TOOL FROM THE COAST OF BAY OF BENGAL

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Sardines are small, oily pelagic fish within the family of clupidae. These small fishes are named after "Sardinia", the Italian island where large schools of these fish were once found. They are primarily marine (one freshwater and some anadromous). More than 20 varieties of fish are sold as sardines throughout the world. There is a clear ambiguity in the number of species found in the coast of Bay of Bengal. The present study was conducted to identify Sardine species of Bay of Bengal using taxonomic tools namely morphometric tool (17 non-meristic, 26 morphometric characteristics, and 7 meristic characteristics) as it is the simplest and basic tool of taxonomic identification and DNA barcoding tool. Sardines were collected from October, 2015 to September, 2016 from St. Martins Island, Cox's bazar and Pathorghata landing sites. Present study identified morphomeristically 1 genera namely *Sardinella* and four species namely *S. fimbriata, S. melanura, S. gibbosa, S. longiceps*. DNA barcoding approach was done for the four species but only one was sequenced and BOLD searched. It has been denoted as *Sardinella longiceps* (Val., 1847) after comparing the gene sequence in NCBI of present sequenced species. However, both taxonomical tools confirmed identification as *Sardinella longiceps* which is considered as a new record of marine fish in our coast.

KETNOTE PAPER

VALUE ADDED SEAFOOD PRODUCTS: LEAD SALES GROWTH AND MEET CURRENT CONSUMERS DEMAND

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Globally, seafood is recognized as an excellent source of low-fat protein, essential fatty acids, minerals, and vitamins and preferred as food with many health benefits. This sector contributes significantly to economies in generating income, employment, and foreign exchange earnings to the fishing communities, fish traders, fish processors and fish farmers. However, a significant proportion of total landed fish remains unused or getting low price due to inherent problems related to unattractive color, flavor, texture, small size, and low quality. Whole/raw fish/shrimp contribute much less in to the total seafood trade compared to the value added products (VAP) like breaded, IQF, cooked, ready meal, dried, salted, smoked, spicy, canned, surimi, etc. Additionally, the byproducts like head, roe & milt, cut-off, backbone, liver, viscera, skin contributes lots more into the income basket by producing snacks products, novel products (Omega-3 & 6 fatty acids, glucosamine, flavor attributes, bio compound, chitosan, etc.), feed, feed ingredients, cosmetics, leather goods, etc. Value addition to fish is an important strategy that reduces post-harvest losses, adds economic value and possibly widens the market performance. VAP not only enhance the nutrition, sensory characteristics, shelf life and convenience of food products, it also helps to reduce fishing pressure. The annual fish production of Bangladesh was 3.68 million metric tons in 2014-15 (DoF 2016). Of which, about 2.68million metric tons of fishes are used for human consumption including export and roughly 1 million metric tons are discarded as by-products. The global seafood market is estimated at US\$ 100 billion per annum where Bangladesh share is only 638 Million USD (2012-13) owing to producing less value added products. Adding value allows for better margins to be made at both local and international level, which contributes to improve the economic condition of the stakeholders of value chain, which in turn contributes to the development of the country.

SAFETY AND HYGIENE ISSUES: STATUS OF AWARENESS AMONG THE DRIED FISH PROCESSORS AT CHALAN BEEL AREA, BANGLADESH

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The present study was conducted in Chalan beel area under Natore, Naogoan, Pabna and Sirajgonj Districts during January'2015 to March'2016 to evaluate the status of awareness among dried fish producers with emphasis on safe and quality dried fish production. Primary data were derived from 60 processors through the administration of a pre-tested questionnaire and analyzed using both descriptive and simple inferential statistics. The findings disclosed that 65% of the processors adopt fish drying as primary occupation, however, 60% were found to have received training on dried fish production. In the aspect of hygiene and sanitation, 55% drying sites were lacking toilet facility. It was noticed that 62% processors were habituated to practice partial washing and dressing, and on the other hand, 35% did not practice dressing and washing before drying. It was the fact that 32% and 28% of the respondents are used to use beel and river water respectively and only 7% use tubewell water upon which training shows no significant (p>0.05) effect. In case of washing hand with soap or ash before and after drying operation, having knowledge on harmful effect insecticide application, the independent variable such as training exhibited the significant (p<0.05) effect. However, the findings also revealed that training did not make effect significantly (p>0.05) on insecticide application, concerned government office linkage, attitudes towards cooperative formation. From the findings, this study attempted to suggest possible measures for addressing the lacking of awareness of dried fish processors.

	Participati	ion in Training		χ^2 cal
Variable	Yes	No	Total	and
				ρ valu
Water source				2
Pond	10(58.8%)	7(41.2%)	17(28.3%)	χ ² _{cal} =1.36 Ρ =0.85
Beel	12(63.2%)	7(36.8%)	19(31.7%)	
River	10(58.8%)	7(41.2%)	17(28.3%)	
Tube well	3(58.8%)	1(58.8%)	4(6.7%)	
Tube well and pond	1(33.3%)	2(66.6%)	3(5.0%)	
Total	36(60.0%)	24(40.0%)	60(100%)	
Know side effect of pesticide				
Yes	28(71.8%)	11(28.2%)	39(35%)	χ ² _{cal} =6.45
No	8(38.1%)	13(61.9%)	21(65%)	P =0.011
Total	36(60.0%)	24(40.0%)	60(100%)	
Apply insecticides				
Yes	19(61.3%)	12(38.7%)	31(51.7%)	χ ² _{cal} =0.44
No	17(58.6%)	12(41.4%)	29(48.3%)	P =0.83
Total	36(60.0%)	24(40.0%)	60(100%)	
Govt. Office linkage				
Yes	9(69.2%)	4(30.8%)	13(21.7%)	$\chi^2_{cal} = 0.59$
No	27(57.4%)	20(42.6%)	47(78.3%)	P =0.44
Total	36(60.0%)	24(40.0%)	60(100%)	

Table 1. Bivariate Distribution of the respondents in terms of training with awareness related variables

Bangladesh Fisheries Research Forum (BFRF)

MICROBIOLOGICAL QUALITY ASSESSMENT OF MOLA (AMBLYPHARYNGODON MOLA), KACKI (CORICA SOBORNA) AND SANITATION STATUS OF A FISH PROCESSING INDUSTRY

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Food quality including safety is a major concern facing the food industry today. A number of surveys have shown that consumer awareness about quality of food is increasing in Bandadesh. The present study was conducted to determine and quantify the occurrence of various types of micro-organisms in raw and final product of two popular SIS species- Mola (Amblypharyngodon mola) and Kaski (Corica soborna), as well as HACCP condition of the some processing plants to enhance food safety. Standard methods were followed for Total Bacterial Count (APC), Coliform count and detection of salmonella and vibrio. The abundance of total aerobic bacteria, total coliform, faecal coliform, Salmonella and Vibrio cholerae were determined in raw and frozen product of Mola and Kaski. In each process, three different samples were examined. The density of total aerobic bacteria detected in all the samples of raw fishes was relatively higher than the frozen samples after processing and carb down them to internationally acceptable limit. The scenario is same in case of Total coliform count (MPN/g) as processing curb down final frozen product to acceptable limit. Salmonella spp. and Vibrio cholerae was not found in any of the raw and frozen samples of Mola and Kaski (Table 1). All data of each processing stage of the processing plant were under limit of international standard which reveals that the condition of the investigated processing plant was hygienic.

Table1. Density (CFU/g) of total aerobic bacteria, MPN count of Total Coliform, Faecal Coliform and presence of *Salmonella* spp., *Vibrio cholera* detected in three different samples of raw and frozen Mola and Kacki

APC(cfu/g)		Sample no		Total and Faecal Coliform (MPN/g)	Salmonell and Vibrio spp.
Raw Mola sample	4.98 x 10 ⁵	3.93 x 10⁵	2.25 x 10⁵	<3 in all samples of both raw and frozen	Absent in all samples of both raw and frozen
Frozen Mola	1.15 x 10 ⁵	1.05 x 10 ⁵	0.98 x 10 ⁵		
Raw Kacki sample	5.15 x 10⁵	5.01 x 10 ⁵	4.83 x 10 ⁵	Total Coliform in Kacki (Average): Raw- 60±8.02,Frozen-29.33 ± 6.98	Same
Frozen Kacki sample	1.86 x 10 ⁵	1.81 x 10 ⁵	1.15 x 10 ⁵	Faecal Coliform in Kacki (Average):Raw- 6.83±1.92, Frozen-3	

POST-HARVEST HANDLING AND QUALITY LOSS OF INDIAN MAJOR CARPS IN THE DISTRIBUTION CHANNEL OF NOAKHALI, BANGLADESH

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The present study was conducted in order to assess the post-harvest quality loss of mrigal (Cirrhinus cirrhosus), catla (Catla catla), rohu (Labeo rohita) and kalibaush (Labeo calbasu) fish and existing handling condition at different stakeholder levels in the markets of Noakhali district during the month of January to May, 2015. Post-harvest quality loss was estimated based on the sensory evaluation and fish handling condition was directly observed in the market situation. As the target species of this study was mainly farm raised fishes so they were in the fresh condition at the farm gate but it was found to loss its' quality constantly from farm level to retailer level. Time, temperature and preservation method also play significant role upon its quality at the different stakeholder levels. According to the current sensory observation, fisherman or farm owner supplied fish to beparies at 5% quality loss, further 10%, 20% and 22% loss was observed towards aratder, retailer and consumer respectively. The DPs (Defect Points) were higher in March-April due to higher temperature which causes relatively swift quality loss of fish. Among at all the stakeholder levels, the DPs were the highest at retailer level due to long term exposure of fish to open air along with unhygienic condition of markets. Different types of baskets were used for the transportation of fish with or without icing. Live fishes were transported with water in gallon or drum. The unsold fishes were preserved in refrigerator and re-icing was adopted by 70% retailer. The ice ratio of fish and ice was 1:1 in March-April and 2:1 in January-February. It was observed that the more deteriorative condition of fish then more ice was used. Poor handling practices during transportation and in markets also caused quality deterioration of some fishes. Post-harvest loss of fish in the distribution channel is not yet considered as a major concern in Bangladesh. However, this loss eventually causes economic loss coupled with food insecurity which could be reduced in a great extent with only some necessary actions like prompt and proper preservation method just after the fish is harvested.

SPECIES AVAILABILITY AND MARKETING SYSTEM OF TRADITIONALLY DRIED FISH IN RANGPUR DIVISION, BANGLADESH

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A survey was conducted on traditional dried fish marketing on Rangpur division. There are two wholesaler markets in Rangpur division, the Ghaghatpara arat, Rangpur and another one is the Saidpur arat, Nilphamari. The present study found that there are 22 species of dried fish available in Rangour of which 15 are freshwater species and 7 are marine water species. Prices of the dried fishes in wholesale or retail markets were found to be varied on the basis of species, size and quality of the final product. In Rangpur retail markets the maximum net profit was calculated as 12.14 Tk/kg for churi (Trichiurus lepturus) dried fish. On the other hand, the minimum net profit was found in small chela (Salmostoma acinaces) fishes. Whereas, in Dinajpur and Thakurgaon retail markets the maximum net profit was found higher in case of Mola (Amblypharyngodon mola) as 18.77 Tk/kg and 32.60 Tk/kg, respectively. The retailers of Rangpur, Dinaipur, Thakurgaon and Panchagarh get dry fish directly from Rangpur or Saidpur arat and finally consumers get the dry fishes from the retailers. Locally produced dry fishes in Rangpur and Saidpur are sold to the wholesaler's of Rangpur and Saidpur arat and finally go to the consumers through the retailers. Several marketing problems were found which include lack of capital, higher transportation cost, storage problem, lower market demand and higher loan interest rate etc.

ANTIBACTERIAL AND ANTIOXIDANT EFFECTS OF GREEN TEA (*CAMELLIA SINENSIS*), TEJPATA (*CINNAMOMUM TAMALA*) AND ANAR (*PUNICA GRANATUM*) EXTRACTS AS NATURAL PRESERVATIVES OF RAW FISH

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The aim of this study was to find locally available natural extracts with antibacterial and antioxidant properties that could be potentially used as natural preservatives in raw fish. The inhibitory effects of Green Tea (*Camellia sinensis*), Tejpata (*Cinnamomum tamala*) and Anar (*Punica granatum*) extracts were evaluated in raw fish at room temperature (~20 °C) and (~40 °C). The influences of these extracts on lipid oxidation in the fish were also investigated. The pH, colour parameters and TBARS (thiobarbituric acid-reactive substances) values were tested periodically. The results showed that all three natural extracts, Green Tea, Tejpata and Anar effective against the bacteria. During storage the colour parameters of the extract-treated fish samples changed slightly, in comparison with significant changes in the control. Treatments with these extracts increased the stability of raw fish against lipid oxidation. Green Tea was the most effective for retarding lipid oxidation and presented the highest antioxidant activity in raw fish. This study suggests that the tested extracts, especially Green Tea have potential as natural preservatives to reduce numbers of pathogenic bacteria, colour degradation and lipid oxidation in raw fish.

QUALITY ASSESSMENT OF ANTIBIOTIC TREATED MRIGAL FISH (CIRRHINUS CIRRHOSUS) IN ICE STORAGE CONDITION

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The present study was conducted to assess the quality of antibiotic treated mrigal fish (*Cirrhinus cirrhosus*) during ice storage condition. Several classes of antibiotics are approved in aquaculture where oxytetracycline (OTC) being used widely due to its high potency against bacterial diseases. In my present study 100 mrigal fish $(18 \pm 0.05 \text{ g})$ were divided into 4 groups (25 fish/group) and kept in the aquaria in duplicates where group I was fed a basal diet (control), group II was fed basal diet supplemented with OTC at 2g/kg body weight. After 3 weeks of feeding, fishes were killed by pithing and transferred into the separate ice boxes. The shelf life was determined in iced condition up to 21 days by determining their organoleptic, biochemical and bacteriological aspects. Organoleptically group I was found to be acceptable up to 14th days while those groups II were found acceptable condition up to 20th days. Proximate analysis showed that the moisture content, TVBN, PO value, increased rapidly and the protein, lipid, NPN compounds decreased highly in OTC treated mrigal fish compare than control fish. The pH and APC values were also decreased rapidly in experimented fish other than in control fish.

NUTRITIONAL STATUS, HEAVY METALS AND PESTICIDES RESIDUES IN SOME MARINE DRIED FISHES OF BANGLADESH COAST

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Six species of marine dried fishes namely silver pomfret (Pampus chinensis), Bombay duck (Harpadon nehereus), ribbon fish (Trichiurus savala), sardine (Salmostona bacaila), anchovy (Setipinna phasa, Colia dussumieri) from fish drying zones of Cox's Bazar, Kuakata and Dubla in Bangladesh coast were used to determine the proximate composition while heavy metals and pesticides residues were estimated for silver pomfret, Bombay duck and ribbon fish. The drying zones and fish species had significant variations for chemical constitution. The moisture content ranged from 11.27% (S. bacaila) to 38.94% (P. chinensis) among the dried fish products. Protein content varied from 51.33 (C. dussumieri) to 77.68% (T. savala). Among heavy metals investigated, As, Fe and Zn concentration were found higher than the permissible level for human consumption. The As concentration varied from 8.41 to 22.27 mg/kg only in T. savala. The Fe content was measured 116.85 to 160.18 mg/kg in H. nehereus and P. chinensis. The Zn concentration varied from 31.08 to 364.74 mg/kg. However, Cd, Cu and Pb tested were found within the recommended level in all three species. The residues of organochlorine pesticide was found within the maximum residue limit level recommended by WHO. The existence of pesticides residues in the samples of this study is a matter of health concern as this slow poison has long term effect in human.

QUALITY ASPECTS OF FISH BALL FROM UNWASHED AND WASHED MIXED MINCE OF PANGAS (*PANGASIUS HYPOPHTHALMUS*) AND TUNA (*SARDA ORIENTALIS*)

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The study was conducted to prepare fish ball from different ratio of mixed mince from freshwater pangas (Pangasius hypophthalmus) and marine tuna (Sarda orientalis) fish and to investigate the effects of heating and washing on the quality of fish ball. Five different blend compositions (P₁₀₀:T₀, P₇₅:T₂₅, P₅₀:T₅₀, P₂₅:T₇₅, P₀:T₁₀₀) from two individual minces were used to prepare fish ball through different cooking process (two-step heating, autoclaving) adding different local ingredients and spices. Textural quality was determined in terms of Softness/Firmness (S/F). Chewiness/Rubburiness (C/R) and Folding Test (FT) by trained 10 panelist using sensory methods. Proximate composition of individual fish, mince blend and their resulted products were determined by standard AOAC and found the compositional differences of individuals' species. Gel forming ability of the individual minces and mince blend were varied in great extent due to their compositional differences and washing with distilled water and different salt solution (0.1% NaCl, KCl, CaCl₂, MgCl₂). Between the two different heating regimes, fish ball from mince blend washed with distilled water showed the better textural properties at two-step heating process (50°C for 1 hr and 100°C for 30 min) than unwashed and autoclaving (120°C, 15lb/Inc² for 15 min) process. Among the five mince blend, the P₅₀:T₅₀ showed highest textural properties in terms of FT, S/F and C/R values. Further, improved textural properties were observed when mince washed with 0.1% NaCl, as compared with other salt solution used. Color attributes of fish ball were highly influenced by individual muscle properties from respective fish species used. Whitish or brightness in fish ball was obtained from pangus mince which was proportionately changed to dark with increase proportion of tuna mince. Texture and color of ball were affected by washing, heating and compositional differences of individuals fish species. Pangas and Tuna both species contain higher amount of protein which influence the nutrient contents of their resulted product from respective mince blend. Washing process slightly decreased the protein and lipid content of fish ball whereas moisture content was increased.

POST-HARVEST QUALITY LOSS OF SMALL INDIGENOUS SPECIES (SIS) IN SYLHET REGION: ENSURE QUALITY UP TO CONSUMER LEVEL

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The present study was designed to investigate the post-harvest quality loss of locally captured Small Indigenous Species (SIS) based on existing marketing system in Sylhet region. A total of 20 fish harvesters, 30 fish handlers (involve in sorting, loading and unloading, transporting, receiving at market), 10 depot owners, 10 auctioneers, 5 aratders was interviewed and 10 markets were visited to collect data about post-harvest activities and marketing of SIS from some areas of Sylhet and Sunamgonj district from July 2015 to December 2015. At harvesting places (100%) fish were the best quality (defect point <2). Fish sold in early market (7am – 9 am) were also acceptable (defect point <2 to <3) in terms of quality. After harvesting rough handling (15%), compactness (3%), delay icing (10%), no icing (45%), marketing process (15%) and transportation (7%) lead to loss of a major proportion of total quality. On the basis of defect point average freshness quality of SIS were found <2 at harvesting places, <2 to <3 in landing center, during sorting, <2 to <3 during transportation and <2 to< 4 at market which were results from different activities associated with SIS handling and marketing.

BACTERIOLOGICAL QUALITY OF FROZEN AND UNFROZEN PABDA (*OMPOK PABDA*) IN THE FISH PROCESSING PLANT OF SYLHET, BANGLADESH

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The present study investigated the bacteriological quality of frozen and unfrozen pabda (Ompok pabda) in the Fish Processing Plant during the period of January 2015 to October 2015. For this experiment five frozen samples from five different lots and five unfrozen samples which were ready for the processing and also preparation for the respective lots of the same plant were taken for the estimation of bacteriological quality of fishes. Bacteriological parameters such as Total Viable Count (TVC), Total Coliform (TC), and the occurrence of Escherichia coli, Salmonella spp. and Vibrio spp were determined. The TVC of frozen samples were 2.9×10⁵, 1.8×10⁵, 1.5×10⁵, 2.5×10⁵ and 3.5×10⁵ CFU/g. On the other hand, the TVC of unfrozen samples were 5×10⁷, 3×10⁶, 6×10⁵, 4×10⁶ and 4×10⁷ CFU/g respectively. The mean bacterial loads of frozen and unfrozen pabda were log5.3668±0.150232 and log7.0154±0.585568. It reveals that the frozen samples contained lower bacterial load than unfrozen samples. The bacterial loads of frozen pabda complied with ICMSF standard but the same of unfrozen Pabda did not comply with this standard. The TC of frozen samples was 20, 15, 20, 21 and 27 MPN/g, whereas the TC of unfrozen samples was 160, 120, 120, 120 and 150 MPN/g respectively. The mean Total Coliform for both frozen and unfrozen samples was 20.6±4.27785 and 134±19.49359. From this study, it was revealed that the Total Coliform of frozen pabda complies with ICMSF standard but the same of unfrozen pabda does not comply with this standard. The detected pathogenic bacteria were Esherichia coli, Salmonella sp. and Vibrio cholera. In frozen pabda all of the identified pathogenic bacteria were absent. All of the unfrozen samples were contaminated with Esherichia coli, but two of the samples contaminated with Salmonella spp. and one sample polluted with Vibrio cholerae. The results of this study indicated that the TVC, TC and all other identified pathogenic bacteria were higher in unfrozen pabda than frozen pabda. So, the bacteriological quality of frozen pabda complied with ICMSF standard but the same of unfrozen samples did not comply with ICMSF standard. For this reason, the findings are more important for ensuring food safety as well as for export to the international market.

DETECTION AND QUANTIFICATION OF ORGANOCHLORINE PESTICIDES IN DRIED PUNTI FISH *PUNTIUS SOPHORE* AVAILABLE IN SYLHET, BANGLADESH

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One of the major problem associated with dried fish is being infested by blow fly, mites, beetles and other insects due to the moisture absorption caused by improper drying, poor storage and humid weather. It has been reported that processors use different types of organochlorine pesticides whatever they are getting within their reach to protect dried fish from insects infestation. Despite higher production of dried punti fish (*Puntius sophore*), the present study was conducted to detect and estimate the concentration of organochlorine pesticides residue in dried punti fish collected from Sylhet district of Bangladesh.

Samples were collected from different fish drying yards and retail markets of Sylhet district. Control samples were prepared in the laboratory. A total of 27 samples (9 samples from each source) were analyzed by Gas Chromatography with Electro Capture Detector (GC-ECD) to detect organochlorine pesticides residue. All the collected samples were extracted by QuEChERS (Quick Easy Cheap Effective Rugged Safe) method and later injected in GC. Six samples were found contaminated with three organochlorine pesticides viz. Aldrin, Dieldrin and Endrin (Table 1). Two samples from each drying yard and market were found contaminated with single pesticide (Aldrin) while, multiple pesticide (Aldrin and Dieldrin/Endrin) contamination were also observed in two market samples. These findings indicate that either processors use mixture of pesticides or both processors and vendors use different pesticides in same dried fish separately. Presence of these pesticides in dried punti fish which are already banned in Bangladesh is alarming for the consumers

Table 1. Concentration of different organochlorine

 pesticides detected in dried punti fish collected

 from different sources of Sylhet district

Sample Source	Contaminated Samples				Ê
	Total	Single Pesticide	Multiple Pesticides	Detected Pesticide	Residue Level (ppr
Drying yard	2	1	-	Aldrin	0.617
		1		Aldrin	0.812
Market	4	1		Aldrin	0.332
		1	-	Aldrin	0.479
		-	1	Aldrin	0.818
				Dieldri n	0.762
		-	1	Aldrin	0.967
				Endrin	0.828
Control	-	-	-	ND	-

ND- Not detected

and may cause chronic diseases and potential long-term risk for human health.

CONSUMERS PREFERENCE ON DRY FISH AND THEIR PACKAGING IN DHAKA CITY

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The choice and acceptability of a food product are mainly based on their sensory properties. However, a product has high sensory acceptability, there are additional issues that have to be resolved to ensure overall acceptability for instance, packaging, price, convenience and cultural habits.Theproper packaging can reduce the qualitative and quantitative losses of dry fishes during storage and distribution stage. There is no such studyin Bangladesh on consumers preference on dry fish and their packaging.The objective of this study is to know the consumerspreference to assess the acceptability of packaged dried fish in the market.

Consumers acceptability and willingness to buy the packaged dried fish was investigated by survey method utilizing a structured questionnaire. A total of 45 consumers (15 in each market) in the retail markets of Dhaka city (Mohakhali Bazar, Kawran Bazar and Bongshal Area Bazar) were selected randomly and surveyed in July 2016. The questionnaire was developed, pretested in field situation and necessary modifications were made prior to final data collection. The questionnaire was organized to investigate the consumers preferences and expectations on different aspects such as their likings, pack size, price, quality and overall attraction of packaged dried fish. All the collected surveyed data was tabulated and subjected to descriptive analyses using the SPSS, version 15.0.1 to understand the differences of the variables.

In the present study, 38% consumers were under the age group of 21-40 years and 27% were above 50 years old. The average family size of consumers was 5.5 and most of the consumers (84 %) were male in the markets. In the study area, 29% consumers had secondary level and 24% had primary level of education. Around 36% consumers were businessmen and 27% were involved in lower class job. Among the consumers, 87 % like to eat dry fish and more than 90% like dry fish due to its unique taste. The consumers choice was limited to the20species available in the market and the most purchased dry fishis Loitta followed by Chapila, Chingri, Kachki and others. Around 50% consumers buy dry fish weekly and spend around 370 BDT per month. In the study area, 71% consumers were satisfied on the overall quality of the dry fish available in the market and 27% were not so satisfied. Most of the consumers (82%)showed interest to buy more dry fish if packaging and quality of the dry fish is improved. Almost all consumers (96%) were agreed to buy dry fish even the price is increased due to proper packaging. In the study area, 100g pack was preferred by 53% consumers and 50g pack preferred by 27% consumers.

Based on the survey results, further study will be done on the development of vacuum and modified atmosphere packaging (MAP) for dry fish and subsequently the quality and shelf-life of dry fish stored under atmospheric temperature will be studied. Thus the proper packaging will increase the accessibility and availability of safe dried fishes for the consumers throughout the year in the market.

EFFECT OF HIGH AND LOW (0°C AND 8°C) TEMPERATURE ON SENSORY, MICROBIOLOGICAL AND CHEMICAL CHANGES DURING STORAGE OF FISH FILLETS

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The present experiment was conducted to evaluate sensory, microbiological and chemical changes of fish fillet in low and high storage temperatures lead to quality and freshness of the fillets. The fillets used on the first day were stored at 0°C temperature while the fillets on days 2 & 4 were stored at 0°C & 8°C temperature. For sensory evaluation odor, color, texture and stiffness were evaluated. Samples were graded 1 to 5 tory scheme scales from unsuitable to excellent. For microbial analysis same samples were used to obtain a 10-fold dilution. TVC were performed on Iron Agar (IA). TVB-N content was measured in mg N/100g flesh. No significant difference (p>0.05) found between samples of day 1 and day 2 at 0°C and 8°C temperature by sensory evaluation. At day 4, the fillets' color, odor and stiffness changed significantly (p<0.05) at 8°C. Microbiological results showed that black colony at 0°C and 8°C fillet were same Log₃ at day 1, but at day 2 for 0°C it was Log_{3.5} and for 8°C it was Log₅. Day 4 of 0°C fillet was Log₆ and 8°C fillet was Log₇. At day 1 of both fillet qualities were good; day 2 of 0°C fillet quality was fair but at 8°C, it was poor. At day 4 both the fillet of 0°C & 8°C was poor quality . TVB-N was 10.61mg at day 1 of 0°C (good), at day two 14.42mg of 0°C fillet (good) but at 8°C TVB-N 23.8 mg (poor). In day- 4 TVB-N was 15.51mg at 0°C temperature (fairly good) but at 8°C it was 76.20 mg (poor). A high correlation was found among sensory evaluation, total bacteria counts and selective counts of H₂S-producing bacteria count and TVB-N value.





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COMPARATIVE QUALITY INDEX FOR SHELF LIFE ASSESSMENT OF TILAPIA (OREOCHROMIS NILOTICUS) RAISED IN CAGE AND POND IN HAOR

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Quality index method scheme was applied in shelf life assessment of monosex tilapia (Oreochromis niloticus), using tilapia samples from cage and pond reared in haor on the basis of their sensory quality evaluation, biochemical composition and microbial load measurements. The sensory, proximate, bio-chemical composition and microbiological analyses were carried out on flesh of fish at 3 days interval during ice storage. It was found that environments and habitat conditions greatly influenced the shelf life of tilapia. Maximum ice storage time was found to be 15 days for cage and 18 days for pond reared tilapia. Significantly strong correlation between assessed quality index and storage time was observed. Calculated quality index (QI) evolved linearly with storage time on ice (QI cage = 3.237 x - 3.451, R2 = 0.991, Std. Err = 0.611; QI pond = 2.813 x - 3.200, R2 = 0.992, Std. Err = 0.633). Total plate count in fresh cage and pond fish muscle on zero-day was rather low i.e. 5.5 log cfu/g and 5.4 log cfu/g as compared to the values found on the 30th day i.e. 8.75 log cfu/g and 8.73 log cfu/g, respectively. Results of bacterial load showed that the samples were in acceptable condition, not exceeding 10⁶cfu/g for 15 days in cages and 18 days in pond fishes in iced storage condition. Overall quality tests showed that the maximum shelf life of tilapia for cage and pond was found in edible condition for 15 and 18 days in ice storage.

POTENTIAL OF TEA LEAVE EXTRACT AS NATURAL PRESERVATIVE INCORPORATING WITH ICE FOR RETARDATION OF QUALITY LOSS AND EXTENSION OF SHELF LIFE OF TILAPIA

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Green tea (Camellia sinensis) extract (GTE) is rich in polyphenolic compounds, especially catechins that are potent antioxidants. The antioxidant property of GTE may make it ideal for use as a preservative for suppressing lipid oxidation in tilapia (Oreochromis niloticus) during iced storage. The present study was conducted to investigate the suitability of frozen GTE in increasing the shelf life of farmed tilapia. GTE was used at different concentrations (1, 3 and 5%, w/v) in ice-stored tilapia. Biochemical characteristics (pH, total volatile basic nitrogen, trimethylamine nitrogen and free fatty acid), microbiological parameters (total viable bacterial count) and sensory quality indicators were determined during storage of tilapia for 20 days at 4°C. The results indicated that the samples stored on frozen GTE had better biochemical and microbiological characteristics, which resulted a increased shelf life of fish samples. The samples stored on frozen GTE with different concentrations (1, 3 and 5%, w/v) were found to be in acceptable conditions till 16, 20 and 20 days of storage respectively, while control sample was rejected only after 6 days. It could be concluded that application of frozen GTE is a promising technique for the preservation of fish, as it gave longer shelf life compared to normal ice. The results further showed that, the best concentration applied for preservation of fresh tilapia was 3% GTE, calculated based on price and other quality impacts.

URGENCY OF FOOD SAFETY THROUGHOUT AQUACULTURE PRODUCTION AND SUPPLY CHAIN

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Every country must have Food Security to sustain. It happens when its entire population has regular physical and economic access to sufficient quantities of diversified food to meet their minimum nutritional requirements. But, food without food safety, i.e., if the food is not hygienically safe, it cannot provide food security. Fish is a highly nutritious food, rich in first class protein, polyunsaturated fatty acids, vitamins and minerals. Fish heavily supports food security in Bangladesh. In 2014-15, fish alone met over 60% of animal protein of which 55% was of aquaculture origin. Aquaculture is, therefore, of particular importance.

Bangladesh has been in a perplexing situation due to quick population increase and the consequent expansion of housing and urbanization already resulting in drastic shrinkage of arable land and water. So, farmers make desperate efforts, often irrationally applying drugs, chemicals, animal manures, etc in the hope of increasing farm productivity and income per unit area of their remaining land & water. The environmental water being often contaminated with sewage, municipality garbage, industrial wastes, run-off water, etc, fish is variously contaminated. Food safety aspect of fish, particularly farmed fish, is thus becoming more and more of concerns. Food safety hazards may be of three types: (a) Biological hazards: bacteria, virus, protozoa, bio-toxins or myco-toxins, worms, etc., (b) Chemical hazards: arsenic & other toxic heavy metals, pesticides, toxicants, prohibited antibiotics, residues of permitted antibiotics and other chemicals beyond their acceptable Maximum Residue Levels (MRLs), dyes, growth hormones, preservative like formalin, etc. and (c) Physical hazards: dirt, pieces of metals, stones, glass, etc.

Farmed fish may be contaminated at any stage of production and post-harvest handling & supply chain. Once, the fish is contaminated with antibiotics, pesticides or toxic heavy metals due to inappropriate farming practices, the processors at a subsequent stage cannot rectify the problem. Similarly, fish produced in a clean aquaculture pond may be contaminated during transportation, marketing, processing, packaging, etc. This is why food safety at all stages is so much stressed. Responsibility for ensuring food safety is to be shared by all those involved in different segments of fish production and supply chain, consisting of fish hatchery, nursery, grow out farm, production & storage of feed ingredients, feed mill, feed & feed ingredient shop, ice plant, fish transport, depot/auction centre, wholesale/retail market, fish processing plant, etc.

FAO-Codex, EU & US FDA, all now stress preventive measures by applying Good Aquaculture Practices (GAqP) at hatchery, nursery and farm levels, Good Hygiene Practice (GHP) and at least the basic principles of HACCP at all levels, and application of detailed HACCP practice at feed mill and fish processing plant levels, & maintaining Traceability Records throughout the food production & supply chain.

Food safety of aquaculture products or of any other category food cannot be accomplished by any one ministry alone. Food safety is a crucial national issue, requiring well-coordinated and serious national efforts to address the problem. A number of measures are recommended for early implementation: (a) Inter-ministry concerted efforts of MoFL, MoA, MoEF, MoI, MoC, MoWR, MoH, MoEd, M/Home, M/LGRD, etc, (b) Adequate resources & manpower be provided, (c) National Food Safety Regulations & their rigorous enforcement, (d) Operators of all segments of production & supply chain be periodically trained in food safety & certified by experts, (e) Yearly licensing only to the compliant facilities, (f) PPP along with international cooperation, and (g) Food safety related education at school, college and University levels.

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EVOLUTIONARY RELATIONSHIPS OF CYPRINID FISHES INFERRED FROM MORPHOLOGICAL TRAITS AND MITOCHONDRIAL GENE CYTOCHROME B

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In Bangladesh, cyprinid fishes are most diversified groups of fishes with 67 species. The evolutionary relationships of the selected taxa of cyprinidae family were inferred from the morphological traits and nucleotide sequences of mitochondrial gene cytochrome b. Thirty morphological traits were observed, counted and recorded from selected 30 cyprinid fishes as well as nucleotide sequences of cytochrome b were collected from NCBI genbank database. The genetic distance, phylogentic tree and timetree were constructed using the Molecular Evolutionary Genetic Analysis (MEGA) software (ver. 6.01) to find the evolutionary relationship. The average nucleotide compositions were T (U) 28.2%, C 28.1%, A 29.1% and G 14.6% and transition/transversion bias (R) was 2.22. Species-wise highest genetic distance was observed 0.348 in between Barilius bendelisis and Esomous danricus and the lowest genetic distance were 0.087 in between L. calbasu and L. gonius. Genus-wise highest genetic distance was observed in between Crossocheilus and Labeo (0.350 and lowest in between Catla and Labeo (0.10). The phylogenetic tree using morphological traits and mitochondrial gene cytochrome b strongly supported monophyletic lineage of leuciscinae subfamily (Fig. 1). Other subfamilies were appeared as polyphyletic group (Fig.1). The timetree revaled the divergence times of speceis from one another. The highest divergence time (10.42) was observed in between B. bendelisis and L. gonius and the lowest divergence time (1.35) was observed in between H. molitrix and A. nobilis (Fig.2). The sequencing of cytochrome b gene from the cyprind fishes to resolve the phylogenetic relationships is highly required.



Figure 1: The phylogenetic relationship of Cyprinidae family

1.60 Labeo gonius 2.00 Labeo calbasu 2.21 Labeo dyocheilus Catla catla 2.85 - Labeo rohita 1.50 3.29 Cirrhinus mrigala 3.65 Labeo bata Garra gotyla 3.90 Crossocheilus latius 2.52 4.32 Cyprinus carpio Barbonymus gonionotus 3.08 Puntius sarana 5.06 Cirrhinus reba 3.14 Ctenopharyngodon idella 5.78 Mylopharyngodon piceus 2.78 Hypophthalmichthys molitrix 2.20 Aristichthys nobilis 1.35 Diptychus maculatus Rasbora daniconius Chela laubuca Securicula gora 5.97 Barilius barila 4.41 3.23 Raiamas bola Esomus danricus Barilius bendelisis Anabas testudineus

Figure 2: The timetree of Cyprinidae family

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SOME BIOLOGICAL ASPECTS OF THREE ENDANGERED FISHES OF THE GENUS Barilius FROM THE ATRAI RIVER, DINAJPUR, BANGLADESH

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Barilius is a genus of cyprinid fishes native to Asia, currently 34 Barilius species recognized in different countries. Among them about 5-6 Barilius spp. are found in Bangladesh in stream and rivers with rocky bottom of Dinajpur, Mymensingh and Sylhet region. According to the updated IUCN red-list, these fishes are considered as endangered in Bangladesh. The present research was undertaken to estimate the length-weight relationship, condition factors and food habits of three fish species of the genus Barilius, namely B.bendelisis, B.barna and B.tileo. Samples were collected monthly from Atrai river for a period of 6 months from November 2015 to April 2016. The total length (TL) and body weight (BW) relationships, and growth pattern were estimated for each species separately. The generalized relationship of over the study period was BW = 0.020TL^{2.77}, BW= 0.17 TL^{2.76} and BW=0.026 TL^{2.62} respectively for *B. bendelisis*, *B. barna* and *B. tileo.* The values of coefficient of determination in all months were high, $r^2 \ge 0.869$, $r^2 \ge 0.820$ and $r^2 \ge 0.791$ for *B. bendelisis*, *B. barna* and *B. tileo* respectively. At 95% confidence limits the 'b' value showed that the growth pattern in January was isometric for all three species and were allometric for all other month. In all three species, condition factors (K) was ranged from 1.258 to 1.110). All three species of the genus Barilius exhibited higher condition factors (K) value in the month of February (1.245±0.084, 1.201±0.110 and 1.258±0.249 respectively for B. bendelisis, B. barna and B. tileo). The higher RLG value for B. bendelisis, B. barna and B. tileo were 2.01 \pm 0.21, 1.93 \pm 0.123 and 1.78 \pm 0.21 respectively. The gut content analyses of B. bendelisis, B. barna and B. tileo showed that, all three fishes were omnivore in food habit, prefers to feed on shrimp, debris, phytoplankton (mostly Chorella). The present findings of length-weight relationship, condition factor and food habits of three species of the genus Barilius would be useful for the stock assessment and revival from endangered situation.

SEED PRODUCTION OF WILD *Cirrhinus reba* (HAMILTON 1822) TO INTRODUCE IN AQUACULTURE AND FOR REVIVAL

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The reba carp, Cirrhinus reba locally known as Khorkia or Bhagna/Tatkini belongs to the cyprinidae family. Recently the fish is considered as "Near Threatened" categories by IUCN-Bangladesh. By considering its threatened situation and aquaculture potentialities, initiatives were taken to domesticate the wild stock in captivity, to investigate the food habit and reproductive biology, and induced breeding through hypophysation. Live C. reba were collected from three rivers of Dinajpur district and reared in the earthen ponds under common broodstocks rearing techniques. Along with the length and weight data, the water quality parameters such as pH, DO, temperature etc. were recorded during domestication of the fish. The food habit was determined by the assessment of gut fullness, gut content and the value of relative length of gut (RLG). Fecundity, and gonadosomatic index (GSI) were determined to assess the reproductive potential of the species. Subsequently three different dosages of carp pituitary gland extract were used for induced breeding of C. reba. The result of domestication of C. reba in captive condition showed moderate growth and survival rate. The comparison of length-weight relationship between domesticated and wild stocks of C. reba showed allometirc growth pattern. It is found that, *C. reba* is an omnivore fish, prefers to feed on debris and plants. The fecundity ranged from 21,44 to 212,570 eggs, where the fecundity increase with the increase of total length, gonad weight and body weight of the fish. The gonado-somatic index (GSI) ranged from 2.00 to 12.20 in female and showed peak in June with the highest ova diameter (2.90mm). The fish ovulated with the hormonal injection of pituitary gland extracts. The ovulation, fertilization and hatching rate were found 60%, 70% and 50% in the initial study. The result of this study showed the potential of seeds production of this fish through hypophysation. The seed production could be the effective means of revival from the being extinction by restoration.

THREATENED FISHES OF THE WORLD: Raiamas bola (HAMILTON, 1822) (CYPRINIFORMES: CYPRINIDAE)

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Raiamas bola, the freshwater trout belongs to the Chedrins subdivision of the subfamily Danioninae of Cyprinidae family (Cypriniformes). Under the Chedrins subdivision, there are about 16 species of genus Raiamas, where R. bola and R. guttatus is available in the Asian countries only. The Asian Raiamas are morphologically differentiated from their African congeners. Due to the habitat distribution, over exploitation and anthropogenic activities, the existence of this species is under threats. Though it is economically important, very little about the habitat, reproductive biology and reproduction of this species is known. The article focuses the identification of R. bola, its distribution, habitat, ecological parameters, reproductive characteristics, threats and conservation status of this fish species in Bangladesh. In the current year, few numbers of individuals of *R. bola* have been collected from the Atrai river of Dinajpur, Bangladesh. The largest specimen collected with a total length of 31cm and a total weight of 229.26 gm, where the smallest one with a total length of 22 cm and a total weight of 93.59 gm. In the collected specimen, the greenish-blue colored spots were found to vary according to the age. The spots become rounded in adult and are distributed in several rows on the body and even in the large specimens spots were also found on the head. The numbers of different fins (D III, 7; A III, 9; P1 13; P2 9; C 19) are found similar with the previous studies mentioned above (Figure 1).



Figure 1: The Raiamas bola collected from the Atrai River, Dinajpur, Bangladesh

ASHURA BEEL IN DINAJPUR DISTRICT: LIMNOLOGICAL ASPECTS AND FISH AVAILIBILITY

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The Ashura beel is the largest beel of Dinajpur district, covered approximately an area of 251.78 ha. In order to study the water quality and fish availability of Ashura beel an experiment was carried out for a period of 8 months during 2013. Samples were collected fortnightly from three sampling sites. Different physical parameters like water temperature, transparency, water depth were found to remain within the productive ranges. Total chlorophyll-a concentration lied between 11.90 to 47.60 µg/L. Positive relationships were observed among pH, alkalinity and total hardness. A total of 34 genera were recorded where phytoplankton includes 29 genera belonging 4 groups such as euglenophyceae, cyanophyceae, bacillariophyceae and chlorophyceae and five genera of zooplankton under the group of copepoda, rotifera, cladocera and crustacean larvae. Phytoplankton was dominated by chlorophyceae and zooplankton dominated by copepods. The abundance of total phytoplankton and plankton was positively correlated with water temperature, transparency, water level, dissolved oxygen, alkalinity, hardness, pH and phosphate-phosphorus. A total of 35 fish species were found which belongs to 7 orders namely Beloniformes, Cypriniformes, Siluriformes, Perciformes, Osteoglossiformes, Synbranchiformes and Tetradontiformes of 17 families. The most dominant fish species were identified under the order of Cypriniformes (37%) followed by Perciformes (28%), Siluriformes (17%), Osteoglossiformes (6%) and Synbranchiformes (6%) during the study period. On the other hand, the order Beloniformes (3%) and Tetradontiformes (3%) were lowest in abundance. The limnological status of Ashura beel indicates that beel is conducive to enhanced fisheries and biological production though different point source of pollution linked to this natural beel. Considering this some conservation measures must be taken by the government to protect the beel from environmental pollution.

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THE DHEPA RIVER FISH SANCTUARY IN PROTECTION AND RESTORATION OF THREATENED FISH BIODIVERSITY

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The Dhepa river, a suitable habitat for large number of freshwater fishes support the livelihoods of fishermen of the northwestern districts Dinajpur, Bangladesh. The abundance and distribution of fishes of the river are decreasing day by day due to environmental degradation and anthropogenic activities. By considering the conservation of threatened freshwater indigenous fishes, a fish sanctuary located in between 25°48' and 26°04' north latitudes and in between 88°29' and 88°44' east longitudes was established across the Dhepa river basin in 2014 by the local administration of Birganj Upazial, Dinajpur. The present fish biodiversity status and the impacts of the sanctuary on the protection of indigenous fishes of the Dhepa river fish sanctuary were mapped from January to December 2015. A total of 47 fish species belongs to 36 genera, 7 orders and 19 families were identified from Dhepa river fish sanctuary. The order Cypriniformes was dominant which contains 49% of the total fishes identified, followed by Siluriformes and Perciformes (19%), Osteoglossiformes (5%), Beloniformes, Synbranchiformes, Clupeiformes and tetraodontiformes (2%). Among 19 families of fishes, the cyprinidae was the dominant which contains 43% of the total fishes. Out of 47 species, 28 (60%) were belongs to small indigenous species (SIS) of fish group and 6 were exotic fish. Twenty threatened fishes were identified in this sanctuary; 2 were critically endangered, 10 endangered and 8 vulnerable. The establishment of sanctuary showed positive impact with increasing fish species. Batasio tengra, Tetraodon cutcutia, Mystus cavasius, Macrognathus aculeatus, Chagunius chagunius, Acanthocobitis botia, Labeo calbasu were found during the study period which were not reported during the baseline survey in the previous year. Further immediate studies and actions are highly required for the *in-situ* and *ex-situ* conservation of fishes of the Dhepa river sanctuary.

FISH BIODIVERSITY AND CONSERVATION STATUS OF THE DHEPA RIVER, DINAJPUR, BANGLADESH

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To investigate the present fish biodiversity and conservation status of the Dhepa river, monthly sampling for a period of 8 months from September 2015 to April 2016 were conducted at three sites of the river. Several biodiversity indices such as Shannon -Wiener diversity index, Simpson's dominance index, Margalef's index and Evenness were calculated to estimate the fish biodiversity status of the river. A total of 61 species belongs to 8 orders and 18 families were identified where Cypriniformes was the dominant fish order which constitute 51 % of the total fishes found in the Dhepa river, followed by Siluriformes (19%), Perciformes (13%), Synbranchiformes (7%), Clupeiformes (3%), Osteoglossiformes (3%), Beloniformes (2%) and Tetraodontiformes (2%). The Highest Shannon Wiener index was found 3.56 at Bangibacha Bridge area followed by 3.19 at Kantanagor area and 2.84 at Karnai area. The maximum value of Simpson's dominance index (D) was observed 0.11 at Karnai area followed by 0.06 at Kantanagor area and 0.04 at Bangibacha Bridge area. The maximum Margalef's richness (M) value was observed 7.62 at Bangibacha Bridge area where minimum value was observed 5.79 at Karnai area. The maximum Evenness (E) value was observed 0.62 at Bangibacha followed by 0.57 at Kantanagor area and 0.37 at Karnai area. During the study period, a total of 25 threatened fish species were identified from the Dhepa River that indicated the availability of threatened fish species. Among 25 threatened fish species, 10 species were abundantly available and other 15 species were poorly available throughout the study period. The study revealed that the Dhepa river consists a very good number of freshwater indigenous fish species with a significant number of threatened fishes. Among three sites, the Bangibacha ghat area was the richest in species diversity, which required protecting from the being of extinction through management of fish sanctuary.



