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TRPSF 2023



Transforming Rural Poverty to Prosperity through Sustainable Fisheries

19-21 July, 2023



Editors

Dr. V.P. Saini

Tapas Paul

Mohammed Ihzan M. P.

Mohammed Meharoof

Manjulesh Pai

Ashutosh K. Singh

Dr. Mamta Singh



Host Institute

College of Fisheries Kishanganj Alumni Association (COFKAA)

(Bihar Animal Sciences University)

In collaboration with

All India Agricultural Students Association (AIASA)-Fisheries Chapter

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**Proceedings
of the National Conference**
**Transforming Rural Poverty to Prosperity
through Sustainable Fisheries**

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PREFACE

It is with immense pleasure and gratitude that we present this conference proceeding as a part of National Conference on "Transforming Rural Poverty to Prosperity through Sustainable Fisheries (TRPSF-2023)" and Fish Fair organized in collaboration with the All India Agricultural Students Association-Fisheries Chapter at College of Fisheries, Kishanganj.

Since its establishment, the College of Fisheries, Kishanganj has been at the forefront of promoting awareness and tirelessly working towards the welfare of fisheries and sustainable development in Bihar. This conference serves as a platform for discussing crucial issues related to the advancement of the field, with a particular focus on transforming rural poverty into prosperity. By exploring transformative technologies, we aim to address the challenges posed by climate change and ensure food security. We envision that this conference will attract substantial investment and inspire technological innovations, including start-ups, to generate employment opportunities and enhance sustainable production in the face of a growing population. Such innovations encourage the emergence of a new generation of young "aqua-preneurs" who are eager to tackle challenges and foster sustainability in aquaculture production. By improving incomes and livelihoods in the fisheries sector, we can elevate the quality of employment and living standards, thereby contributing significantly to its overall development within a limited timeframe.

We extend our heartfelt appreciation to all the participants, organizers, and sponsors who have contributed their valuable insights, suggestions, and unwavering support in organizing this remarkable event. We would also like to express our gratitude to the National Bank for Agriculture and Rural Development (NABARD) for their generous financial assistance enabling us to print the conference proceeding.

We sincerely thank each and every individual who has played a part in making this dynamic exposition a reality in our esteemed state of aquaculture. We anticipate an extraordinary conference and wish the TRPSF-2023 great success.



*Dr. V P Saini
Dean
College of Fisheries, Kishanganj*

मो० आफाक आलम

मंत्री

पशु एवं मत्स्य संसाधन विभाग
बिहार, पटना



कार्यालय : विकास भवन, न्यू सचिवालय

पटना-800 015

फोन नं०/फैक्स : 0612-2230496

ईमेल – ahd.minister@gmail.com

पत्रांक

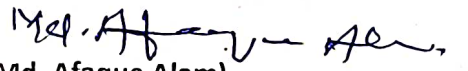
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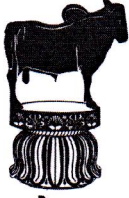
MESSAGE

It gives me pleasure to write a few words of appreciation for the National Conference on “Transforming Rural Poverty to Prosperity through Sustainable Fisheries (TRPSF-2023)” and Fish Fair organized by College of Fisheries Kishanganj Alumni Association (COFKAA) in collaboration with All India Agricultural Students Association-Fisheries Chapter at College of Fisheries (BASU), Kishanganj from 19-21st July, 2023.

Aquaculture in India has stride through many phases and now striving to become an economically viable enterprise for improving the livelihood of people of India. Technologies with the ability to tackle climate change threats and disasters have been developed thus ensuring food security. Utilisation of degraded lands for aquaculture will bring back the tradition and nutritional security of yesteryears. Transformative technologies and visionary planning can aid in transforming rural poverty to prosperity among the people of India.

I applaud the efforts of College of Fisheries, Kishanganj, BASU for hosting the conference with AIASA-Fisheries Chapter. Hopefully, with the active participation of various stakeholders' viz., farmers, students, scientists, industrialists, professionals, and technocrats from across the country, the conference will come out with practical thoughts and strategies to move forward for further resilience and success in this direction.


(Md. Afaque Alam)



बिहार पशु विज्ञान विश्वविद्यालय

बिहार पशु चिकित्सा महाविद्यालय प्रांगण, पटना - 800014
BIHAR ANIMAL SCIENCES UNIVERSITY
BIHAR VETERINARY COLLEGE CAMPUS, PATNA – 800014

डॉ० रामेश्वर सिंह
कुलपति
Dr. Rameshwar Singh
Vice-Chancellor

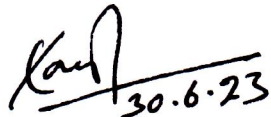
☎ : 0612-2222221
☎ : +91-94728-64654
E-mail : vc-basu-bih@gov.in
vicechancellorbasu@gmail.com

MESSAGE

It gives me a great pleasure to mention that the **National Conference on “Transforming Rural Poverty to Prosperity through Sustainable Fisheries (TRPSF-2023)” and Fish Fair** is being organized by the College of Fisheries Kishanganj Alumni Association (COFKAA) in collaboration with All India Agricultural Students Association-Fisheries Chapter at College of Fisheries (BASU), Kishanganj from 19-21st July, 2023.

Fisheries sector is a principal source of livelihood for a large section of the economically underprivileged population of the country. Govt. of India has started several schemes to boost rural entrepreneurship, uplift blue economy and make India self-reliant. There is a wide scope for development in rural areas by utilizing the untapped & degraded land areas and wetlands for aquaculture production in an environmentally sustainable manner especially in Bihar. TRPSF-2023 is focused on making India self-reliant through provision of nutritional security, livelihood and income of rural families. I trust the deliberations will deal with farmers friendly innovations for uplifting the fishing communities in rural areas with focus on the region. The conference is likely to put forward new ideas and thoughts for harnessing the potential of sustainable aquaculture and fisheries.

I sincerely appreciate the organizing committee for and all stakeholders for bringing this conference to Kishanganj for the benefit of our students, faculty and fisheries sector in the state.


30.6.23
(Rameshwar Singh)

Dr. N. Vijaya Lakshmi, I.A.S., Ph.D

डा० एन० विजयलक्ष्मी, भा.प्र.से., पी.एच.डी.

Principal Secretary

प्रधान सचिव

Deptt. of Animal & Fisheries Resources, Govt. of Bihar
पशु एवं मत्स्य संसाधन विभाग, बिहार सरकार



2nd Floor, Vikas Bhawan, Bailey Road, Patna-800 015

दूसरा तल, विकास भवन, बैली रोड, पटना-800 015

Tel./फोन : 0612 - 2217543

Fax/फैक्स : 0612 - 2217010

E mail/ई-मेल : secyahd-bih@nic.in

Message

It is heartening to note that a **National Conference on “Transforming Rural Poverty to Prosperity through Sustainable Fisheries (TRPSF-2023)”** and **Fish Fair** is being organized by the College of Fisheries Kishanganj Alumni Association (COFKAA) in collaboration with All India Agricultural Students Association-Fisheries Chapter at College of Fisheries (BASU), Kishanganj from 19-21st July, 2023. Keeping in view the state of food and nutrition security in the country and the UN Agenda 2030, the theme of the Conference is most timely and topical.

The prospects for increasing the standard of living and achieving comprehensive food and nutritional security will rely on uplifting the fishing communities in rural areas. It calls for focussed system approach on innovations, technology and planning in aquaculture-led transformation of our social, economic, and environmental settings. A substantial part of our fisheries growth thus must come through the application of innovative technologies at different segments of aquaculture and value chain to promote both food security and nutritional security. Trust, the Conference will discuss these aspects in detail and come up with effective action plans for alleviating poverty and hunger through sustainable fisheries.

I sincerely appreciate the students, academics and scientists and the organizing committee for organizing this conference on an important issue.

I wish the conference and fish fair a great success.


(Dr. N. Vijaya Lakshmi)



भारतीय कृषि अनुसंधान परिषद

कृषि अनुसंधान भवन-II, नई दिल्ली-110 012

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

KRISHI ANUSANDHAN BHAVAN-II, PUSA, NEW DELHI-110012

Ph.: 91-11-25846738 (O), Fax: 91-11-25841955

Email : ddfgs.icar@gov.in, jkjena2@gmail.com

डॉ. जे.के. जेना

उप महानिदेशक (मत्स्य विज्ञान)

Dr. J.K. Jena

Deputy Director General (Fisheries Science)

Message

I am delighted to learn that the College of Fisheries Kishanganj Alumni Association (COFCAA) is organizing the **National Conference on “Transforming Rural Poverty to Prosperity through Sustainable Fisheries (TRPSF-2023)” and Fish Fair** in collaboration with All India Agricultural Students Association-Fisheries Chapter at College of Fisheries (BASU), Kishanganj from 19-21 July, 2023.

I am glad that the College of Fisheries, Kishanganj is planning to discuss on diversified issues, inviting experts and students to discuss the merits and relevance of the issues of alleviating poverty and hunger through sustainable fisheries. I look forward to effective knowledge sharing which will help in making major reforms in fisheries and in the production of nutritious and energy-rich food to all sections of the people. This Conference would be a platform to discuss the importance of farmers'-friendly fisheries innovations in uplifting rural communities.

I believe that the conference would be a forerunner towards reorienting our approach to sustain production without any harm to natural resources and the environment. I hope the Conference will identify and bring out new strategies and pathways to attain complete food and nutritional security, particularly among the deprived sections of society with the paradigm shift in the policies and approaches of various agencies/institutions involved in the noble mission of achieving nutritional security of poor and marginalised.

My hearty wishes to the organisers for the great success of the Conference and congratulations to the students for hosting the conference, discussing the contemporary issues involved in Indian aquaculture and attaining inclusive growth in the fisheries sector.

(J. K. Jena)

Dilip Kumar

Adviser , Assam Fisheries Development Corporation (AFDC) and National Platform for Fish-workers
Chairman, Board of Directors, Institute of Livelihood Research and Training (ILRT), Hyderabad
Aquaculture, Fisheries and Rural Development Adviser
International Civil Service FAO of the UN - Retired
Ex Director / VC, CIFE (ICAR), Mumbai, India
E mail – dk.dilipkumar@gmail.com

Message

I am elated that the College of Fisheries Kishanganj Alumni Association (COFKAA) is organizing the **National Conference on “Transforming Rural Poverty to Prosperity through Sustainable Fisheries (TRPSF-2023)” and Fish Fair** in collaboration with All India Agricultural Students Association-Fisheries Chapter at College of Fisheries (BASU), Kishanganj from 19-21st July 2023.

The conference’s main theme of transforming rural poverty into prosperity is vital in the present scenario. As India is attaining the status of meeting its food demand by increasing food supply through various technological interventions, no future generation will suffer for want of food. I hope this conference will be a strong platform for participants across India to discuss their findings with contemporary research workers for prescribing workable policies for the Government. I am sure that the proceedings on this occasion will be highly useful and informative for all the stakeholders working in fisheries and aquaculture.

I wish great success to the National Conference and my hearty congratulations to the organisers for choosing the six important issues to deliberate on and prescribing workable policy prescriptions to the Government for adoption.



(Dr. Dilip Kumar)



डॉ. यल. नरसिम्हा मूर्ति, एआर एस

वरिष्ठ कार्यकारी निदेशक

Dr. L. Narasimha Murthy, ARS

Senior Executive Director / Hc chief executive

राष्ट्रीय मात्स्यिकी विकास बोर्ड
National Fisheries Development Board
मत्स्य पालन विभाग
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Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India

स्तम्भ संख्या - 235, पी.वी.एन.आर. एक्सप्रेस वे, डाक - एस.वी.पी. एन.पी.ए, हैदराबाद - 500 052
Pillar No. 235, PVNR Expressway, SVP NPA Post, Hyderabad-500 052
फोन/Phone No. 040-24000104, ईमेल/email: senior-ed@nfdb.gov.in;
वेबसाइट/website: nfdb.gov.in

Message

Dt. 14/07/2023

It is a great moment to share the pleasure of joining you in this memorable event **National Conference on “Transforming Rural Poverty to Prosperity through Sustainable Fisheries (TRPSF-2023)”** and **Fish Fair** is being organized by the College of Fisheries Kishanganj Alumni Association (COFKAA) in collaboration with All India Agricultural Students Association-Fisheries Chapter at College of Fisheries (BASU), Kishanganj from 19-21st July, 2023. Fisheries and aquaculture remain an important source of food, nutrition, employment and income for millions, especially the rural populations. In fact, the sector provides livelihood to about 25 million fishers and fish farmers at the primary level and twice the number along the value chain. The country is well on its way to harness the potential of fisheries and is visible from the increased production from 3.84 MMT in 1990-91 to 16.23 MMT in 2021-22

Fisheries must not be seen only as a profession, but more as a commitment and dedication to serve the human community by eliminating hunger, malnutrition and poverty. A sustainable food and aquaculture system is a collaborative network that integrates several components in order to enhance a community's environmental, economic, and social well-being. It is built on principles of ecological, social, and economic values of a community and region. In India traditional farming system coupled with advanced technical know-how may provide suitable way for enhanced output, income and food & nutritional security. It is ther to identify the potential growth clusters/areas for development of fisheries and aquaculture and to develop an integrated cluster with requisite interventions/activities, forward and backward linkages and with facilities for quality brood, seed and feed, critical infrastructure, processing and marketing networks, etc. for the development of the livelihood and sustainability of fisheries sector.

The main theme of the conference Transforming Food Security to Nutritional Security is a very apt issue for the discussion to take India to the next level for reaching a status of attaining inclusive food and nutritional security of the country. I am sure the conference will provide a strong platform for participants from various parts of India and the souvenir will be useful and informative for all associated closely with. Initiatives have been taken by GoI towards framework of policy, institutional and structural reforms in fisheries sector, overall performance of States/UTs in fisheries sector with special reference to the sustainable fishing practices and enforcement of regulatory and management framework, having fisheries management plans etc. With the support of Department of Fisheries, Govt. of India, NFDB has been playing a vital role in enhancing sustainable and responsible fish production and productivity by effectively promoting modern technology and utilizing the untapped potential resources of the country in a coordinated, integrated and holistic manner. As an initiative towards Aatma Nirbhar Bharat, GoI and NFDB with the support of research institutions and organisations are tirelessly working for the species diversification to address the issue of supply of specific pathogen free brood stock, supply of Indian white shrimp, nucleus breeding centre for tiger shrimp, genetic improvement of Scampi, Etroplus etc.

I hope this conference will be useful for the fishers, entrepreneurs, stakeholders, researchers etc and wish the organizers, editorial team, and participants a grand success.


(Dr. L. Narasimha Murthy, ARS)



अखिल भारतीय कृषि छात्रसंघ All India Agricultural Students Association (AIASA)

(Registered Society under Societies Registration Act XXI, 1860)

Regd Office: A/G-4, National Societies Block,
National Agricultural Science Centre (NASC) Complex, New Delhi-12

Website: www.aiasa.org.in

MESSAGE

The present proceeding is being brought on the occasion of National Conference on “Transforming Rural Poverty to Prosperity through Sustainable Fisheries (TRPSF-2023). TRPSF-2023 is being jointly organized by All India Agricultural Students Association (AIASA), College of Fisheries Kishanganj Alumni Association (COFKAA) at College of Fisheries, Kishanganj, Bihar in hybrid mode from 19th – 21st July, 2023.

This proceeding comprises lead lectures, and abstracts of national importance that focus on innovations in fisheries, sustainable livelihoods, employment opportunities, and strategies for transforming the fisheries sector. The fisheries sector plays a significant role in India's economy and provides livelihoods for millions of fisherfolk. India is the world's third-largest fish-producing nation and the second-largest in aquaculture production. The Blue Revolution in India has highlighted the importance of the fisheries and aquaculture sector.

The Government of India has adopted various holistic approaches to meet the Sustainable Development Goals (SDGs) and improve the quality of life and economic well-being of people in rural areas. In this regard, the involvement of youth in fisheries and agriculture is crucial. The energy, productivity, and openness to new ideas and advanced technologies exhibited by young individuals make them valuable assets for our country. They possess the courage to take risks and challenge conventions, which is greatly needed in the farming sector. It is imperative to make fisheries a lucrative occupation that attracts rural youths by providing them with sustainable and gainful employment opportunities in rural areas. Platforms like the "Fish Fare" create a conducive environment for young individuals to showcase their work and learn about innovations.

AIASA, a professional society comprising current and former students in the field of agriculture, veterinary science, dairy science, horticulture, fisheries, forestry, home science, sericulture, agribusiness management, and other related fields, has been established with the mission of empowering youth in agriculture for the development of the sector and the nation. AIASA aims to strengthen the bond between students and professionals in agriculture and allied subjects.

AIASA advocates for techno-administrative reforms in agriculture, including the creation of “Indian Agricultural Services” and increased involvement of agriculturists in policy formulation and implementation. Over time, there has been a growing disconnect between the technical workforce and the bureaucracy, greatly impacting the farming sector and farmers at both the state and national levels. AIASA envisions a common platform where agriculturists and bureaucrats work together in a “Right Person at Right Place” mode, to promote the application of science.

I firmly believe that the outcomes of this conference will contribute to the advancement of fisheries in India and aid in achieving the ambitious Sustainable Development Goals.

Vivek Saurabh

(Vivek Saurabh)
National President, AIASA

कृषिः मूलं हि जीवनम्

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INVITED LECTURES

Fisheries Sector and its Potential

Dilip Kumar

*Adviser, Assam Fisheries Development Corporation (AFDC) and National Platform for Fish-workers (Inland)
Chairman, Board of Directors, Institute of Livelihood Research and Training (ILRT), Hyderabad
Aquaculture, Fisheries and Rural Development Adviser
International Civil Service FAO of the UN - Retired
Ex Director / VC, CIFE (ICAR), Mumbai, India
E mail – dk.dilipkumar@gmail.com*

Abstract

I hope this finds our students, fisheries professionals and practitioners filled with enthusiasm and a passion for fisheries science. As our students embark on their journey as future professionals, I am here to convey an important message that holds tremendous significance for your career prospects and the immense potential in the fisheries sector. First and foremost, let me assure you that fisheries science offers a bright future towards providing nutritious food for humanity with numerous opportunities for development and growth. The world's population continues to expand, and with it, the demand for nutritious and sustainable food sources. As fisheries professionals, you are poised to play a pivotal role in meeting this ever-increasing need and contributing to global food security, and while doing so, you also ensure your bright career prospect.

The fisheries sector is a crucial component of the broader aquaculture industry, which has experienced remarkable growth in recent years. Aquaculture has become the fastest-growing food production sector globally, surpassing wild-capture fisheries in production. This trend opens possibilities for fisheries science graduates like yourselves, as you possess the knowledge and skills necessary to excel in this expanding sector.

Furthermore, the importance of fish as a valuable protein source cannot be overstated. With heightened awareness of the health benefits associated with aquatic food consumption, the demand for fish products is projected to continue its upward trajectory. As dedicated professionals in the fisheries field, you have the opportunity to contribute to the sustainable management of aquatic resources, ensuring the availability of nutritious and high-quality fish for generations to come.

Beyond food production, fisheries science offers a diverse range of career paths. Whether you are interested in research, conservation, policy development, or even entrepreneurship, the possibilities are endless. Your expertise in areas such as stock assessment, ecosystem management, fish health, and aquaculture techniques positions you as valuable assets in a variety of sectors, including government agencies, research institutions, conservation organizations, and private enterprises.

It is essential to acknowledge the role that your dedication and commitment will play in shaping your successful career in fisheries science. The sector promises a good career, but it is up to each of you to cultivate your skills, stay updated with the latest advancements, and maintain a passion for lifelong learning. Your hard work, combined with the continuous exploration of new knowledge and approaches, will ensure that you remain at the forefront of this dynamic and evolving field.

In conclusion, my dear fisheries science graduate students, be confident in the immense potential that awaits you. The fisheries sector offers a bright future filled with opportunities for development, growth, and making a significant impact on global food security. Embrace your role as a dedicated professional and continue to pursue excellence in your field. Your commitment and contributions will not only shape your career but also contribute to the sustainable development of fisheries and aquaculture on a global scale.

Wishing you all the best in your journey towards a rewarding and fulfilling career in fisheries science

One health approach in fish health management

Basanta Kumar Das, Vikash Kumar and Amiya Kumar Sahoo
ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata 700120 India

Introduction

Fisheries comprise the fastest growing food sector meeting the global protein requirements. Being an affordable enterprise, it is considered as a safe source of food with high nutritional value. One third of the animal protein produced on the planet comes from the water. Half of this is from the aquaculture sector- mainly the farming of fish, crustaceans and molluscs. The sector offers many positive aspects: poverty alleviation in some of the lowest-income regions, production increases from technological advances and selected species lines, the use of non-fed (for example, molluscs) and extractive (for example, seaweed) species with benefits of farms for proximate marine biodiversity, comparatively lower environmental impact of some types of aquaculture and smaller spatial footprints compared with both capture fisheries and land-based agriculture. Moreover, to facilitate sustainable growth and generation of safe, tradable products attention must be focused on integration of diverse sustainability metrics into the supply chain. This will maximize benefits for producers and consumers while minimizing adverse effects on farm animals and the environment where aquaculture is practiced. With the output of the worldwide capture fisheries expected to plateau over the next three decades, aquaculture will become the dominant provider of primary source of protein for a population expected to exceed 10 billion by 2050. However, there are significant sustainability issues that must be addressed across the diverse range of aquaculture sectors. For example, economic gains in the global shrimp sector have been prioritized in spite of evidence of major mangrove forest degradation, bonded labour and social inequities, and potentially high carbon footprints. The profitable Northern Hemisphere Atlantic salmon aquaculture industry farms native stocks, but claims of subsequent pathogen spillover, native populations genetic integrity loss and wider environmental degradation of sensitive habitats persist. Similarly, antibiotic overuse in Southern Hemisphere Atlantic salmon production remains disproportionate to the economic benefits in otherwise deprived rural communities. Concern for safe practises is necessary in this situation to ensure the welfare of the fish as well as the workers' health and safety. Integrative One Health approach provide promising solution to develop disease resilience strategies to understand the interactions between environment, animals and humans and develops policy, and legislative framework to prevent transmission of zoonotic and emerging diseases (Jamwal and Phulia 2020).The areas of work in which a One Health approach is particularly relevant include food safety, the control of zoonoses (diseases that can spread between animals and humans, such as flu, rabies and Rift Valley Fever), and combating antibiotic resistance (when bacteria change after being exposed to antibiotics and become more difficult to treat).

One health approach

The term 'One Health' was first used in 2003 - 2004, and was associated with the emergence of severe acute respiratory disease (SARS) in early 2003 and subsequently by the spread of highly pathogenic avian influenza H5N1, and by the series of strategic goals known as the 'Manhattan Principles' derived at a meeting of the Wildlife Conservation Society in 2004, which clearly recognized the link between human and animal health and the threats that diseases pose to food supplies and economies. These principles were a vital step in recognizing the critical importance of collaborative, cross-disciplinary approaches for responding to emerging and resurging diseases, and in particular, for the inclusion of wildlife health as an essential component of global disease prevention, surveillance, control, and mitigation (Vergis et al., 2021).

One Health is defined as an approach that is "collaborative, multi-sectoral, and trans-disciplinary- working at local, regional, national, and global levels-to achieve optimal health and wellbeing outcomes recognizing the interconnections between people, animals, plants and their shared environment. One Health recognizes that humans are not isolated systems but are an interactive part of the ecosystem. As a result, human well-being depends on the overall health of other constituents of the ecosystem, including animals and plants. One Health also recognizes the role of socioeconomic factors, education and civic awareness in sanitation and disease outbreaks (Figure 1). Thus, One Health is a collaborative approach requiring inputs from professionals belonging, but not limited, to the disciplines of medicine, veterinary, environment, economics, education and social sciences. The concept of One Health also involves policy-level interventions to promote a healthy human-animal-environment interface. The concept is universal in its approach and can be applied to tackle many other socioeconomic problems that can be difficult to address using conventional approach. For example, a collaborative team of

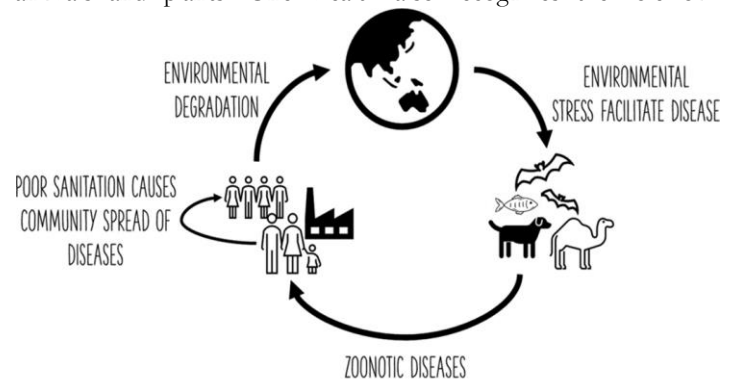


Figure 1: One Health aims to achieve optimal health and well-being of all the components of the ecosystem.

doctors, social workers, experts on electronic, print and social media platforms, and religious leaders can help to develop effective strategies to promote vaccination of children and counter anti-vaccine narrative perpetuated by the use of religious sentiments through social media platforms.

One Health approach aims to achieve optimal health and well-being of all the components of the ecosystem. Environmental degradation creates conditions that facilitate the spread of disease amongst the wild animals, which, in turn, pass those diseases to humans. (Jamwal and Phulia 2020)

One health approach in fish health management

Health has been discussed in a broader concept, encompassing fish, human and environmental health. The One Health approach has been recognized as a major element of disease control and prevention strategies by international agencies, including the Food and Agriculture Organization of the United Nations (FAO), the World Organization for Animal Health (OIE), and the World Health Organization (WHO). Fisheries and aquaculture directly depend on healthy animal (fish) and environment; hence, the applications of One Health principles are apparent. Also, the safety of fish as a food component depends on

sanitary awareness of the workforce and responsible waste discharge. The objective of any economic sector should not be limited to the generation of income. Rather, the generation of revenue should go together with the socioeconomic welfare of its workforce. This necessitates a One Health approach that includes a wholesome appraisal of the social and economic status of the business model and people involved in fishing, aquaculture, processing and marketing of fish and fish products (Figure 2) (Stentiford et al., 2020).

In fish, disease outbreaks caused by biotic and abiotic stressors are considered as the primary cause of production loss in farming system. With intensification and climate change variables the novel, infectious microbes and emergent disease have moved to the forefront and brought socio-economic and environmental unsustainability to the aquaculture industry. The economic losses in aquaculture sector from disease outbreak has been calculated by FAO to be over of US\$9 billion per year, that is approximately 15 % of world aquaculture fish and shellfish production, by value. The conventional antimicrobial agent, viz., antibiotics application can inhibit the spread infectious bacteria pathogens and provide protection to fishes; however, prolonged application especially at sub therapeutic doses has resulted in the emergence of multidrug-resistant bacterial strains. In addition, the presence of residual antibiotics in commercialized aquaculture products constitutes another problem for human health, as antibiotics consumption might lead to an alteration of the normal human gut microbiota and can also generate problems of toxicity and cause of life-threatening immune-mediated drug reactions that are considered off-target including anaphylaxis.

The One Health concept clearly focusses on consequences, responses, and actions at the fish, human and ecosystems interfaces, and especially emerging infectious diseases, the latter being responsible for a much greater burden of disease in the developing world, with a major societal impact in resource-poor settings; antimicrobial resistance (AMR), as resistance can arise in humans, animals, or the environment, and may spread from one to the other, and from one country to another and food safety. Hence, of novel biomolecule to boost fish robustness and welfare against biotic and abiotic stressors would have possible one health application, particularly relevant in food safety, the control of zoonoses and combating antibiotic resistance (Misra et al., 2006; Sahu et al. 2007; Kumar et al. 2022).

One health approach towards combating AMR in Aquaculture: Indian Initiatives

In India, since 2018, FAO in collaboration with ICAR has initiated One health approach towards combating AMR in Animal and Fisheries sector under the working group INFAAR, i.e., Indian Network of Fisheries and Animal Antimicrobial Resistance (INFAAR) with major focus on 1) to document AMR in different production systems including land based and aquatic based farming systems, 2) to describe the spread of resistant bacterial strains and resistance genes, and 3) to identify trends in resistance bacteria through a structured national surveillance programme. Currently the INFAAR platform is operational through 18 organizations (15 ICAR institutions and 3 State Agriculture Universities) in 20 centers (9 centers from fisheries and 11 from the livestock sector) spread across the country. In addition, INFAAR majorly work on i) surveillance of AMR in target microorganisms isolated from healthy farmed animals and fish/shellfish in India, and ii) awareness on AMR among the farmers, fish health professionals and policymakers through effective communication, education and training. For freshwater fish species the targeted

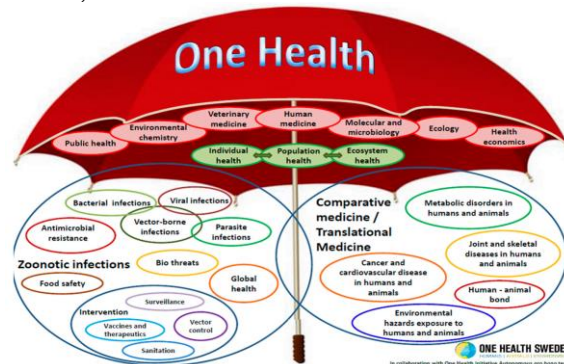


Figure 2: The One Health Umbrella developed by One Health Sweden and the One Health Initiative Autonomous

Pro bono team.

bacteria are *Aeromonas* species, *Escherichia coli*, *Staphylococcus aureus*. While for brackish water fish and shrimp culture, targeted bacteria is *Vibrio* species, including *Vibrio parahaemolyticus*.

ICAR-CIFRI is currently working on AMR surveillance in fish farms of different districts of West Bengal i.e., Hooghly, Burdwan, N-24-PGS and S-24-PGS and Purba Midnapur. In addition, fish samples from the East Kolkata Wetland have been investigated for the *E. coli* resistance. A total of 54 fish samples were collected representing different seasons. Of the 54, 50 fish species were positive for *E. coli* by both biochemical and molecular methods. A high percentage (>80%) of resistance exhibited against ampicillin coming under the beta-lactam group. A medium to low level resistance was recorded against amikacin (aminoglycoside), ceftazidime (2nd generation cephalosporin), cefotaxime (2nd generation cephalosporin), ciprofloxacin (quinolone) and tetracycline. In addition, AST, specific resistance gene (TEM-1) was used to screen the positive isolates (Fig.3). Screening for TEM-1 resistance genes showed that 40% of the total isolates were positive. This is the first report showing increased portion of *E. coli* isolates carrying TEM1 resistance gene in fish species from East Kolkata Wetland, a sewage fed fisheries (Sahoo et al. 2023).

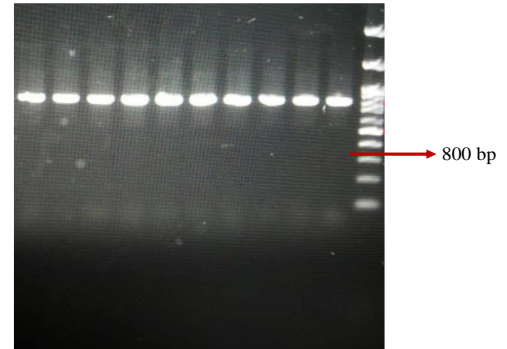


Fig. 3: Amplification of TEM-1 gene at 800 bp.

Conclusion and future perspective

The One Health approach captures detailed aspects of the ecosystem aquaculture approach and broader targets from the United Nations Sustainable Development Goals. The extension of the One Health approach beyond zoonotic diseases to address grand societal challenges such as food security was proposed in programmes such as the Network for Evaluation of One Health. These approaches will enable national policies to collectively contribute to aquaculture sustainable production. Data collection for monitoring success metrics will require interaction across government departments and a broad range of aquaculture stakeholders. Accountability must extend beyond national borders; particularly where high-income countries obtain food from medium- to low-income and/or less stable regions at the cost of those ecosystems and people. Given seafood is one of the most traded commodities, the unaccounted burdens of international, unsustainable socio-ecological practices require attention within the aquaculture sector - and seafood in general. Success metric achievement at national levels, coupled with international cooperation, forms the cornerstone of widespread One Health adoption. Aquaculture can mitigate the negative consequences associated with land-based food production systems, particularly where land and water-based systems are integrated to protect terrestrial habitats from the impact associated with some current farming systems. The One Health principles will facilitate increasing production of aquaculture species with efficient food production and sustainable environmental footprints, while supporting local socio-economic needs. If put into practice, the success metrics presented here will serve as an example for the design and assessment of not just aquaculture, but whole food systems.

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Promotion of domestic fish consumption

Dr. L. Narasimhamurthy, Chief Executive,
National Fisheries Development Board, Hyderabad

Introduction

Promotion of fish consumption in domestic market is strategically important to sustain the rapidly growing fish production sector in the country and contribute for National Sustainable Development Goals (SDGs) set by the Government. The flagship fisheries development scheme of Government of India – Pradhan Mantri Matsya Sampada Yojana (PMMSY) has target of doubling the per capita annual consumption of fish from 5 kg in 2019-20 to 12 kg by 2024-25.

PMMSY envisages to increase the fish production from 14.16 million metric tons (MMT) in 2019-20 to 22 MMT by 2024-25 with a sustained annual average growth rate of 9%. Achieving these targets require paradigm shift in our national strategy and action plan from the as usual forward linkage approach of “production to consumption” or “farm to fork” to the backward linkage approach of “consumption to production” or “fork to farm”. This means along with availability (total production), we need to focus on accessibility (distance of fish vending stalls from customer and presenting the fish in different forms and styles according to customer demands) and affordability (different price ranges as per spending power of customers). First step towards this new paradigm is understanding the food habits of consumers.

India is one of the largest fish producing countries in the world and shares 8 per cent of the total global production. The importance of fisheries sector can be gauged from the fact that it contributes 1.1 per cent to India's Gross Value Added (GVA) and 6.72 per cent (2021-22) to the agricultural GVA. Known as the country's sunrise sector, fisheries have shown impressive growth with an annual growth rate of 10.34 per cent during the last few years. Despite high production, fish consumption in the country remains low. Fish and shell-fishes are highly sought after food due to their nutritional components which favours good health of consumer. The synonym 'heart food' and 'brain food' for fish is mainly due to presence of good quantity of essential fatty acids like 'Eicosapentaenoic acid' and 'Docosahexaenoic acid'. Presence of polyunsaturated fatty acids helps in lowering the blood cholesterol level and helps in increasing memory. Eating good quality fish at right proportion is also related to reduced risk of cancer and alzheimer's disease. Apart from this, fish is also regarded as one of the best source of protein with good quantity of essential amino acids. Fish is also a good source of vitamins and minerals required for the normal functioning and well being of human beings. Knowing the importance of fish in healthy diet, many organizations including World Health Organization (WHO) have stipulated the regular consumption of fish. WHO recommends per capita consumption of 11 kg fish per annum for maintaining better health. The American Heart Association has recommended eating fish, particularly fatty fish, atleast two times a week (minimum of two servings or 198 to 226g). Similarly, Dietary Guidelines for Americans also suggests consuming 226 g of seafood per week. National Institute of Nutrition (NIN), Hyderabad (2011).

Fish production and per capita fish consumption

India has made a paradigm shift in the food availability transforming from a begging bowl to bread basket during the course of around seven decades. The fisheries sector registered a sustainable growth rate of over 10 per cent and contributed over one per cent of India's annual gross domestic product during the last decade

Fish production in India has increased by 146.18% over last 17 years from 66 Lakh MT in 2005-06 to 162.48 Lakh MT in 2021-22 (DoF, MoFAHD, GoI, 2023). This means an additional 96.48 Lakh MT of fish was added to Indian fish basket as on 2021-22. Concomitantly, fish export from India increased from 5.13 Lakh MT (Rs 7245.3 crore) in 2005-06 to 13.69 Lakh MT (Rs 57586.48 crore) in 2021-22. The fish export again increased in the last financial year which accounted to 17.35 Lakh MT (Rs 63969.14 crore). During the same period, population of India has increased from 117 crores in 2006 to 142 crores in 2022. This means an additional 25 Crore people in 2022 and the per capita fish consumption per annum has increased from 5.26 Kg in 2005-06 to 6.31 Kg in 2021-22. This means, the quantity of fish consumed by individual person has increased by 19.96 % over last 17 years.

Both for poor and rich on one side, fish could be a poor man's protein (low value fishes) ensuring food security, and on the other, a delicacy offered at huge prices and comparable with other protein sources (high value species like shrimps, pomfrets and seer fishes). It's been estimated that around 60 percent of the Indian populace consumes fish and the consumption pattern varies spatio-temporally and across the different social fabric. The annual per capita consumption of fish for the entire population is estimated at 6.31 kg whereas for the fish eating population it is found to be 8-9 kilogram, which gain is a poor 50 percent of the global rates.

Intervention required to enhance domestic fish consumption.

Globally, fish provides 3.3 billion people with at least 17% of average per capita animal protein intake. In last few years, along with fish production and export, India has also witnessed growth in the domestic fish consumption. However as compared to the total fish production in the country, the domestic fish consumption stands low –

with an annual fish consumption of 6 Kg per capita. This consumption rate stands considerably low when compared to the global consumption of 20.2 Kg per capita (2020). Following are some of the initiative that can be undertaken to enhance the domestic fish consumption in India: -

(1) Diversification of species:

Major thrust is given for the diversification of species in both freshwater and brackish water culture systems, especially with suitable native fish species having high preference and demand in domestic market by establishing hatcheries, brood stock multiplication centers and nuclear breeding centres. Research and Development programs will focus on developing breeding, hatching, seed rearing and grow-out technology for identified alternative species suitable for aquaculture by bringing in/adoption of advanced technologies and practices to enhance production and productivity. Priority will be for propagation of area specific integrated farming systems for adoption after evaluation and field trials.

(2) Product and market diversification

Increased attention will be given for product and market diversification in exports with improved infrastructure, trained human resources and support facilities to move up the value chain and meet international standards. Steps should be taken for diverting the surplus production to the domestic areas having production shortage, but increased demand. Promotion of fish as health food and creation of consumer awareness about increased fish protein consumption would be taken up in a major way for increasing domestic demand-supply for fish.

(3) Encourage the sales of preserved and processed fish

Steps would be taken to encourage the sales of preserved and processed fish in the national and overseas markets. Development of appropriate packaging material for fish and fishery products will be encouraged. Steps will be taken to facilitate export as well as promotion of domestic consumption fish, GI in fish, branding of fish like 'Himalayan Trout', 'Tuna branding etc.

(4) Organising fish festivals/fish mela

In India 40% people are vegetarians. In some States/UTs, especially the North-eastern States, fish consumption is quite high. There is a need to promote domestic fish consumption across the country as there are several health benefits. This would create adequate demand and spur further production & consumption. To popularize fish as food and increase the per capita consumption of fish, NFDB is extending financial assistance for construction of hygienic wholesale and retail fish markets, fish outlets, mobile fish vending vehicles, processing units, etc. Further, to popularize fish consumption, 'Fish Festivals' are organized in different parts of the country to campaign and create awareness among consumers by exhibiting preparation of different fish menu and showcasing various ready to cook and ready to eat value added fish products. NFDB provides 100% financial assistance to the State/UT Fisheries Department to organize Fish Festivals or Melas to create awareness on fish production, adoption of technology and promote fish and fishery products. For organising these events i.e., fish festivals and Melas a lumpsum amount of minimum Rs. 3.00 lakh to Rs. 5.00 lakhs per year per State/UT is funded on a case to case basis by NFDB. NFDB has also organized digital campaign, broadcasting the jingles, advertising in print media, preparing posters on nutritional aspects of fish etc.

(5) Online fish marketing

Fish vendors doing business online sounds crazy in India where vendors have a virtual monopoly over door sales of both sea and inland fish. Moreover, fish being a highly perishable product, the idea was found too difficult to implement unlike other consumables where online marketing rules the roost. However, things changed drastically over the last couple of years particularly in urban areas. E-marketing has gained popularity over the past decade. In contrast to traditional marketing, E-Marketing takes marketing techniques and concepts, and applies them through the electronic medium of the internet. Internet marketing offer the possibility to tracking almost every action a visitor or potential customer takes in response to marketing messages and how they navigate through their buying cycle. Online marketing giants such as Amazon and Flipkart have been showing tremendous growth over the years in Indian e-retail market space. Hence, idea of e-markets is not new for Indian customers and they have become used to it. But fish being a highly perishable commodity, adhering to quality standards makes its sales, marketing and promotion a risky affair.

With an increased knowledge, attitude and better perception about health, quality and safety issues related to fish consumption, customers are fast switching to online fish markets. There are various e-commerce sites such as www.freshtohome.com, www.dailyfish.in, www.mathafreshfish.com, www.suvichar.in, www.onedaycart.com, www.freshandhealthy.in, www.wildfish.in, www.biggro.com, www.healthyfishonline.com, www.onedaycart.com etc. are into business and is expanding their market base day by day. These fish E-commerce sites offer a rich array, mostly the variety available on local coast. Pre-ordered fresh fish reaches consumers 'doorstep in curry cut, steak, fully cleaned or even as whole fish at prices affordable to the discerning homemaker. However, they are still far away from disrupting traditional fish vending systems.

(6) Need of Infrastructure Development and Post- Harvest Management

Various schemes and policies of the Government has supported interventions in the best way at each step of the fish value chain for developing fisheries sector across the State through enhanced production and leveraging value addition and export opportunities. It has been observed that, despite having highest production in the country, the per capita consumption of fish in the India is signifying low. Currently the fish supply chains in India are mostly unorganized and run by multiple private players, entrepreneurs. Moreover, availability of quality aqua products at the right place at the right time has been a gap area for the state and is one of the critical factors behind low per capita consumption of aqua products in the India. However, due to change in food consumption habits and nutrition & health consciousness among the people, demand for quality aqua products is increasing at fast pace in the urban, semi-urban as well as rural area. Hence, there is a need to improve the supply of different aqua species to every corner of the state at a standard price and quality. The emerging markets in nearby cities and rural areas has tremendous potential and capacity to absorb these fish and aqua products. The fish supply chain in India is commonly dependent upon unorganized players, so the fish fishermen are also dependent upon the local aggregators and traders to sell their produce or catch. This supply chain model lacks standardization in terms of quality of the products and the price realization at primary purchase from the farmers is non-remunerative at times. Hence there is a need to create a well-structured fish value chain in India where large number of farmers/fishers can avail a guaranteed market and remunerative price and facilitate supply of standard aqua products at a competitive price to the end consumers.

For example, the State of Andhra Pradesh has launched a dedicated program for development of fish and aqua product value chain to enhance the per capita consumption of fish in the State. The primary objective of the program is to enhance the domestic consumption. The model envisages to augment per capita domestic consumption of fish by ensuring easy access to live, fresh, frozen fish and aqua products along with marinated and processed products to the end consumers. With this stated objective, a well-structure Hub & Spoke model has been developed to cater quality aqua products to the households across AP. In this context, establishment of the Aqua Hubs and the spokes or retail units will be the key intervention to meet the State's need under fisheries sector. Aqua Hubs will play the most critical role in the entire value chain and will operate as an aggregation point. It will aggregate different types of products from multiple pre-registered sources and will supply to the registered retail outlets within a defied geography. At the same time these hubs will conduct multiple activities such as, processing, quality check etc. These hubs will be responsible for seamless supply of products to the retail outlets as per the demand. Multiple models of retail outlets have been designed to cater different segment of the consumers and to have a significant outreach across the state.

(7) Promotion of Domestic Fish Consumption and Branding

The Aqua hubs and the retail outlets (spokes) will benefit multiple stakeholders of the fish value chain and the end consumer as well. It will provide guaranteed market and remunerative price realization to the fishermen or fish farmers. The consumers are expected to have access of quality and hygienic fish of different variety at a competitive price. To reach out the consumers with proper information and to create a higher degree of awareness among the consumers, there is a need of organized campaigning and awareness drives. To achieve the project's key objective "Improving per capita consumption of aqua products", branding will play a crucial role by communicating the product characteristics, quality parameters, benefits, and unique selling propositions (USP). The brand value will help in easy identification of products by the customers as this will differentiate the product from others. An Aqua product brand with significant outreach will attract the entrepreneurs, fish farmers and other stakeholders to participate in the value chain and simultaneously the space and opportunity will grow in the fisheries sector.

(8) Standard Fixing Exercises

NIFPHATT is actively participating and contributing to the standard fixing exercises for fish & fishery products at national and international level by serving as an expert member in Bureau of Indian Standards (BIS/ISO), Food Safety and Security Authority of India (FSSAI), Shadow Committee for CODEX and Technical Committee for Risk Assessment for Import of Fish & Fishery Products into India.

(9) Development of "smart packaging technology for indicating fish freshness indicator at field level:

Understanding the ever increasing demand for fish in the state, retail marketing and online marketing is flourishing and the price of fish is also increasing. However, fish is being highly perishable in food commodity, freshness decreases continuously from the moment fish is taken out of water. Loss of freshness will be more when proper icing or chilling is not followed leading to formation of various chemicals like histamine, lipid oxidized products which pose threat to human health. For fresh and chilled fish, only ice prepared from good quality potable water can be used as preservative not any other adulterants. Recently reported frequent incidents regarding the use of adulterants to maintain the freshness of fish poses serious damage to life and health of consumers. This has badly affected the fish business as well as the trust of the consumers. The freshness of fish is either ensured by sensory attributes or by analytical methods. The analytical methods are time consuming, costly and are not real time in nature. This has resulted in relying on sensory quality assessment to judge the freshness

and quality of fish being marketed. At many instances consumers are buying inferior quality fish and it will be known only while cooking or while consuming. This is true for both whole and cut fish marketed in the fish markets as well as for packed fish marketed in retail outlets.

Availability of simple, low cost and easy to use device will benefit consumers in purchasing quality fish while it is also helpful to the producers or traders to maintain better conditions to retain the freshness. Knowing the importance of this, a simple paper based technology need to be developed for freshness indicator of fish and packed fish.

At present, ICAR-CIFT is in the process of developing such technology in which a paper disc is attached inside the pack without coming in contact with the fish. This absorbs the chemical compounds released during the storage period and gives a simple, distinguishing colour change. This colour change can be easily read by anyone to judge the freshness of fish without any elaborative and costly laboratory tests. This freshness indicator can be used for variety of fish and shellfishes, for chilled, refrigerated and iced fish. The use of freshness indicator is beneficial to both producer/ manufacturer and consumer. Freshness indicator is helpful to Producer/ Manufacturer in controlling the loss of freshness by proper maintenance by using sufficient quantity of ice or with the desirable temperature and acquires the trust of consumers. It also allows monitoring of supply chain and hence food safety control to the manufacturer and retailers. Consumer will benefit by getting better quality, safe and healthy food products. It is a win-win situation for both without much additional cost.

Conclusion

Fish purchase and consumption is a dynamic process that is constantly evolving and changing. Consumer focus is shifting to quality and convenience rather than price. Online fish marketing is far away from disrupting traditional vending and sustainability of online fish marketing counts mostly on consumer satisfaction and continued patronage. Maintaining the choice of products, better price range, quality and safety guarantees, delivery systems and improved consumer accessibility over mobile and social media platforms are found to drive growth in online fish vending sector.

Transforming efforts for sustainable livelihood and nutritional security harmonizing through conservation and management of aquatic genetic resource in India

Dr. U. K. Sarkar

ICAR-National Bureau of Fish Genetic Resources, Lucknow - 226 002, India

Abstract

Aquatic resources are vital for human survival, economic development, and to support all human, animal and plant life. The fisheries and aquaculture produced resources are growing due to contemporary food demand and utilization across the globe. Increased anthropogenic activities coupled with climate change have been degrading aquatic resources. Sustainable development and use of aquatic resources are the need of the hour considering their role in food security, nutrition, ecosystem services and livelihood generation. India is blessed with vast aquatic resources that need to be harnessed sustainably and efficiently to meet the nutritional security and needs of our growing population. Global studies on sustainable use and conservation of aquatic resources suggest that aquatic resource management is complex and needs a multi-pronged approach. Most of the stakeholders are mainly associated with utilizing the resource without planning for the future. Conscious efforts are required to organize and plan policies along with participatory management suited to local conditions for sustainable management of resources and also for the benefit of diverse stakeholders holding claims to these resources. Sustainable management of this growing sector is essential for prosperity of associated human resources. In this regard, transformative efforts may support the sustainable livelihood and nutritional security harmonizing through conservation and management of aquatic genetic resources in India. The present article highlights the importance of conserving biodiversity and discussed the ICAR-NBFGR's contributions in the conservation of the fish genetic resources and suggested approaches for sustainable management.

Keywords: Transformative Efforts; Sustainable Livelihood; Nutritional Security; Conservation and Management; Aquatic Genetic Resources

1. Aquatic Genetic Resources (AqGR)

Aquatic resources refer to the vast and diverse group of water-dependent habitats like rivers, streams, floodplains, reservoirs, ponds, estuaries, lagoons, wetlands, rice fields, open oceans and seas (Dugan et al., 2002). Sustainable aquatic resources are the foundation for human survival and economic development, and supporting all human, animal and plant life (Agboola and Braimoh, 2009). Aquatic resources are vital for their role in food security, nutrition, livelihood generation and climate change mitigation (Sarkar and Borah, 2017). Aquatic resources provide livelihood options for many people in the rural areas of the developing world. Foraging for aquatic biodiversity resources such as crabs, prawns, snails, insects, aquatic plants, etc. in paddies and other waterbodies are the important livelihood component. Aquaculture in such aquatic resources also plays an important role in low-income countries, which produce over 75% of world aquaculture production generating valuable foods, income and employment in support of the development of disadvantaged regions. They are known to form the wealthiest habitat of global biodiversity and provide a wide range of benefits to the people. Aquatic Genetic Resources (AqGR) is referring to the finfish and aquatic invertebrate genetic material that is of the current or potential value. AqGR is gaining importance due to dependency for food, medicines, materials, recreational and eco-tourism. The global AqGR is contains 36,385 valid fish species of which 18,427 species belonging to freshwater habitat (Fricke et al., 2022). The global fisheries and aquaculture production is increasing with 214 million tonnes with employing about 58.5 million people (FAO, 2020). India has a rich and diverse aquatic resource ranging from deep seas to lakes, ponds, rivers which harbours nearly 10% of the global biodiversity in terms of fish and shellfish species. India has a vast coastline of 8118 km of with 5.3 lakh square km of continental shelf which mainly supports marine fishing and navigation. India is also blessed with 1.95 lakh km long river and canal system which supports numerous towns and cities and freshwater capture fisheries, 8.12 lakh hectares of floodplain lakes, 21 lakh hectares of ponds and lakes, 31.5 lakh hectares of reservoirs, 12.4 lakh hectares of brackish water bodies and about 12 lakh hectares of saline areas. Total EEZ area is 2.02 million square km with total territorial water of 159,265 square km (Table 1) (National Fisheries Policy, 2020).

Table 1: Aquatic resources in India and their utilization modes

Resource type	Resource size	Fish production system
Continental Shelf area (million Sq. Km)	0.53	Capture fisheries
Exclusive Economic Zone (million Sq. Km)	2.02	Capture fisheries
Rivers and canals (Lakh km)	1.95	Capture fisheries
Ponds and tanks (Lakh ha)	24.1	Aquaculture
Reservoirs (Lakh ha)	31.5	Culture-based fisheries/Stock enhancement/Cage culture
Floodplains and lakes (Lakh ha)	8.12	Culture-based fisheries and pen culture
Brackish water area (Lakh ha)	12.4	Aquaculture
Bheels (million ha)	1.3	Culture-based fisheries/ Aquaculture
Wetland (Inland and coastal) (million ha)	15.26	Capture and aquaculture
Mangrove (Sq. km)	4975	Livelihood enhancement

(Source: National Fisheries Policy, 2020); ICAR-NBFGR & Alliance of Biodiversity Alliance and CIAT, 2020).

Rivers: India's river systems comprise of 14 major rivers, 44 medium and 153 small rivers and a large network of inland water bodies provides great potential for economic capture fishery. The major river basins of the country are Ganga, Brahmaputra, Brahmani, Cauvery, Godavari, Indus, Krishna, Mahanadi, Mahi, Narmada, Periyar, Sabarmati and Tapi which covers 85% of the surface flow.

Estuaries: The estuary is an area where a freshwater river or stream meets the ocean. Estuaries are the finest nurseries and breeding grounds for some commercially as well as ecologically important fish, prawn and other organisms includes fishes, shrimps, oysters, mussels, lobsters, prawns, crabs, dolphins and crocodiles. India has 53 estuaries consisting of diverse habitats, such as mangroves, salt marshes, sea-grasses and mudflats.

Coastal Lagoons: Coastal lagoons are semi-enclosed coastal water bodies which has a free connection with the open sea and within which the seawater is diluted with the freshwater derived from land drainage. Lagoons are rich in biodiversity due to the coexistence of different ecosystems. In India, there are around 17 coastal lagoons which include Chilika, Vembanad, Pulicat, Ashtamudi, Pennar, Paravur, Bendi, Ettikulam, Nizampatnam, Murukumpuzha, Muttukadu, Veli, Muthupet, Talapady, Gulf of Mannar and Lagoons of Mumbai and Lakshadweep.

Mangroves: Mangrove is a salt tolerant evergreen forest ecosystem found mainly in tropical and subtropical coastal and/or inter-tidal regions, they exhibit morphological and physiological adaptations (e.g., succulent leaves, sunken stomata, aerial breathing roots, vivipary, stilt roots, buttresses, etc.) to survive in the harsh climatic conditions. They provide a fertile breeding ground the aquatic organisms and an important source of livelihood (viz. honey, tannins, wax, etc) for the coastal communities. It also acts as a carbon sink. The mangrove cover of India is around 4,975 sq km, which is 0.15% of the country's total geographical area. West Bengal is having 42.45% of India's mangrove cover, followed by Gujarat 23.66% and Andaman & Nicobar Islands with 12.39%.

Wetlands: Wetlands are transition lands between terrestrial and aquatic ecosystems where the water table is usually at or near the surface, or the land is covered by shallow water permanently or seasonally. Wetlands can be classified as glacial, tectonic, crater, oxbows, marshes, swamps, flood plains, fens, bogs, estuaries, backwaters, mudflats, coral reefs and manmade wetlands. Wetlands range from high-altitude lakes of Himalayas, floodplains and marshes of Ganga-Brahmaputra alluvial plains, saline flats of the Great Indian Desert to extensive marshes and coral reefs bordering the country's coastline and islands.

Coldwater resources: Coldwater fisheries have a great potential in generating income in the hilly states of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, Assam and West Bengal. The Himalayan region has around 8,243 km long streams and rivers, 20, 500 ha natural lakes, 50,000 ha reservoirs and 2,500 ha brackish water lakes (ICAR-NBFGR & Alliance of Biodiversity Alliance and CIAT 2020).

1.1 Ichthyofaunal diversity

The ichthyofaunal diversity of India is comprised of 3192 native fish species under 1036 genus, 254 families and 53 order as per the Aquatic Genetic Information System of India (AqGRISI) (<https://aqgrisi.nbfr.res.in/#/>). This roughly covers 10% of the global fish diversity. Majority of these species are reported from marine ecosystem (1554 fishes) while the occurrence of 924 species were from freshwater ecosystems. The grouping of the Indian fish species under the IUCN conservation status revealed 1204 species under 'Least Concern', 116 under 'Vulnerable', 85 under 'Near Threatened', 84 'Endangered' and 21 species under 'Critically Endangered' status. It is also worth mentioning that around 219 fish species reported from India are grouped under 'Data Deficient' category.

2. Importance of Aquatic Genetic Resources

2.1 Ecosystem services:

Aquatic resources also provide important ecosystem services. The Millennium Ecosystem Assessment report defines ecosystem services as services provided by the natural environment that benefits people, which includes: provisioning (food, water supply, raw materials); regulating (air, water quality and climate); supporting (genetic resources, nutrient cycling, production of oxygen, habitat for biodiversity) and cultural services (spiritual, religious, aesthetic, recreational, art and design) (MA, 2005). There are two categories of services provided by the aquatic ecosystem, namely 'fundamental' and 'demand-driven'. The 'fundamental ecosystem services' are those essential for ecosystem function, resilience and they are prerequisites for human existence (e.g., plant, fish, animals and their products; fresh water, wood, fiber, medicine etc). The 'demand driven' ecosystem services (e.g., carbon sequestration, climate regulation, detoxification, waste decomposition, purification of waste water, flood protection, pest and disease control, mitigate natural disaster and pollination) are formed by human values and demands, and not necessarily fundamental for the survival of human societies (Holmlund and Hammer, 1999). Wetlands and floodplain ecosystem contribute to climate change mitigation through Carbon sequestration, and act as buffer against flood and rain water (Sarkar and Borah, 2017).

2.2 Food and nutritional security:

Food security can be defined as secure access to enough food at all times for everyone. A person needs adequate health, good environment, and food for their surveillance, which is therefore closely linked to the economic and social health of a nation, society, and individual (FAO, 2000). Aquatic resources provide and support agriculture, livestock

rearing, inland and marine fisheries production meeting food and nutritional security. Aquatic foods are diverse and packed full of micronutrients and essential fatty acids, which also increase the bioavailability of other nutrients. They support the uptake and absorption of nutrients from other foods. The diversity of aquatic foods, both nutritionally and ecologically, also means they can be harvested in various contexts and geographies to improve local and regional food security.

2.3 Livelihood opportunities:

Aquatic resources directly support water-based activities like fishing and fishing trade. About 58.5 million people are directly employed in the primary fishing sector (FAO, 2022). Aquatic resources also support navigational-related jobs, transport sector jobs and provide inputs to lots of small- and small-scale industries.

3. Fisheries and sustainable development

The ecosystem system services obtained from inland and coastal water bodies essential to achieving the Sustainable Development Goals. For instance, the strong positive correlation was observed between inland fisheries and various SDGs including Zero Hunger (SDG 2), Clean Water and Sanitation (SDG 6), Responsible Consumption and Production (SDG 12) and Life on Land (SDG 15). The positive correlation between inland fisheries and SDG was reported with SDG-8 (Decent Work and Economic Growth), SDG-13 (Climate Action) and SDG-14 (Life Below Water). Apart from these, the strongest bi-directional relationship was reported between inland fisheries and SDGs viz., No Poverty (SDG 1), Gender Equality (SDG 5) and Affordable and Clean Energy (SDG 7) (Lynch et al., 2020).

4. Conservation and management of aquatic genetic resources: Transformative efforts

Throughout the world, aquatic ecosystems are experiencing serious threats to both biodiversity and ecosystem stability. Continuous population growth, increased economic movements in addition to climate change have all put pressure on aquatic resources (Mahanayak and Panigrahi, 2021). As pressure on the world's water resources increased, concerns grew about the impact on poor communities, mainly fishers and pastoralists who are dependent on these and the need for conservation and sustainable use of aquatic resources. Aquatic resources have been traditionally managed on a sectoral basis with little integration either between sectors or with other environmental management procedures, ignoring vital interactions with much wider ecosystems and other functions, and ecological services related to water (Brahmoh and Craswell, 2008). The popular conservation and management models with transformative efforts have been listed below:

4.1 Integrated Water Resource Management (IWRM)

IWRM is a means to ensure equitable, economically sound and environmentally sustainable management of water resources. It is an empirical concept that emerged around the 1980s in response to increasing pressures on water resources from competition amongst various users for a limited resource, the recognition of ecosystem requirements, pollution and the risk of declining water availability due to climate change. IWRM is defined by the Global Water Partnership (GWP-2000) as 'IWRM is a process which promotes the coordinated development and the management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. It is a holistic approach that seeks to integrate the management of the physical environment within that of the broader socio-economic and political framework. It tries to address the "three E's": Economic efficiency, Environmental sustainability and social Equity, including poverty reduction. IWRM addresses both the management of water as a resource, and the framework for provision of water services to all categories of users, and it addresses both water quantity and quality. India's Natural Water Policy (2012) has enumerated the integrated perspective of water resources planning, development and management. The policy stresses that planning, development and management of water resources need to be governed by common integrated perspective considering local, regional, State and national context, having an environmentally sound basis, keeping in view the human, social and economic needs (Goyal, 2006; GoI, 2010). Goyal *et al.* (2020) applied IWRM concept to Ur River watershed in Madhya Pradesh and provided suggestions on water management, land management and livelihood management. They were of the opinion that through a participatory approach, the IWRM plan was enhanced and acceptable to all stakeholders in a Public-Private-People-Partnership mode.

4.2 Management planning by prescription

Prescription is a means by which water resources can be sustainably managed to provide security for all water users, now and into the future. The definition of water rights by prescription is a process in which the state defines the priorities to be given to different uses, while users are considered as the recipients of this formalization process. Rights are usually defined at the basin level and often distinguish between "bulk users" (such as urban water utilities, large irrigation scales and industries) that are granted an official license (or permit) and "small users," who are granted access to water without a permit. "Small users" typically include people withdrawing water for domestic use, backyard gardens or "livelihood use (Molle, 2004). Prescription establishes a system for more sustainable sharing of the nominated resource and protects against the unregulated extraction of additional water. Water resource development is allowed to continue up to designated sustainable limits. Once these limits are reached, further development can still occur through trading of water. Security of water access is therefore increased and conflicts over water sharing reduced. Water users are licensed to take a defined allocation of water. The water licence provides water users with a level of

clarity and certainty in relation to their access to water. A water licence can also be a valuable asset. Generally, under prescription, all water users, including the environment, will be protected from over use and degradation of the resource. The long-term health of the area's wetlands and rivers is maintained by ensuring that the needs of water dependent ecosystems are protected. Molle (2004) in a case study in Sri Lanka opined that the results were not optimistic and needs tailored solutions to local problems than bureaucratic solutions.

4.3 Management by defining conservation outcomes

Management by defining conservation outcomes was developed in recognition of the legal requirement to protect specified features on statutory, and other, sites. In outline, this approach is based on identifying the most important features of a site. The desired outcome for each feature is defined, and these are the management objectives. Although a features approach is imperfect, it is the most appropriate approach for many sites (Alexander, 2008). This approach is mainly used for protecting species at risk in these sites or areas having high biodiversity and areas under anthropogenic threat.

4.4 Establishment of protected areas

Protected areas (PAs) like national parks, marine parks, biodiversity hotspots, rich biodiverse areas, Ramsar sites, closed areas play an important role in conserving genetic, species and ecosystem diversity, and in ensuring delivery of ecosystem services from natural habitats. By protecting key habitats and associated species, PAs can contribute to averting biodiversity losses and meeting global conservation targets (Bastin *et al.*, 2019). Globally, there are more than 100,000 protected land and marine sites of which the aquatic ecosystems only occupy a small area but consist of one of the most threatened biomass and habitat by human activities. Aichi Target 11 of the Strategic Plan for Biodiversity 2011–2020 of the Convention on Biological Diversity (CBD), aims to conserve by 2020 at least 17% of terrestrial and inland water areas through effectively and equitably managed, ecologically representative and well-connected system of PAs. PAs are extremely important for conserving aquatic biodiversity and supporting human water security necessary for people to survive and thrive. Some of the important ones are listed below:

- **Biodiversity hotspots:** Bio-diverse rich region which has lost at least 70% of its original natural vegetation, usually due to human activity and is in imminent danger of being lost. There are 36 biodiversity hotspots which represent just 2.5% earth's land surface but support about half of the world's flora and fauna. India has 4 biodiversity hotspots-Himalayas, Western Ghats, Indo-Burman region and sundaland.
- **Ramsar sites:** These are wetlands deemed to be of international importance. A Ramsar tag makes it incumbent upon authority to strengthen the protection regime there and also creates defences against encroachment etc on wetlands. Designating a wetland as a Ramsar site also means that it gets more public attention. Globally 2,466 sites are in Ramsar list. Recently 11 Ramsar sites were added in India, taking the total to 75 with maximum number of sites in Tamil Nadu (14) followed by Uttar Pradesh (10).
- **Marine Parks:** Balbar and Metaxas (2019) have reported 746 marine protected areas in the world. In India, there are 6 Marine National Parks, Marine National Park, Mahatma Gandhi Marine National Park, Malvan Marine Sanctuary, Gahirmatha Marine Sanctuary, Gulf of Mannar Marine National Park, and Rani Jhansi Marine National Park. Maharashtra.
- **Freshwater Aquatic Sanctuary:** The establishment of PAs play key role in the of fresh water fish diversity conservation in India (Sarkar *et al.*, 2008). The freshwater habitats located within the terrestrial/wildlife PAs hold rich fish diversity with increased abundance. These areas shall be used/designated as freshwater aquatic sanctuary (FAS) to conserve the threatened fish species from various threat factors (Sarkar *et al.*, 2013).

4.5 Experimental management technique

The experimental management technique has been shown to be an effective approach for quantitatively characterizing hydrologic and water quality use in mixed-land-use watersheds. Typically, the study designs utilize a series of sub-catchments inside a larger water basin or watershed to monitor land use impacts on environmental variables of interest. It enables researchers to partition and quantify the influencing processes observed at the sub-catchment scale, and thereby determine the influence and cumulative effect of dominant land-water use types on the response variable of interest (Hubbart *et al.*, 2019). ICAR-NBFGF has been testing this technique in Godavari basin wherein the entire ecosystem services offered by the watershed is being studied and management programmes planned.

4.6 Co-management and participatory approach

Understanding that top-down management schemes aimed at conserving aquatic resources were unsuccessful, participatory approaches involving end users or local stakeholders at various levels became popular. Participation, co-management, and governance revolve around the theme of institutions where stakeholder participation is widely considered a precondition for sustainable processes by reducing conflicts and tapping the potential of ecosystem user knowledge which can then lead to sustainable solutions (Glaser and Glaeser, 2012). The participatory approach and co-management strategies played essential role in the management of ecologically sensitive areas such as mangroves,

coral reefs, seagrasses etc. in India. Further, the co-management also lead to the use of fishermen's traditional knowledge on identification of essential fish habitats i.e. breeding and feeding grounds of threatened fish species.

4.7 Awareness on aquatic resource conservation

The essential aspect of managing aquatic resources and its conservation is bringing awareness among the user community. This can be achieved through educational programs, awareness campaigns, and volunteer monitoring programs. The "Ganga Biodiversity Calendar" designed by Wildlife Institute of India to inculcate awareness in school children about biodiversity of Ganga River. The concept of formation of self-motivated group of volunteers from local community called '*Ganga Prabari*' (Guardians of the Ganga) by National Mission for Clean Ganga (NMCG) and WII with the objective of creating awareness about the ecosystem services of clean Ganga, and linking them with various agencies working for a clean Ganga. This kind of activities enhances the understanding about the ecosystem at grassroot level and lead to its sustainable utilisation.

4.8 Conservation of genetic resources & sustainable aquaculture

One of the important dimensions of conservation of aquatic genetic resources is sustainable aquaculture production. Some of the targeted areas can be conservation friendly aquaculture practices; equal attention by management bodies for both biodiversity and the genetic diversity important to sustainable aquaculture etc. Moreover, research plans could be prioritized to address important questions such as characterization of populations; optimizing fast and efficient genotyping and phenotyping tools, evaluating environmental factors and protection approaches not only for species richness but also genetic diversity, and estimating effects of stock enhancement programs on genetic components of wild populations.

4.9 Linking aquatic germplasm conservation and livelihood: Community Aquaculture

The inventory and cataloguing of aquatic biota are must for diversifying the germplasm resources of the country. The development of breeding and rearing protocols of such newly discovered species not only contribute to its conservation but also open up the avenue for its sustainable utilisation. Further, the aquaculture of such species will alleviate the poverty among the local community by uplifting their socio-economic conditions. ICAR - National Bureau of Fish Genetic Resources (NBFGR), Lucknow has taken initiatives to catalogue and designed concepts to validate a replicable working model for harmonising biodiversity conservation and promotion of livelihoods through Community aquaculture in the coastal Maharashtra and Lakshadweep islands. Through this program periodical biodiversity surveys have been undertaken to reveal the hidden diversity and captive propagation of such species mitigate the destruction of marine bio-resources and maintain the ecological balance. Furthermore, hatchery production, adaptation, and supply of marine ornamentals by coastal and island communities will create more employment opportunities in this region and raise the hope of the people and their living standard (Kumar et al., 2020).

5. ICAR-NBFGR's transformative efforts for conservation and management of aquatic genetic resources

5.1 Discovery of new species:

The institute has discovered 49 new fish species and 6 new shrimp species for enhancing fishery and aquaculture in future.

5.2 State fish: transformative efforts for conservation and management

ICAR-NBFGR is the pioneer institute conceptualized and employed the innovative approach of 'State fish' in 2006 for the first time in India which has exemplified a considerable improvement in fish conservation efforts. Presently, 20 states and one Union Territory have adopted the concept and declared their respective 'State fish'.

Several studies indicated the depletion of the wild fish stock in natural waters. By declaring state fish, the natural population may be conserved and enhanced through ex-situ and in-situ conservation measures like captive propagation, cryopreservation, stock enhancement and restoration through ranching. At the Germplasm Resource Centre, genetic management of the stocks will be carried out for the sustainable fisheries development. Captive breeding technologies could be developed and the produced seed will be used in commercial aquaculture and enhancement of natural stocks.

Under PMMSY, Government of India has given emphasis for quality seed production for stock enhancement through the river ranching program. So, there is a need to develop a national program on the conservation and utilization of the proposed State fish species. As India possesses vast aquatic resources and immense potential in aquaculture and fisheries development. ICAR-NBFGR sets following criteria to declare the State fish:

- a. The fish should have food/ ornamental/ conservation value.
- b. Fish should have regional significance and/or cultural importance.
- c. Fish seed production technology should be available or in the process of development.

List of States/UTs declared their respective State fish

S. No.	State/UT	Common Name	State fish	Scientific Name
01.	Andhra Pradesh	Striped Murrel		<i>Channa striatus</i>
02.	Arunachal Pradesh	Golden Mahseer		<i>Tor putitora</i>
03.	Bihar	Magur/Walking catfish		<i>Clarius batrachus</i>
04.	Goa	Flathead Grey Mullet		<i>Mugil cephalus</i>
05.	Haryana	Calbasu/Orange-fin Labeo		<i>Labeo calbasu</i>
06.	Himachal Pradesh	Golden Mahseer		<i>Tor putitora</i>
07.	Jammu & Kashmir	Golden Mahseer		<i>Tor putitora</i>
08.	Karnataka	Carnatic carp		<i>Barbodes carnaticus</i>
09.	Kerala	Pearl spot/Karimeen		<i>Etroplus suratensis</i>
10.	Lakshadweep	Butterfly Fish		<i>Chaetodon decussatus</i>
11.	Madhya Pradesh	Tor Mahseer/Tor Barb		<i>Tor tor</i>
12.	Manipur	Pengba		<i>Osteobrama belangeri</i>
13.	Mizoram	Ngahvang/Burmese Kingfish		<i>Semiplotus modestus</i>
14.	Nagaland	Chocolate/Copper Mahseer		<i>Neolissochilus hexagonalepis</i>
15.	Odisha	Mahanadi mahseer		<i>Tor mahanadicus</i>
16.	Sikkim	Ketly/Chocolate Mahseer		<i>Neolissochilus hexagonalepis</i>
17.	Telangana	Striped Murrel		<i>Channa striatus</i>
18.	Tripura	Pabda		<i>Ompok bimaculatus</i>
19.	Uttar Pradesh	Chitol/Indian Knifefish /Featherback		<i>Chitala chitala</i>
20.	Uttarakhand	Golden Mahseer		<i>Tor putitora</i>
21.	West Bengal	Hilsa		<i>Tenualosa ilisha</i>

5.3 Exploration And Documenting Aqgr

- Exploratory surveys – documenting AqGR-various River systems
- Ganges, Gandak, Burhi Gandak, Bagmati, Mahanadi, Godavari, Cauvery, Sharavathi, Zuari, Mandovi, Luni, Chaliyar, Chalakkudy
- Developed Aquatic Genetic Resource Information System of India (AqGRISI), a fish diversity database of India containing information about 3,173 species
- Discovered new geographical distribution records of many species

5.4 Live Fish Germplasm Resource Centers

- ICAR-NBFGR, Lucknow has established 7 live gene banks across the country (Lucknow, Kochi, Lakshadweep, Airoli, Gauhati, Telangana, Imphal) with an emphasis on conservation and culture of indigenous and threatened fishes.

5.5 Community Aquaculture Centers

- Established and supported four community aquaculture units in Agatti Island – marine ornamental shrimps are successfully raised to marketable size by 45 women beneficiaries
- Innovative approach to community aquaculture of marine ornamental organisms - open avenues in livelihood development of the island women - along with conservation
- Hon'ble President of India, Smt. Droupadi Murmu visited Lakshadweep during March 18-19, 2023 and interacted with the beneficiaries associated with institute's community aquaculture units
- The Hon'ble President mentioned and lauded ICAR-NBFGR's activities and hand-holding the community aquaculture units for enhancing the income of native women islanders

5.6 Captive Propagation Of Clownfish At Airoli

- Established clownfish breeding and training center at Airoli –livelihood development of coastal fishers
- Hands-on training for capacity building has been provided to beneficiaries of three districts of Maharashtra
- Hatchery bred clown fishes, *Amphiprion percula* and *A. ocellaris* were provided to the beneficiaries
- Steps towards Marine Ornamental Village in coastal districts of Maharashtra

5.7 Captive Propagation & Cryopreservation

- Captive breeding protocols developed for 15 ornamental fishes
- Captive breeding and milt cryopreservation protocol has been developed in 10 endemic and endangered fishes of the Western Ghats
- Sperm cryopreservation protocols - 35 fish species developed and seed produced for 24 species - field level validation of IMCs

5.8 Fish Cell Line & Up-Scaling Milt Cryopreservation

- World's largest collection of fish cell lines
- National Repository of Fish Cell Lines (NRFC) cell line accessions – 81
- Up-scaling of fish milt cryopreservation
- 370 hatchery professionals trained in 12 training /field demonstrations
- 126 lakh spawn produced from cryopreserved milt in 38 hatcheries of 11 states
- Species-specific protocol developed for prioritized species *Viz. Pangas, reba and Gonius*

5.9 Quality seed supply for livelihood

- The institute produced 1,144 lakh spawn of 12 species and a revenue of Rs. 31,40,000/- generated
- Fish seeds were supplied to Fisheries Departments, fish farmers, and hatchery owners

5.10 Molecular biology and genomics – tool for conservation

- Generated Whole genome sequencing of fin fishes; *Clarias magur, Labeo rohita* and *Tenualosa ilisha* & fungal pathogen *Aphanomyces invadens*
- Submitted 9,022 COI records of 424 fish species found in India
- Molecular markers for 35 finfish species identified
- Population genetic structure of 26 finfish and shellfish species studied
- Developed a genomics resource portal called FisOmics
- The portal hosts 5 genomic websites viz. FBIS, FishMicrosat, FMiR, Fish Karyome and HRGFish
- These databases have integrated tools for taxonomy, molecular phylogeny analysis, primer designing for SSR markers etc.
- The Institute also provides access of High-Performance Computing (HPC) for carrying out bioinformatics analysis on request basis to limited users

5.11 Initiatives in NEH region

- A total of 11 collaborating partners are involved in research and extension activities
- Established 2 live fish germplasm resource centres (Guwahati, Assam and Imphal, Manipur)
- Exploratory surveys being undertaken currently in 7 rivers of NE region including, caves of Meghalaya
- Karyotyping and chromosome preparation of endemic fishes of NE is being carried out through cytogenetic characterization of endemic fishes of North-Eastern India

5.12 Fish Disease Surveillance

- National Surveillance Programme for Aquatic Animal Diseases (States covered: 19; Collaborating centres: 31)
- Surveillance & aquatic animal disease diagnostics to help farmers reduce disease losses
- Strong network of diagnostic laboratories across the country
- Scientific advice to the fish farmers
- Nine new pathogens detected from the country for the first time
- Alerts/advisories to the stakeholders following first time report of new emerging diseases
- Phase II – recently launched

5.13 National Fish Museum & Repository

- Recognized and designated NBA as the nodal repository agency for the transfer of fish resources under Biological Diversity Act, 2002 of India
- The National Fish Museum and Repository integrates different collections like vouchers, tissue, DNA, bacteria, cell lines, fish milt
- Displays finfish voucher specimens of freshwater, marine, and brackish water environments including shellfish
- Radiographic facility to enable a comprehensive understanding of vertebrae counts, fin rays, and other osteological features

5.14 Outreach programmes – Livelihood development

- Mass awareness programs were organized at village Kalauli, Sonebhadra, Malda and Sundarbans for SC farmers including women and inputs were provided
- Promoting Indigenous Fish Culture as potential livelihood option for small and marginal SC farm families in the Mayiladuthurai district of Tamil Nadu
- Technological and infrastructure support for tribal farmers under TSP scheme in Uttar Pradesh

6. Recommendations

6.1 Sustainable utilization of biodiversity for livelihood development & conservation

- Trade-offs between biodiversity and livelihoods/human well-being need to be settled in a progressive manner
- Declaration of protected areas imposes restrictions on subsistence-based livelihoods by enacting stricter management regulations and thereby alienating local stakeholders

- Community aquaculture centers for potential fish species – region-wise for prioritized species

6.2 Genetic based approach

- Adhering basic genetic management principles - effective population sizes and minimizing inbreeding needs to be given serious thought in aquaculture practices
- Stock-specific replenishment of endangered fish species – Genetic stock structure analysis before river ranching
- Potential climate resilient management strategies must be adopted to cope up with adverse impact of climatic variability and associated stressors and to conserve fish genetic resources.
- The fish species identified as climate resilient fishes from Ganga basin using reproductive vulnerability framework and modelling can be included in aquaculture for increased profitability.
- Stations should be established for a real-time ecological data generation on important resources to generate a long-term database which will serve as a basis for management and policy decisions
- Stakeholders' inclusion in decision making process especially in the context of managing AqGR
- Combining biological data with suitable statistical tools and models - in generating meaningful projections on the impact of climate change/variability on inland fisheries.
- More research emphasis on live gene bank resources, captive breeding, resilient conservation tools, carbon sequestration and greenhouse gas emissions in aquatic system

6.3 Creation of focused awareness and practices for responsible fishing & aquaculture

- The diversity of the AqGR ensures that the needs of future generations for the supply of fish and seafood can be met, even under changing environmental conditions
- National and international agencies like FAO, NACA, APAARI to develop and create awareness on package of practices for responsible and sustainable fishing & aquaculture

6.4 Upholding Commitment

- COP15 - 30 by 30 deal (December 19, 2022)-200 countries reached an agreement at United Nations biodiversity summit to protect 30% of land and marine areas by 2030 up from currently protected 17% of terrestrial and 10% of marine areas
- Incentivize farmers to upskill and upgrade to sustainable fishery practices
- Management bodies may pay attention not only to biodiversity alone, but also to the genetic diversity important to sustainable aquaculture
- Research plans could be prioritized to address important questions such as characterization of populations, optimizing fast and efficient genotyping, evaluating environmental factors and protection approaches and estimating effects of stock enhancement programs on genetic components of wild populations

Value Addition & Supply Chain management of aquatic food products for food and nutritional security.

B. B. Nayak

ICAR – Central Institute of Fisheries Education, Versova, Mumbai – 400061

Abstract

Food security involves both quantitative and qualitative components. The quantitative component encompasses volume, while the qualitative component includes nutrient quality and food safety. In recent years, access to food, equitable distribution, rights to food, food preferences and the sustainability of production also come under the ambit of food security. The food production and distribution is directly linked to half of the sustainable development goals of united nation. Aquatic foods stand out among different foods because they are key to food & nutritional security of millions who are engaged in small scale fishing and small farming. Besides quality proteins, the aquatic foods supply many micronutrients such as calcium, phosphorous, zinc, vitamins and iodine along with omega-3 fatty acids. In other words, aquatic foods meet the complete nutritional security of millions in terms of quantity of food required with quality nutrients. However, the consumption of aquatic foods is not uniform among countries and even within the territories of countries. Therefore, the problems of equitable distribution, accessibility and affordability need to be addressed.

The blue transformation is the new vision of Food and Agriculture Organisation, which along with sustainable production, aims to upgrade the value chains to ensure the social, economic and environmental viability of aquatic food systems, and secure nutritional outcomes. The activities and the stages through which the aquatic food progresses should create enough value to benefit all the stake holders in the chain. The system that operates in India and many other under-developed nations for aquatic foods do not raise the value enough affecting the profitability as well as sustainability. The inclusion of indicators of social wellbeing and environmental health, need that the value chain be analyzed and management measures be taken so that economic gain is not at the cost of environment or rights of the stake holders. In order to improve the value chain of aquatic food products, transparency of operation, efficiency of the supply chain, value addition of the raw materials are key considerations.

The value addition of aquatic foods can precede the harvesting. The pre-harvest quality can determine the value realization. Captures from wild and from unpolluted water, when demonstrated to be so, fetch better price. Pre-harvest quality can be affected by method of culture, location of culture, types of feed used and many such factors. There are certification systems that document and certify such products leading to better value realization from the products. Sale of live fish has been a common practice in many parts of the world including India. Demonstrating a live animal is also a means of guaranteeing freshness when freshness is a component of quality. Harvesting plays important role in deciding quality and thus add value to the harvest. Aquatic animals that struggled less have delayed rigor adding to their keeping quality as well as gastronomic quality. Pre-processing after harvest can also be a quality and value determinant. Just like cold and heat shortening in animal meat, the fish meat is also affected by temperatures of slaughtering or post-slaughter holding. Though rigorous studies have not been done, research data indicates that there could be considerable saving just by manipulating pre-processing conditions. Processing method, packaging and storage conditions may also add value to the aquatic foods. Value addition otherwise is a creation of additional value by converting or improving a product to give better utility, appeal or convenience to impart better satisfaction to the consumers. Efficiency of a supply chain results in better utility of a product. The value addition therefore can happen at every step of the supply chain, improving efficiency of distribution, spread of distribution and reduce cost due to wastage while creating more value. Value addition of aquatic foods is a key step towards food security.

Present status of fish value addition in India: Constrains and Future Prospectus

Balange Amjad K.

Division of Animal, Poultry & Fisheries Science, ICAR-LARI, Assam

Introduction

Value addition to fish meat-based products implies a degree of innovation that can be acquired in terms of extended shelf life, enhanced textural properties, better sensory performance, improvements in processing, convenience and delivery of functional-based products coupled with compounds of bioactivity (Toldrá, Aristoy, Mora, & Reig, 2012). Imitation or analogue meat products endeavour to mimic explicit kinds of meat with ravishing qualities such as texture, flavour and appearance (Alexander, Brown, Arneth, Dias, Finnigan, Moran, et al., 2017).

Fish is a rich source of easily digestible protein that also provides polyunsaturated fatty acid, vitamins and minerals for human nutrition. A large proportion of total landed fish remains unused due to inherent problems related to unattractive colour, flavor, texture, small size and high fat content. Most of these fishes belong to pelagic species and some are unconventional species. A need for their conservation and utilization for human consumption has been recognized in order to prevent post-harvest fishery losses. Recovery of flesh by mechanical deboning and development of value-added products are probably the most promising approaches. These include surimi and surimi-based products. As most of the fish goes in raw and frozen form from India, the percentage of value addition i.e. ready to eat or ready to serve product is very less. Some of the important value-added fish products are discussed in the present article

Value added fish products

Surimi

Surimi is a washed fish mince and used as a base material for making different types of value-added products like fish cutlet, fish sev and fish wada, fish Kheema, etc. The initial work done on the production and sell of value-added fish products showed great business potential. Surimi, the wet concentrate of myofibrillar protein produced from under-valued fish is utilized in the creation of luxury imitation products such as lobster, crab, shrimp and scallop. The exceptional attributes (gel-forming ability, whiteness and insipid taste) of the surimi allow the various flavors to permeate into the meat and modify its aesthetic properties (appearance, texture, taste and colour). The uptake of ready to eat or ready to cook value-added fish products are radically expanding because of the demand and also due to globalization.

Surimi is a Japanese word for deboned and minced fish meat that has been washed off lipids, water-soluble or sarcoplasmic proteins, and other impurities for use in the manufacture of imitation seafood products such as imitation crab legs (Alakhrash *et al.*, 2016). In general, white lean fish such as Alaska pollock, Pacific whiting and threadfin bream which are low in lipid content are widely utilized in the preparation of surimi. Because of the over-exploitation of lean fish and decline in the surimi resources, there have been attempts to exploit new fish resources for surimi industry such as dark flesh and low cost fish. However, it is difficult to acquire high quality surimi from dark flesh fish species because of the high content of lipids and myoglobin present in the dark muscle (Arfat and Benjakul, 2013). Due to limited species resource of pollock, there have been attempts to exploit new fish for surimi industry (Mahawanich *et al.*, 2010), such as Pacific whiting (*Merluccius productus*), Yellow stripetrevally (*Selaroides leptolepis*), small pelagic sardines (*Sardinops sagax* and *S. neopilchardus*), and red tilapia (Arfat and Benjakul, 2012). In India, mostly Pink perch, Croaker, Ribbon fish, Lizard fish, Indian mackerel, Sardine, and Bigeye snapper etc. are widely used for surimi production and overexploitation of these species has resulted in depletion of the raw material and increased the value of the raw material. The global production of surimi products is about 600–700 thousand metric tons per year (Pascal, 2012). According to under current magazine, May 14, 2018, the world surimi production in 2017 was 820,000 MT. The tropical fish surimi has been reported as 480,000 MT, which has shown a decreasing trend in comparison to previous years, e.g. 500,000 MT (2014-15) as reported on April 14, 2016, clearly indicates reduction in stocks of desired raw material.

Surimi from freshwater fish

According to Galal-Khallaf *et al.*, 2016, the presence of low trophic level and aquaculture species suggests that current trends in surimi production are moving towards sustainability. The global aquaculture sector has grown continuously and contributed 44.1% to total global seafood production, where food fish production through aquaculture was 73.8 million tonnes in 2014 (FAO, 2016). Nowadays, tilapia is considered as the second most farmed finfish species after carps. The global production of tilapia in 2015 was estimated at 6.4 million metric tons (MMT), (FAO, 2017) and the Nile tilapia (*Oreochromis niloticus*) is the 6th most cultured species in the world (Reantaso, 2017). Tilapia is a prolific breeder, omnivorous, very hardy species and grows faster which makes this species as one of the candidate species for

aquaculture. MPEDA also has listed it as a candidate species of aquaculture in India. Monosex culture practices have recently increased in India (RGCA Annual Report 2014-15). There are two constraints limiting the use of tilapia fish for surimi production; Firstly, its high content of pigments and non-structural lipids which might cause a high intensity of muddy and fishy odour (Yarnpakdee *et al.*, 2014). Secondly, the poor gel forming ability which is commonly encountered with the freshwater fish proteins (Qiu *et al.*, 2013).

Gel-forming ability of myofibrillar proteins is the prerequisite to provide the excellent quality of surimi-based products. In order to augment the gel forming ability of myofibrillar proteins, elimination of endogenous proteolytic enzymes is essential. Washing is the basic stride in the creation of surimi, which enhances the quality by removing fat and undesirable substances. The number of required wash cycles depends on species, condition, type of wash, and the desired quality of the surimi end product (Carvajal *et al.*, 2005). In generation and production of 1 kg of surimi nearly around 15 kg of water is utilized (Granata *et al.*, 2012). The extensive utilization of freshwater in surimi production threatens the availability of this resource for other users and the negative impact on the environment as a result of discharging untreated processing water. So, there is a need for an eco-efficient production of surimi with reduced number of washing cycles not only to prevent environment pollution but also to maximize the yield and decrease the wash water volume. The various researches contemplated and found that all the distinctive washing media with increasing number of washing cycles is effective against increasing the quality parameters of surimi. Conventional washing in common carp, grass carp, silver carp, and tilapia was studied (Luo *et al.*, 2001, Rawdkuen *et al.*, 2009). Alkaline saline washing in sutchi catfish (Priyadarshini *et al.*, 2016) and silver carp (Zhou *et al.*, 2016) were studied with three washing cycles. Generally, it is found that freshwater fish have standard gel quality contrasted with that of marine fish. But these results differ accordingly by fish species, age, size, season, habitat, etc. Washing process concentrates the myofibrillar protein by removing sarcoplasmic proteins and protease enzymes such as cathepsins B and H except L (Hamzah *et al.*, 2015). Zhong *et al.* (2012) reported that MBSP (Myofibril bound serine protease) were more effective than cathepsin L in promoting the degradation of myofibrillar proteins, which are not exiled through washing to enhance the properties and acceptability, a variety of additives with different functions such as protease inhibitors and protein cross linkers are incorporated into surimi. Some of these additives of animal or plant origin have been forbidden due to several reasons. There is a growing demand of consumer for the utilization of natural components derived from plants in food systems to enhance the quality and restrict the use of chemical/ synthetic compounds.

Polyphenols are the secondary metabolites of plant materials which react with the side chain of amino groups of peptides covalently or non-covalently under oxidizing conditions, leading to protein- phenol cross linking (Maqsood *et al.*, 2013). Coconut husk, the mesocarpic fibrous outer portion of the coconut, is a by-product of the copra extraction process and is generally regarded as a waste (Vázquez-Torres *et al.*, 1992). The extracts from coconut husk are rich in powerful antioxidants such as catechin, which possesses pharmaceutical value. The interaction of phenolic compounds with surimi of marine fish species (Sardine) has been reported (Buamard and Benjakul, 2015; Buamard and Benjakul, 2018) but no information is reported on phenolic- protein interaction of proteins from freshwater fish such as Tilapia.

Globally cluster bean/guar (*Cyamopsis tetragonoloba*), a member of family Leguminaceae, is an important crop of arid and semi-arid regions (Kumar *et al.*, 2015). Globally, India ranks first in production of cluster bean by producing about 75–82% of the world's cluster bean. In India, with 75% of total production, Rajasthan is the top cluster bean producing state (Kumar *et al.*, 2017). Because of their natural abundance, rich in protein content, galactomannan, low cost and other desirable functionalities can be utilized in enhancing the gel strength of the surimi. Galactomannans are polysaccharides extracted from legume seeds, most widely used in the food industry. Polysaccharide–protein interactions are well documented in enhancing the gel strength and functional properties of surimi. Though the trypsin inhibitor activity was reported to be low in cluster bean extract, still can be used as a filler or extender in surimi.

In recent years, much attention has been paid to develop convenient and fresh ready-to-cook (RTC) fish-based products such as analogues products and different diversified products. These products are susceptible to chemical and microbiological spoilage during storage. To prevent these, low temperature storage accompanied with preservatives is extensively used to enhance the quality of the products. However, due to the growing concerns regarding the safety of chemical and synthetic preservatives, alternative use of natural compounds from have been increasingly employed (Hassoun and Çoban, 2017) from plant sources. The compounds extracted from plant sources are not only rich in antioxidant and antimicrobial properties but also has potential to enhance the functional properties of the surimi-based products.

Utilization of seaweeds

Seaweeds refer to any large marine benthic algae that are multi-cellular, macrothalic and thus differentiated from most algae that are of microscopic size. It includes both wild and cultivated macrophytic algae growing in saltwater. Seaweed occupy a wide range of ecological niches. They mainly occur in the intertidal and shallow waters of the sea and also in

estuaries and backwaters. Their common inhabit is the part of a sea that is close to the shore (the littoral zone) and within that zone more frequently on rocky shores than on sand or shingle. Seaweeds forms one of the most commercially important marine living renewable resources. They are classified into Rhodophyta (red), Phaeophyta (brown) and Chlorophyta (green) marine macroalgae.

Seaweeds are a part of staple diet from time immemorial in the orient as they are nutritionally rich materials; but to a much lesser extent in the rest of the world (Deleris *et al.*, 2016; Mohammed, 2016; Prabhasankar *et al.*, 2009). They are mostly consumed in countries like East Asia, e.g. Japan, China, Korea, Taiwan, and Southeast Asia. Seaweeds are commonly used in soups, salads, deserts, sushi wrapping, seasonings, condiments, vegetables, porridge, pickles and many other dishes (Ortiz *et al.*, 2006). Some of the well-known traditional foods in Japan are Nori (*Porphyra*), Kombu (*Laminaria*) and Wakame (*Undaria*) (Dharmananda, 2002). The consumption of seaweed as a result of better understanding of their health benefits has increased and spread to Western countries (Machu *et al.*, 2015). Edible seaweeds are well known for excellent source of biologically active compounds like antioxidant, dietary fibre, essential fatty acids, vitamins and minerals (Chandini *et al.*, 2008; Dharmananda, 2002; Lee *et al.*, 2008). They also contain different variety of inorganic and organic substances which can be used for human health for examples polyphenols, carotenoids and tocopherols, terpenes, ascorbic acid, alkaloid, phycobilins, polysaccharides, sterols and phycocyanins (Chanda *et al.*, 2010; Cian *et al.*, 2014). The red, brown and green seaweeds have been shown to have therapeutic properties for health and disease management, such as anticancer, antiobesity, antidiabetic, antihypertensive, antihyperlipidemic, antioxidant, anticoagulant, anti-inflammatory, immunomodulatory, antiestrogenic, thyroid stimulating, neuroprotective, antiviral, antifungal, antibacterial and tissue healing properties in vivo (Kumbhar *et al.*, 2014; Mohamed *et al.*, 2012). Protein content of seaweeds varies from 5-10% (brown algae) to 30-40% (red) of dry matter. It has little fat content, ranging from 1-5% (d/w), although seaweeds lipids have a higher proportion of essential fatty acids compared to terrestrial plants. They are the extraordinary source of the minerals and account upto 36% of its dry weight. Seaweed has high fibre content, making up 32-50% of dry matter (Dharmananda, 2002). Several seaweeds have been authorized for human consumption. So, they become important vegetable (fresh or dried) and food ingredient in the human diet (Fleurence, 1999).

Seaweeds are mainly used for food, confectionary, feed, fertilizer, medicine, cosmetics, textile, paper, leather and major sources of Phycocolloids (agar, carrageenan and alginates). The most widely known seaweed used for food is *Porphyra*. Seaweeds are also used as gelling and thickening agents in the food or pharmaceutical industries. Although previously the seaweeds were used as food additives, recent researches have revealed their potential as complementary medicine. In India, seaweeds are used as raw materials for the manufacture of agar, alginates and liquid seaweed fertilizer (Kaliaperumal *et al.*, 2004). Currently, there are 46 seaweed based industries – 21 agar and 25 alginate – but not functioning up to their rated capacity, as there has been a short supply of raw materials. Among the 21 agar factories, only ten are presently functioning (Subba and Mantri, 2006).

The total aquatic plants (mostly seaweeds) production in the year 2012 was around 23.8 million tonnes (wet weight) from aquaculture, while capture production was 1.1 million tonnes (FAO, 2014). India, having a coastline of 8,129 kms, is rich in algal biodiversity and highly diversified and comprises mostly of tropical species. Out of approximately 700 species of marine algae found in both inter-tidal and deep water regions of the Indian coast, nearly 60 species are commercially important (Mohammed, 2016). The production of total seaweeds in India in 2000 was approximately 600,000 tons (wet weight) (Khan and Satam, 2003). In all, 271 genera and 1153 species of marine algae, including forms and varieties have been enumerated till date from the Indian waters (Subba and Mantri, 2006). They are found in all along the coast of India. Despite of having vast seaweed resources, major quantity of seaweed is still remained unutilized in India.

Extrusion is a method of continuous food processing in which raw food materials are thermo-mechanically cooked in a screw barrel assembly by a combination of moisture, pressure and temperature in order to be mechanically sheared and shaped (Riaz, 2001). Extrusion can be categorised as a high temperature short time (HTST) processing. It is one of the most important food processing technologies which have been used since the mid 1930s for the production of breakfast cereals, ready to eat snack foods, and other textured foods (Brennan *et al.*, 2011; Singh and Heldman, 2014). The thermo mechanical action during extrusion brings about starch gelatinization, protein denaturation and inactivation of enzyme, microbes and many anti-nutritional factors, all this occur in a shear environment resulting in a plasticized continuous mass (Bhattacharya and Prakash, 1994). There are several advantages of extrusion process and one of this is that HTST process can minimize heat degradation of food, nutrients, while improving digestibility by gelatinizing starch and denaturing protein (Harper, 1981). During extrusion process various process or design variables work together such as screw speed, temperature of barrel, feed mixture ratio, moisture content of feed etc., and non-design variables such as expansion ratio, bulk density, final product moisture, longitudinal expansion index and other physical and sensory properties (Pansawat *et al.*, 2008). Due to high number of design and non-design variables

multivariate analysis or response surface methodology (RSM) is applied for extrusion process optimization (Garg and Singh, 2010).

Snacks foods have become an integral part of the diet of majority of the world's population and extrusion cooking is one of the major process for producing expanded snack foods (Pankyamma *et al.*, 2014). However, as starch is the main constituent of the extruded snacks and is responsible for most of their structural attributes, they are dense in energy but are nutritionally poor and it gives a possibility to add some beneficial nutrients to them (Dehghan *et al.*, 2010). Currently, fortification of routine foods with various bioactive compounds is quite common. The development of composite extruded products by mixing starchy raw materials with other products has been an alternative for getting products with better sensory, physicochemical and nutritional characteristics (Guy, 2001). Fortification of foods with nutraceuticals has become popular as a method to increase the nutritional level in food products to meet the demands of health-conscious consumers (Shahidi and Ambigaipalan, 2015). So incorporation of seaweeds as a functional food to the extruded snacks will increase its nutritional level and also will give a great opportunity to promote the consumption of seaweeds as food in India. Functional foods have become a relatively new component of the human diet. Now a days, increased consumer interest in healthier food products is driven by a variety of factors including growing awareness of the link between diet and health, the desire to age 'gracefully' by maintaining good health, greater convenience in meeting nutritional needs and preventing chronic diseases such as diabetes, cancer, cardiovascular diseases and respiratory diseases. Consumers are more conscious of the maintenance of good health through diet, thereby gravitating towards foods that offer additional benefits beyond that provided by conventional food. Interest amongst policy makers in the functional foods industry is also increasing, due to rising public health consciousness (Malla *et al.*, 2013).

Constrains and future prospectus

Though there is tremendous market potential for value added fish products in Indian market, it has not been explored aptly by the Industry and other stake holders. Several value-added fish products have been developed by the different fisheries colleges and Institutes in India but it needs to be reached in the market through industry partners. Efforts are therefore required to refine the technology developed for different value-added fish products by the Colleges and Institutes to make it market ready and building the confidence in the Industry to buy these kinds of technologies. A value chain has to be strengthened by building infrastructure in the form of cold storages, ice plants, procurement of sophisticated machineries etc with some financial assistance from Govt which can attract more industry partner. There is also a need of massive media campaign for popularizing these value-added fish products among the common people in India with major focus on health benefits by fish consumption.

Different avenues in aquaculture and Fisheries

Prof. Hemendra Kumar Vardia

Retd. Dean Fisheries, Chhattisgarh

Abstract

The fisheries and aquaculture in particular is one pretty large industry that accommodates several avenues. It is a known fact that a lot of people are making money in the fisheries area because fishes and fish based products are eaten all across the globe. Advancement in farming technology has shown that location is not a barrier in starting a fishery related business. If you are looking towards leveraging on the fish related industry to generate huge income, then there are many fish related business and service opportunities. Fisheries entrepreneurship can be grown by conducting market research and feasibility studies, in any part of the world to pitch your business.

High value high volume species e.g. Tilapia, Pangasius, carps, prawn, shrimps, etc and low volume species' like groupers, snappers, lobsters and crabs etc. are preferred for farming over others for better revenue through local sale and export. The utilization of submerged areas to undertake aquaculture activities especially for fish and shrimp farming can be taken up. Importance of hygienic handling of fish catch from the level of harvest to marketing for better export earnings and reduction of post-harvest loss is another avenue. Fisheries sector with its important role played in the socioeconomic development of the country has become a powerful income and employment generator and stimulates the growth of a number of subsidiary small, medium and large scale industries.

Now, majority of schemes support operations on business projects as a measure of enhancing the foundation for new technology based industries and establishing a knowledge-based economy. It focuses on harnessing new ways of doing business in fisheries and allied fields by finding doors to unexplored markets. Various incubation centres help prospective entrepreneurs, by providing pro-active and value-added business support in terms of technical consultancy, infrastructure facility, experts' guidance and training to develop technology based business ideas and establish sustainable enterprises. It acts as a platform for the speedy commercialization of the technologies developed by research organisations, through an interfacing and networking mechanism between research institutions, industries and financial institutions. The Incubator at various institutions differs from traditional business incubators as it is tailored specifically for technology based industries and is operational at an area with a high concentration of fish production. This industry specific incubator also allows new firms to tap into local knowledge and business networks that are already in place. Their services are offered to industries all over India through virtual incubation. Beyond promoting business growth, the incubation centres are also trying to bring its benefits to all the fisheries communities in India.

In addition to farming, fish processing and value addition has evolved over the years as the sunrise sector in agriculture domain. Globally many new species are being introduced in the aquaculture sector. A comprehensive study on the suitability of these species for value addition has to be carried out to propose optimized utilization protocols. Functional fish products will be in much demand in future; the challenge will be to retain the functional benefits of fish & shellfish meat by way of adopting product specific processing protocols or alternate delivery systems for sensitive components. These issues offer ample scope for Innovation coupled with entrepreneurial skills for the creation of wealth and employment in fisheries sector.

Some fishery related business ideas an entrepreneur or as an employee can choose from, are as follows:

A. Farming business/ Culture of various fish species

1) Carp farming, 2) Tilapia farming, 3) Catfish farming, 4) Shrimp farming, 5) Prawn farming, 6) Farming of salmon, 7) Farming of minnows, 8) Farming of ornamental fish, 9) Oyster farming, 10) Crayfish farming, 11) Abalone farming, 12) Trout farming, 13) Farming of Crustaceans, 14) Mollusc farming, 15) Clam farming, 16) Farming other species (e.g. Seaweed, Alligators, Frogs and Turtles), 17) Farming in cages, 18) Farming in pans

B. Farming allied business

1) Open a fishing tools and accessories store, 2) Construction of aquariums & start selling Aquariums, 3) Open a fresh fish shop, 4) Start a pond construction business, 5) Sale of fish medications and nutrients, 6) Production of fish medications and nutrients business, 7) Offer vet services to fish farms, 8) Fish feed plant & sale, 9) Manufacture of pond ameliorates, 10) Cage & net manufacture, etc.

C. Processing & value addition

1) Start a fish processing plant, 2) Fishing vessels and boat production plant, 3) Start a fishing vessel and boat rental business, 4) Start breeding and selling baits, 5) Start a fish smoking business, etc.

D. Fish capturing

- 1) Traditional fishing, 2) Fishing in coastal sea, 3) Fishing in offshore sea, 4) Deep sea fishing, 5) Fishing in reservoirs, 6) Fishing in rivers, etc.

E. Fishing allied business:

- 1) Fishing competition business, 2) Fish and pay or catch and release business, 3) Manufacture & supply of ice to fishers, 4) Fishing net repair shop, 5) Start a fishing vessels and boats servicing and repair business, 6) Production of hooks, floaters, fishing nets, and fishing lines, etc.

F. Sale of fish

- 1) Live fish sale, 2) Sale of iced fish, 3) Sale of frozen fish, 4) Sale of dressed fish, 5) Sale of ready to eat fish, 6) Sale of processed fish products, 7) etc.

G. Fishery ancillary businesses:

- 1) Fish photography business, 2) Fish documentary business, 3) Fishing blog or fish magazine, 4) Writing books about fish and fishing, 5) Running a fishing club for kids, etc.

H. Seed Production / Hatchery business

- 1) Fish seed production, 2) Crustacean seed production, 3) Mollusc seed production, etc.

I. Service sector in fisheries & aquaculture

- 1) Hatchery operator, 2) Hatchery Manager, 3) Marketing executives, 4) Sales executives, 5) Fishers, 6) Business managers, 7) Fish processors, etc.

J. Fishery Education & Research services

- 1) Indian Council Agricultural Research Services, 2) State Agricultural Universities, 3) State Fishery Departments, 4) Forest service's: Central & state, 5) Administrative services: state & central, 6) Banks, 7) NABARD, 8) Wildlife & Biodiversity Boards, etc. 9) Water pollution Departments: Central & state, 10) State Fisheries Corporations, etc.

The Prospect of Higher Education in the Fisheries Sector

Dr. Shivendra Kumar

College of Fisheries, Dholi (Muzaffarpur), Dr. Rajendra Prasad Central Agricultural University, Pusa

Introduction

Global fish output has surpassed 178 million metric tonnes, with a total value of USD 281.5 billion. Aquaculture produces a significant portion of the fish sold in international markets and has been the world's fastest-growing food production sector for more than 40 years. From 9.9 kg in 1960, the estimated worldwide fish consumption is predicted to increase to 22 kg per capita by 2024. However, this anticipated growth conceals a growing global disparity in fish consumption, with the poor continuing to consume little of it worldwide. International governments must think about how to increase the availability of fish to the poor on a sustainable basis to address this issue. Fisheries and aquaculture are not only a source of money and good health, but they also provide millions of people with employment and a way of life.

Food Security in India

India's population has hit 1.408 billion people and is set to surpass China this year. India must focus on agriculture if it wants to attain its aim of national food security. The backbone of India's economy is agriculture, with over 70% of the people working in associated industries. In India, the incidence of undernutrition is 16.3%, according to the Global Food Security Index 2022. Additionally, 33.4% of Indian children are underweight, 33.9% are stunted, and 3.8% are considered under obesity. The human development index for India is 0.65 (The Financial Express, 2023). According to United Nations population forecasts, India's current population would increase by 0.3 billion by 2045. As a result, in the following three decades, the nation will have to feed 1.5 billion additional mouths. Without quick remedial action, the yearly per-capita availability of foodgrains and nutrients may further decline. The growing population makes it impossible to rely solely on cereals and pulses to provide the necessary amount of dietary protein. Expanding the production of grains and pulses may not also be beneficial for India. To boost food grain production to a level that can support the population boom, policymakers are aiming for a second green revolution. We should thus take use of the potential of cattle and fisheries to satisfy our need for dietary protein as well as other nutritional needs. Despite the fact that Indians consume a substantially lower percentage of fish in their diets, the fishing industry, particularly aquaculture, has the potential to play a key role in the future supply of animal protein. Compared to other agricultural commodities like meat, food grains, pulses, milk, and eggs, cultured fish is now the one that is growing the quickest, and there is limited room to increase output of marine fisheries, which have already reached a plateau. As a result, aquaculture is crucial to guaranteeing the nation's food and nutritional security.

Fish Production in India

Fisheries is a rising industry with a variety of resources and potential, employing more than 14.50 million people at the primary level and many more throughout the value chain, according to the Annual Report 2022–23 (DOAHDF). The total fish production during FY 2022-23 is estimated at 16.25 MMT with a contribution of 12.12 MMT from the Inland sector and 4.13 MMT from the Marine sector. The export earnings from the sector registered at Rs. 57586.48 crores in 2021-22 (US \$ 7.76 billion). In 2021–22, according to the DOAHDF (2022-23), the industry contributed around 1.09% to the national GVA and 6.72% to the agricultural GDP.

Production	
Total fish (million tonnes/ year)	16.25
Inland fisheries sector (million tonnes/ year)	12.12
Marine sector (million tonnes/ year)	4.13
Export earnings	Rs. 57586.48 crores
Contribution	
National GVA (%)	1.09
Agricultural GDP (%)	6.72

Despite the Blue Revolution, one-fourth of the world's hungry and impoverished people still reside in India. In addition, the gap between total factor productivity and greater yield productivity in our food and agriculture system will likely double by 2050. According to studies, by 2030, only 59% of India's total demand for food and agricultural products will be satisfied due to declining land, water, and biodiversity assets, rising market volatility, and other factors (Fifth Deans' Committee Report, ICAR, 2017).

System of Fisheries Education

Currently, fisheries education is provided at three levels in the country: primary (school), secondary (undergraduate), and tertiary (postgraduate). Fisheries education at three levels is required primarily to:

- carry out developmental, research, and educational activities.
- carry out high-level extension activities to facilitate technology transfer.
- Supply decision makers from the lowest level of government (Gram Panchayat) to the highest level of government (Department, Corporations, Agencies, and Ministries).

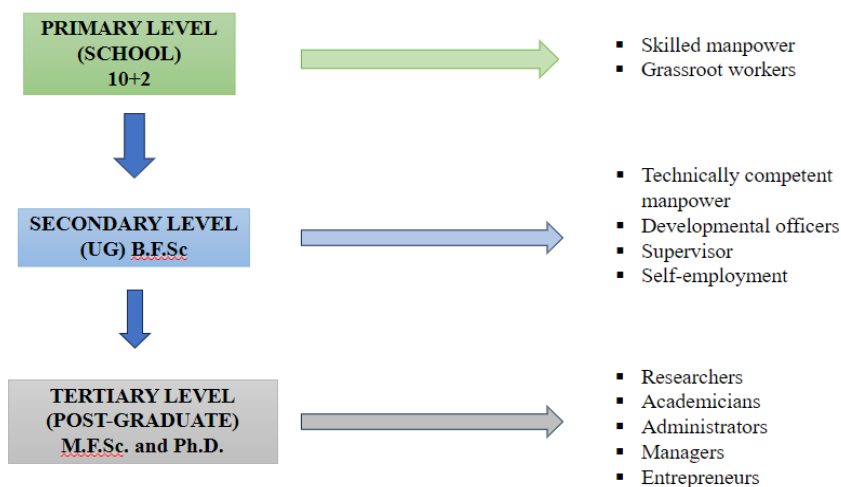


Figure 1: System of Fisheries Education in India

Higher Education in Fisheries Science

In India, professional fisheries education began somewhat later than veterinary and agricultural education. With the establishment of the first Fisheries College in Mangalore in 1969 under the patronage of the University of Agricultural Sciences, Bengaluru, a new era in professional fisheries education in India's State Agricultural/Veterinary Universities began. 31 professional fisheries colleges in India, including State Agricultural Universities, three Central Universities, and one deemed-to-be university, ICAR- Central Institute of Fisheries Education, Mumbai. Institutes offering higher education (Master and Ph.D) in fisheries science in India is illustrated in Table 1.

Table 1: Institute offering higher education in Fisheries Science

Sl. No.	Institute Name	University Name
01.	College of Fisheries, Mangalore (Karnataka)	Karnataka Veterinary, Animal & Fisheries Sciences University, Bidar
02.	Fisheries College and Research Institute, Thoothukudi (Tamil Nadu)	Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Nagapattinam
03.	College of Fisheries, Panangad (Kerala)	Kerala University of Fisheries & Ocean Studies, Kochi
04.	College of Fisheries, Ratnagiri (Maharashtra)	Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli
05.	College of Fisheries, Berhampur (Odisha)	Orissa University of Agriculture & Technology, Bhubneshwar
06.	College of Fisheries, Pantnagar (Uttarakhand)	Govind Ballabh Pant University of Agriculture & Technology
07.	College of Fisheries, Dholi (Bihar)	Dr. Rajendra Prasad Central Agriculture University, Pusa, Bihar
08.	College of Fisheries, Raha (Assam)	Assam Agricultural University, Jorhat
09.	College of Fisheries, Veraval (Gujarat)	Junagadh Agricultural University,
10.	College of Fisheries, Nellore (Andhra Pradesh)	Sri Venkateswara Veterinary University (SVVU), Tirupati
11.	Faculty of Fisheries Science, Kolkata (West Bengal)	West Bengal University of Animal & Fishery Sciences, Kolkata
12.	College of Fisheries, Lembucherra (Tripura)	Central Agricultural University, Imphal,

13.	College of Fisheries, Udaipur (Rajasthan)	Maharana Pratap University of Agriculture & Technology, Udaipur
14.	Faculty of Fisheries, Srinagar (Jammu and Kashmir)	Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir
15.	College of Fisheries, Faizabad (Uttar Pradesh)	Narendra Dev University of Agriculture & Technology, Kumarganj, Faizabad, U.P
16.	College of Fishery Science, Telankhedi, Nagpur (Maharashtra)	Maharashtra Animal & Fishery Sciences University, Nagpur
17.	College of Fishery Science, Udgir (Maharashtra)	Maharashtra Animal & Fishery Sciences University, Nagpur
18.	College of Fisheries, Ludhiana (Punjab)	Guru AngadDev Veterinary & Animal Sciences University
19.	College of Fisheries, Kawardha (Chhattisgarh)	Chhattisgarh Kamdhenu Vishwavidalaya, Durg
20.	College of Fisheries Science, Jabalpur (Madhya Pradesh)	Nanaji Deshmukh Veterinary Science University, Jabalpur
21.	Tamil Nadu Dr. M.G.R. Fisheries College and Research Institute, Ponneri (Tamil Nadu)	Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Nagapattinam
22.	College of Fisheries, Navsari (Gujarat)	Navsari Agricultural University, Navsari
23.	College of Fisheries Science and Research Campus, Etawah (Uttar Pradesh)	Chandra Azad University of Agriculture and Technology, Kanpur
24.	College of Fisheries Engineering, Nagapattinam (Tamil Nadu)	Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Nagapattinam
25.	College of Fisheries Science, Gumla (Jharkhand)	Birsa Agriculture University, Ranchi
26.	College of Fishery Science, Pebbair (Telangana)	P.V. Narasimha Rao Telangana Veterinary University, Pebbair
27.	Dr. M.G.R. Fisheries College and Research Institute, Thalainayeru (Tamil Nadu)	Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Nagapattinam
28.	Postgraduate Institute of Fisheries Education and Research, Gandhinagar (Gujarat)	Kamdhenu University, Gandhinagar
29.	Institute of Fisheries Postgraduate Studies, Vaniyanchavadi, Chennai (Tamil Nadu)	Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Nagapattinam
30.	Central Institute of Fisheries Education, Mumbai (Maharashtra) Established: 1961	Deemed-to-be-University
31.	College of Fisheries, Kishanganj (Bihar)	Bihar Animal Sciences University

Research in Fisheries Sector

Through a network of Research Institutes, including the Central Inland Fisheries Research Institute (CIFRI), Barrackpore, the Central Marine Fisheries Research Institute (CMFRI), the Central Institute of Fisheries Technology (CIFT), the Central Institute of Fisheries Education (CIFE), and the Central Institute of Brackish water Aquaculture, Chennai; Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar; National Bureau of Fish Genetic Resources (NBFGR), Lucknow and Directorate of Cold Water Fisheries Research (DCFR), Bhimtal; the Indian Council of Agricultural Research is leading national programmes on aquaculture and fisheries research, higher education, and frontline extension. Additionally, the State Universities of Agriculture and Fisheries are working on top-notch research projects for the advancement of Indian aquaculture and fisheries. With the support of these Institutes and Universities' research, aquaculture development in the nation has greatly improved productivity and output from a variety of water bodies, accelerating the sector's rate of expansion.

In addition to this, possibilities for resource management-focused employment are emerging to preserve natural resources and create sustainable production systems. Opportunities are quickly developing in fields including aquacology in animal conservation, remote sensing, satellite & GPS applications in fishing fish discovering resource mapping, and programme analysis in Android apps. Aquaculture engineering and technology offer several potentials for the structural and environmental management of biological and mechanical systems. Professionals in aquaculture engineering are employed in farm operations, the production of bio-fuels, and sectors like testing, sales, and technical support.

Development of study abroad programs

Developing nations must choose where and how to train the upcoming generation of fisheries educators and researchers. Looking at how Japan evolved after opening to the world after the Meiji Restoration in the late 1860s

following 200 years of seclusion offers a lesson. In order to learn about new agricultural practices and crops, Japan dispatched a sizable mission to the USA and Europe. It also recruited professors from the east and sent more than 600 Japanese students abroad to further their studies. In the 1960s, India adopted this training methodology. The different Governmental scholarships across the globe are shown in Table 2. According to a significant analysis of international graduate education, there is a "net gain for the countries whose citizens travel abroad for advanced training and education."

Table 2. Governmental Scholarships across the Globe

Sl. No.	Country	Fellowship
01.	Germany	DAAD (https://www.daad.de/de/)
02.	Netherland	Study in Holland (https://www.studyinnl.org/)
03.	Finland	Study in Finland (https://www.studyinfinland.fi/)
04.	Belgium	Vliruos (https://www.vliruos.be/en/home)
05.	Australia	Australia Award Scholarship (https://www.dfat.gov.au/people-to-people/australia-awards/australia-awards-scholarships)
06.	South Korea	Study in Korea (https://www.studyinkorea.go.kr)
07.	Singapore	SINGA (https://www.a-star.edu.sg/Scholarships)
08.	New Zealand	MFAT (https://www.sit.ac.nz/International/International-Student-Scholarships/MFAT-Scholarships)
09.	Hong Kong	https://www.studyinhongkong.edu.hk/en/
10.	China	Chinese Scholarship Council (https://www.chinesescholarshipcouncil.com/)
11.	Japan	Monbukagakusho (Ministry of Education, Culture, Sports, Science and Technology) Scholarship programme (http://www.studyjapan.go.jp/en/toj/toj0302e.html) 2 for PG and 5 for UG students

Table 3: Currently approved European Master programmes in the field of maritime and aquatic sciences

Title	URL
EMBC ((Erasmus Mundus Master of Science in Marine Biodiversity and Conservation)	embc.marbef.org
Comem Erasmus Mundus MSc (Coastal and Marine Engineering and Management)	www.comem.tudelft.nl
EURO-AQUAE (Euro Hydro-Informatics and Water Management)	www.euroaquae.org
European Joint Master in Water and Coastal Management	www.ualg.pt/EUMScWCM

Scope of Job Opportunities in the Fisheries Sector

As far as job opportunities are concerned the field of fisheries offers various job opportunities related to the management, research, conservation, and commercial aspects of aquatic resources. In a broad spectrum, the various job opportunities offered by the sector can be enlist as Fisheries Biologist, Aquaculture Manager, Fisheries Officer, Fishery Technician, Fishery Extension Officer, Fishery Economist, Fishery Policy Analyst, Fishery Conservationist, Seafood Quality Assurance Manager, Fishery Educator, etc.

These are just a few examples of job opportunities in the field of fisheries. The specific job titles and responsibilities may vary depending on the organization, location, and specific focus of the work.

- i. **Aquaculture Farming:** Start your aquaculture farm where you can raise and breed fish, shellfish, or other aquatic organisms for commercial purposes. This can involve freshwater or marine aquaculture, depending on your expertise and local resources.
- ii. **Fish Processing and Packaging:** Establish a fish processing and packaging facility where you can prepare and package fish products for distribution to restaurants, supermarkets, and other buyers. This can include filleting, freezing, smoking, or canning fish.

- iii. **Seafood Export/Import:** Become an intermediary between seafood producers and international markets by establishing an export/import business. You can source high-quality seafood from local fisheries and supply it to global buyers or import seafood products that are in demand domestically.
- iv. **Fish Feed Production:** With the growing demand for aquaculture, there is a need for high-quality fish feed. You can set up a fish feed production facility and manufacture nutritious and sustainable feeds for fish farmers.
- v. **Fisheries Consultancy:** Offer your expertise as a consultant to fisheries companies, government agencies, or NGOs. You can provide advice on sustainable fishing practices, fish stock management, regulatory compliance, and environmental impact assessments.
- vi. **Fish Farm Equipment and Technology:** Start a business that supplies fish farmers with essential equipment and technology such as fish cages, nets, aeration systems, water quality monitoring devices, and automated feeding systems.
- vii. **Ecotourism and Recreational Fishing:** If you have access to scenic coastal areas or freshwater bodies, you can establish an ecotourism business that offers fishing experiences to tourists. This can include guided fishing trips, boat rentals, and accommodation services.
- viii. **Fish Health and Disease Management:** Become a specialist in fish health and disease management. You can provide services such as disease diagnosis, treatment, and prevention strategies to fish farmers.
- ix. **Research and Development:** If you have a passion for scientific research, you can pursue a career in fisheries research and development. This can involve working for research institutions, universities, or private companies to develop innovative solutions for sustainable fisheries and aquaculture.

Suggestions to improve Higher Education in Fisheries Science

Constituting about 7.96% of the global fish production and export earnings of 57586.48 crore (2021-22), India has become the second largest aquaculture nation in the world. Foreseeing the huge scope for employment and to bridge the demand supply gap, experts feel the need to have more seats in colleges offering programme in fisheries. The industry currently needs around 25000 experts while professional fisheries colleges cannot produce more than 1000 graduates annually. In the current scenario, India has close to 35 ICAR approved colleges offering various courses in fisheries. Moreover, increasing the seats and streamlining the curriculum, there is a need to improve the existing infrastructure, so that the quality of graduates is not compromised. The approach to enhance the current status of fisheries education in India includes different streams of the sector like academic, research, human resource, industry, etc. The industry-institute consortia gaps should be identified. The mismatch occurring between the skills required by the industry and the manpower skills available has to be worked out and rectified. Self-employment and entrepreneurship ventures in fisheries are very rare because of its capital- and labour-intensive nature. This can be overcome by introducing entrepreneurial training programs, study circles, tracking programs, human resource management programs, business management programs, etc., which will certainly be beneficial to students.

Conclusion

The analysis of educational programs, the main degree programs and the features of the formation of students' professional competencies is carried out. It is noted that the high level of graduates' training and their demand in the labour market are due to the active development of the fishing industry in the region. Also, a well-organized educational process using a modern scientific and production base and high-quality, practical training at the enterprises of the fisheries complex has a significant impact on the formation of personnel. International cooperation in aquaculture and fisheries education is still predominantly managed by individual institutes or local partners but is increasingly regulated on a European level for instance through the ERASMUS Mundus programme of the European Commission. Finally, international education cooperation is evolving from pure development cooperation to cooperation with mutual benefits between equal partners, a reassuring notion.

Blue growth through aquaculture of introduced exotic catfish in India: Issues and Challenges

Dr. Atul K. Singh

National Bureau of Fish Genetic Resources, Canal Ring Road, P.O. Dilkusba Lucknow-226002 Uttar Pradesh, India

Abstract

Striped Catfish *Pangasianodon hypophthalmus* (Sauvage) and African Catfish *Clarias gariepinus* (Burchell, 1822) are the two popular exotic fish introduced to India being native to Vietnam and north Africa respectively. They are widely and intensively cultured in several parts of the country including coastal areas and foot hills (Singh and Lakra, 2011; Singh and Lakra, 2012). The *P. hypophthalmus* was officially introduced during 2008 while *C. gariepinus* was introduced illegally during 1994 (Singh and Lakra, 2011). Striped Catfish *Pangasianodon hypophthalmus* is largely cultivated in the states of Andhra Pradesh and Telangana yet its culture is now available in many states such as Kerala, Tamil Nadu, Karnataka, Maharashtra, Odisha, Chhattisgarh, Uttar Pradesh, Bihar and north eastern states. On the other hand, African catfish is cultured in almost entire country including coastal areas and foothills of Himalaya. The state of West Bengal happens to be the hub of seed production for both the fish while other states have also now developed hatcheries for their breeding and seed production. Ponds, cages and pens are three major production systems for *P. hypophthalmus* in India cultivating over 0.855 metric million tons by 2018 (Figure 1) whereas African catfish is cultured mainly in ponds, tanks and cement cisterns feeding on slaughterhouse waste and chicken wastes (Singh et al., 2012) and there is no official records of its aquaculture production. The production level of pangasius is very high and is produced in the range of 56-70 tons/ha or even more (Belton et al., 2017). However, there is no authentic record of the over-all production level of *C. gariepinus* in the country yet it is recorded that 20 to 30 tons/ha/ye is the usual range of its production (Singh et al., 2015). Today, these introduced exotic fish species are flourishing under aquaculture on large scale basically due to the fact that they grow fast (Figure 2) and require easy farm operations and thus involve large number of farmers to practice their culture (Singh and Lakra, 2011; Singh et al., 2015; Singh and Lakra, 2012; Belton et al., 2017). The recently launched Pradhan Mantri Matsya Sampada Yojana (PMMSY) a scheme to bring about second Blue Revolution through sustainable and responsible development of fisheries in India (NFDB 2017, 2020) has encouraged the aquaculture of pangasius *P. hypophthalmus* having high production and market potential such. Accordingly, NFDB invited tender for procuring quality fry and fingerlings of *P. hypophthalmus* from hatchery producers for its supply to different states vide letter no NFDB/Supply of Pangasius seed /2022-23 dated 16/09/2022.

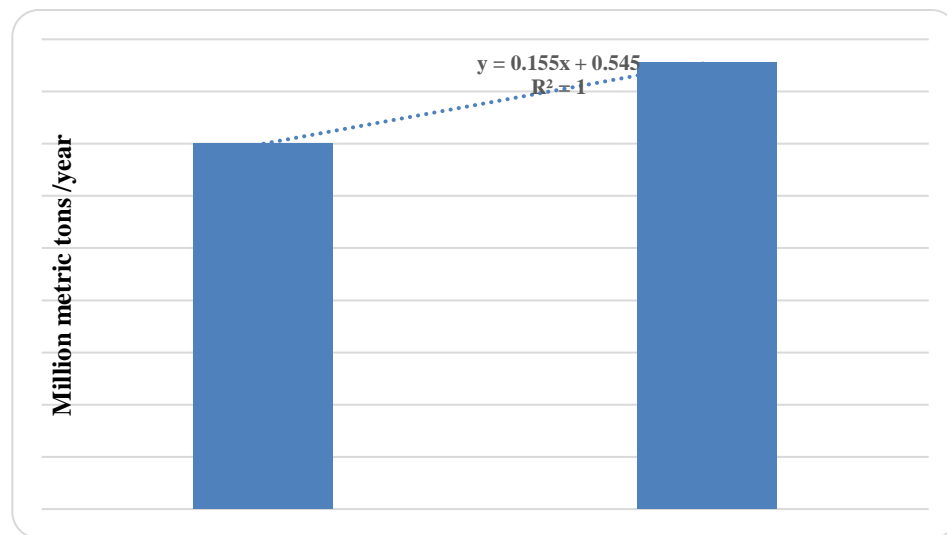


Figure 1: Contribution of *Pangasianodon hypophthalmus* in Indian aquaculture

In the country, culture practices, seed production, improved feed and live transportation of *P. hypophthalmus* have been accomplished to make pangasius industry viable (Belton et al., 2017). On the other hand, culture of African catfish is considered as good scavenger and is produced to recycle slaughterhouse waste and chicken waste making the culture production easy (Singh et al., 2012). Inland cage culture further, offers new opportunities for optimizing *P. hypophthalmus* in reservoirs, lakes, floodplain wetlands and for developing new skills among fishers and entrepreneurs to enhance their incomes.

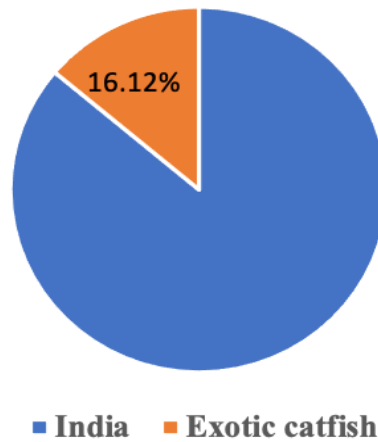


Figure 2: Contribution of introduced exotic catfish in Indian aquaculture

Development measures of modern culture standards, food safety, green certification and safe processing are the emerging issues. The government through regulatory guidelines supported the pangasius production in India while restricting the African catfish culture yet limited success could be realized in mitigating the environmental and social impacts. In this paper, it was attempted to generate information from available publications and also from my own field experiences to assess ecological, technological, biodiversity and regulatory issues of the expanding aquaculture production of *P. hypophthalmus* and *C. gariepinus* in India. In this paper these issues have been analysed and possible management aspects have been addressed for sustainability. It is suggested that culture practice of *P. hypophthalmus* should be improved on the lines of standards laid down by the Aquaculture Stewardship Council (ASC) while culture of *C. gariepinus* should be restricted through strict enforcement and legislation.

Keywords: *Pangasianodon hypophthalmus*; *Clarias gariepinus*; aquaculture; sustainability; risks; regulations

Resource Distribution, Eco-tourism and Conservation of Mahseer (*Tor*, *Neolissochilus* and *Naziritor spp.*) in India

Dr. Debajit Sarma

ICAR-Central Institute of Fisheries education, Mumbai

Abstract

Mahseer, the king of freshwater scaly fish belong to the important genus *Tor*, *Neolissochilus* and *Naziritor* are distributed in the entire IHR (Indian Himalayan region) and peninsular region. The importance of mahseer as a world famous game and sport fish is well known. Keeping the importance of this fish in IHR and peninsular rivers, streams and lakes, mahseer is considered as the flagship/bioindicator species in fresh water eco-system. However, the population of this magnificent fish is declining in natural water bodies and it is considered as an endangered fish (golden mahseer) as per IUCN status due to various natural and anthropogenic factors. Therefore, knowledge information regarding habitat distribution and its sustainable management, standard protocol for breeding and hatchery management is necessary for improving the status of the fish. The technology for breeding and hatchery management of golden and chocolate mahseer has been developed to attain year round availability of mahseer seed in captive condition, which will be discussed in detail in this talk. The breeding biology in terms of ultrastructural and histological changes in the embryonic and larval surface during organogenesis of the endangered golden mahseer has been studied and will be presented. Significant success stories will be highlighted in the presentation in terms of establishment of fish sanctuaries, hatcheries, mahseer watching and eco-tourism centre in different parts of India. The talk embodies the present status of mahseer diversity, its breeding biology, hatchery management practices and eco-tourism avenues of mahseer, so as to take appropriate steps to mitigate the challenges for its rehabilitation and conservation.

Fish as food and nutrition security

K. C. Dora

Department of Fish Processing Technology, Faculty of Fishery Sciences, West Bengal University of Animal and Fishery Sciences Kolkata, West Bengal

1. Introduction

Fish make an irreplaceable contribution to food and nutrition security. Global capture fisheries output is static, but aquaculture is growing rapidly. Capture fisheries remain the most important source of fish for many poor people. The two sectors' contributions to food and nutrition security are highly complementary. Nutritional security is defined as a situation that exists when all people, at all times, have physical, social, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Considering the role of fish for nutritional security it not only forms a source of protein but also a source of healthy fat and essential macronutrients namely long-chain omega-3 fatty acids, iodine, Vitamin-D and calcium. Consuming fish in the diet increases the amount of iron and zinc that the body absorbs from other foods. Inland fish is a low cost source of fish for the rural poor to reside in non-coastal areas. The benefits of eating fish include: a lower risk of chronic diseases such as cardiovascular disease, better maternal health during pregnancy and lactation, better physical and cognitive development in early childhood, and mitigation of health risks associated with anaemia, growth disorders, and blindness in children. The nutritional value of fish gives it the potential to combat the triple burden of malnutrition, overweight and obesity, and micronutrient deficiencies. In low-income food-deficit countries and least developed countries, fish can therefore play an important role in improving food security and the nutritional status of individuals, where populations may be overly dependent on a relatively narrow selection of staple foods, which cannot provide adequate amounts of essential amino acids, vitamins, micronutrients and healthy fats.

1.1. Fish as a food and its health benefits covering the nutritional security

As a food product, fish is of greater importance in developing countries where it accounts for 75% of the daily animal protein, referred to as "rich and poor food" as an important companion. Compared with other animal protein sources, fish is readily available even in poorer communities at a relatively cheaper price. Furthermore, fish production through aquaculture is considered sustainable and the most efficient way to produce high quality proteins for human consumption.

1.2. Fishery resources and its consumption pattern

Fish is very crucial to a nutritious diet in many areas across the world and it provides about 3.3 billion people with almost 20% of their average per capita intake of animal protein. As the global population increases, potential nutritional concerns are raised, and fish represents an important source of animal protein. For this reason, global fish for human consumption is projected to increase by 16.3% indicating that 90% of the fish being produced will be utilized for human consumption by the year 2029. In 2018, fish accounted for about 17% of the total animal protein and 7% of this was animal protein consumed globally. The consumption of fish and the fish products has experienced major changes in the past decades. The world evident per capita fish consumption has been increasing steadily from an average of 12.5 kg in the 80's to 14.4 kg in the 90's and reaching 20.5 kg in 2017. This expansion in the consumption have been driven not only by the increase in production but also by the nutritional standards it has shown to provide to the people, reduced waste, better utilization, improved distribution channels, and increased demand. Therefore, the increase in the consumption globally is an indication that the health benefits of fish consumption are manifold and well-understood from both scientific and nutritional perspectives. This also means that fisheries and aquaculture will continue to play a very crucial role in meeting the animal protein demands of the global population, with aquaculture being the dominant supplier.

1.3. Suggestions to meet the nutritional security

1.3.1 Innovative approach

Innovative fish products have the potential to attract consumer appeal increase product consumption. *Pangasianodon hypophthalmus* is a widely cultured fish in India. It has relatively lower market price and offers new scope for innovative value addition as its meat has good nutritional qualities and excellent sensory properties. A few novel value-added products can be prepared from *Pangasius* mince namely colored noodles, Sausages, Nuggets etc. A variety of novel mince-based products of high sensory acceptability can be prepared from *Pangasius* mince.

Seafood is perceived as an excellent source of nutrients especially quality protein which is characteristically tender and easily digestible. Pasta products, being one of the most popular and widely consumed foods globally are the ideal

sources for incorporating marine functional ingredients to reach the target population. Judicious formulation of ingredients in pasta helps to cut down the calorie making it more nutritious.

Fisheries and aquaculture programs can address and mitigate issues of malnutrition in India by increasing the access to fish due to its nutritional value. Therefore, increasing fish production could increase the access to fish products and improve the nutritional status in children which has the potential to end malnutrition and food insecurity.

1.4. Govt. Schemes encouraging for the production of fish

Among the different Government schemes available for the benefit of entrepreneurs and fish farmers, the key targets of Pradhan Mantri Matsya Sampada Yojana are as follows:

- Increasing fish production from 13.75 million metric tons in 2018-19 to 22 million metric tons by 2024-25.
- Improving aquaculture productivity from 3 tons per hectare to 5 tons per hectare.
- Enhancing domestic fish consumption from 5 kg to 12 kg per capita.
- Increasing contribution of the fisheries sector to the Agriculture GVA from 7.28% in 2018-19 to about 9% by 2024-25.
- Doubling export revenue from Rs. 46,589 crore (US\$ 6.37 billion) in 2018-19 to Rs. 100,000 crore (US\$ 13.68 billion) by 2024-25.
- Reducing post-harvest losses to about 10%.
- Creating 55 lakh direct and indirect employment opportunities across the value chain.

Conclusion

Technological changes in aquaculture have dramatically increased fish supply, lower relative fish prices, and reigned in price volatility. Policies that recognizes and safeguard the diversity and complementarity of roles played by capture fisheries and aquaculture are needed to ensure that the transition in fisheries sustainability improves food and nutrition security.

Diversification of Aquaculture and Fisheries Resource Management and its Challenges

Dr. Binay Kumar Chakraborty

Shobhit Institute of Engineering & Technology (Deemed to be University) Meerut, UP, India & Researcher and Consultant/Executive Director, Mud eel, Mud crab, Aquaculture and Management Centre

Abstract

An ecosystem includes indicators of habitat, species and resources, such as water and its physico-chemical characteristics. An aquatic resource of Bangladesh belongs to a. Inland Open Water (Capture): River and Estuary, Sundarbans, Floodplains, Beel, and Kaptai Lake b. Inland Close Water (Culture): Pond, Seasonal cultured waterbody, Baor, Shrimp, Prawn and crab Farm, Pen Culture and Cage Culture c. Marine Fisheries Industrial and Artisanal. Data and information sources are used from the direct interview with individual, publication of the Department of Fisheries, internet and related grey literature. The country has an inland water area of about 4.72 mill.ha and about 710 km long coastal belt. Fisheries sector contributes 3.52% to the national GDP, 26.37% to the agricultural GDP and more than 1.35% to the total export earnings. The total fish production was crossed by producing 4.621mil.mt in 2020-21, whereas, inland open water (capture) contributes 28.16% (1.301mil.mt) and inland closed water (culture) contributes 57.10% (2.639mil.mt). Finally, contribution of total production from inland fisheries was 85.56%. On the other hand, marine fisheries production was 0.681mil.mt and its contribution to total fish production was 14.74% with growth rate 1.51%. The growth rate of inland fisheries was 2.81% and overall total growth rate was 2.62%. The growth performance from inland aquaculture shows a moderate increased trend. The total fish production was increased about six times more (0.754 mil.mt to 4.621mil.mt) during the last 38 years and regression type was polynomial and the equation was $y = 0.0024x^2 + 0.0157x + 0.6763$ ($R^2 = 0.9981$). In sustainable aquaculture and fisheries resource management, ecosystem of waterbody and biological management (live feed production and outlet of polluted substance) is necessary. In recent years, the fisheries resources have been facing with challenges posed by numerous natural and anthropogenic causes such as climate change, natural disaster, environmental pollution, industrialization, overfishing, using destructive fishing gears, pesticide and agrochemicals. So, more important national program and biological management technology would be developed for aquaculture and open water management to restrict the declination of resources and enhance production. Aquaculture and fisheries management technology of Bangladesh can enhance the aquaculture policy of Manipur state of India.

Introduction

Fish habitats in Bangladesh are primarily a deltaic country in the Ganges, Brahmaputra and Meghna (GBM) drainage systems. Important Rivers the Padma, Jamuna, Teesta, Brahmaputra, Surma, Meghna and Karnaphuli exists in the country. The country is blessed with huge open water resources with a wide range of enriched aquatic diversity, comprising almost 260 freshwater fish species (FSYB, 2020-2021). Besides, a total of 20 species of prawns, 4 species of crabs and 26 species of molluscs are known to occur in Bangladesh's freshwaters (Siddiqui et al., 2008). However, due to mainly decline and degradation of wetland resources, the share of inland capture fisheries has been reduced remarkably during recent past decades. The natural migration and recruitment of fishes and other aquatic lives between rivers and floodplains have been blocked. As a result, many important fish, prawn species and other aquatic lives of rivers, floodplains and estuaries have become threatened and endangered (IUCN, 2000).

Fish plays an important role for food security and nutrition by providing food and income. However, fish, fisheries and aquaculture are often kept on the side of debates relating to food security and nutrition. Three fundamental aspects stand out to ground the importance of fish for food security and nutrition: (i) the protein and nutrient content of fish as food; (ii) the role of fisheries and aquaculture activities as a source of income and livelihoods; and (iii) the relative efficiency of fish to produce and transform proteins (FAO, 2014).

Aquaculture in rural areas provides a high quality of animal protein and essential nutrients, especially for nutrition vulnerable groups, such as pregnant and lactating women, infants, and pre-school children. It was proven that after supplied with sufficient needed nutrition which can be found in fishes, such as Omega-3 fatty acids, vitamin B₁₂, Vitamin D, Iron, Phosphorous, Niacin, calcium and potassium, unfortunate cases like child blindness and infant mortality has substantively decreased (Ahmed and Garnett, 2011). In rural aquaculture context, most of the time farmers' household tends to eat the small fish. These small fishes are eaten together with their head and bones, added more micronutrients, vitamins and mineral that could not be found in larger fish (Ahmed and Garnett, 2011).

A healthy diet has to include sufficient protein containing all essential amino acids, lipid with essential fatty acids, vitamins and minerals. Provided its rich nutrient content is preserved, fish constitutes a rich source of these nutrients. Fish in the human diet can therefore help reduce the risks of both malnutrition and of non-communicable diseases (FAO, 2014).

Materials and Methods

The study was conducted in 64 districts of Bangladesh. A sampling plan was run for a long time to get an accurate picture of the catch and catch composition. A semi-structured questionnaire was developed. Primary data was collected by focus group discussion (FGD), local ecological knowledge (LEK) and direct interviews with the individual respondent. Questions were asked systematically, with the framed questionnaire. Being a rapid survey, the study gives

only a broad picture of a stock of fauna that was recorded through fish landing centers, wholesalers, different market surveys, directly from fishers', hatchery owner and fish farmer. Secondary data were collected mainly from the Department of Fisheries (DoF) and internet sites. The data were analyzed through one-way ANOVA using SPSS program to find out whether any significant difference existed among different data (Duncan, 1955; Zar, 1984). Standard deviation in each parameter was calculated and expressed as mean \pm S.D.

Results and discussion

Fish Production

The fisheries sector contributes 3.57% to the national GDP, 26.37% to the agricultural GDP and more than 135% to the total export earnings (FSYB, 2021). Fish alone supply a per capita fish consumption of 62.58 g/day in daily dietary requirement. Bangladesh is one of the world's leading fish producing countries with a total production of 4.621 mill.mt in 2020-21 (Fig. 1). The fisheries sector was contributed to 0.754 mill.mt in 1983-84, and 1.89 mill.mt in 2001-02.

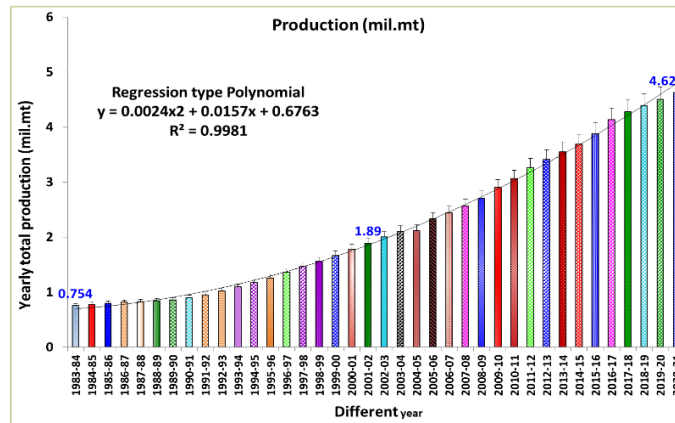


Fig. 1: Total fish production percentage (%) of the last 37 years in Bangladesh.

Finally, in 2020-21, the fisheries sector contributed 4.621 mill.mt. and total fish production was increased sharply with in 38 years. The regression type was polynomial and the equation was $y = 0.0024x^2 + 0.0157x + 0.6763$ and where, R^2 is 0.9981 (FSYB, 2021).

Contribution of inland capture fisheries

Inland open water area belongs to 3.917 (mill. ha) which includes rivers and estuaries,

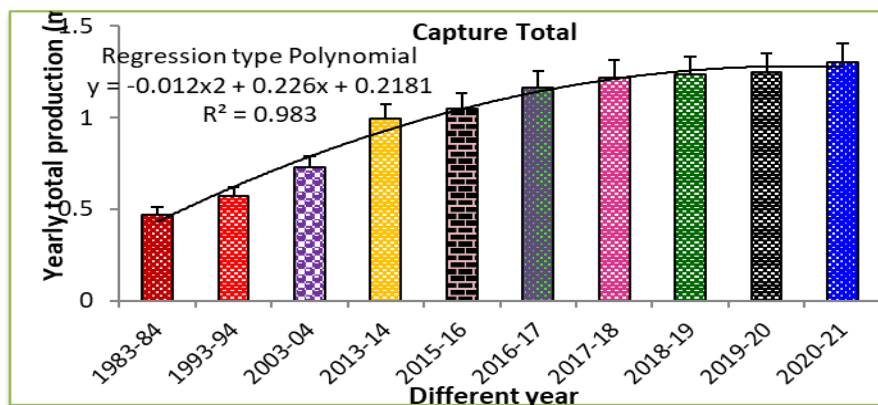


Fig. 2: Fish production percentage (%) of inland open water (capture) from 1983-84 to 2020-21.

Sundarbans water resource in the forest, beels, Kaptai Lake and floodplain. In 1983-84, the contribution of inland capture fisheries fish production was 0.472 mill.mt and production percentage was 62.59% and in 2013-14, inland capture fisheries fish production was 0.9958 mill.mt and decreased at 42.36%. Finally, in 2020-21, inland capture fisheries fish production was 1.301 mill.mt. and total fish production was decreased sharply with a value of 62.59% to 28.16% during last 37 years (Fig. 2). The regression type was polynomial and the equation was $y = -0.012x^2 + 0.226x + 0.2181$ and where, R^2 is 0.983 (FSYB, 2021).

Contribution of inland closed water (culture) fisheries

Inland closed water (culture) area belongs to 0.80 (mill.ha) which includes Pond, Seasonal cultured waterbody, Baor, Shrimp/Prawn /crab Farm, pen and cage culture. In 1983-84, the contribution of inland closed water fish production was 0.117 mill.mt and production percentage was 15.53% and in 2020-21, inland capture fisheries fish production was 1.9569mill.mt and increased at 43.36%.

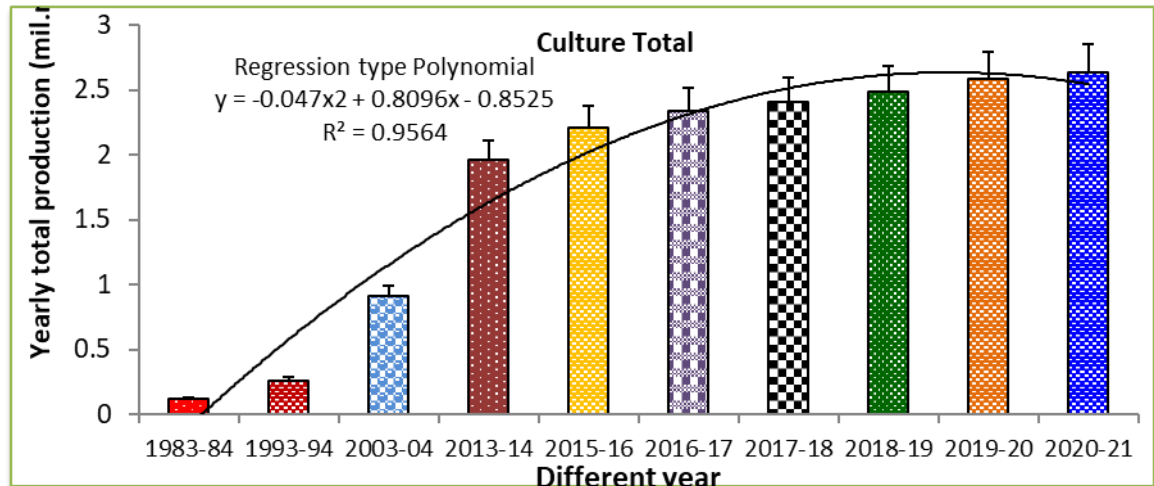


Fig.3: Fish production percentage (%) of closed water (culture) last 38 years in Bangladesh.

Finally, in 2020-21, contribution of inland culture fisheries fish production was 2.639mill.mt. And total fish production increased sharply with a value of 15.53% to 57.10% during the last 37 years (Fig. 3). The regression type was Polynomial and the equation was $y = -0.047x^2 + 0.8096x - 0.8525$ and where, R^2 is 0.9564 (FSYB, 2021).

Contribution of marine fisheries

The area of marine fisheries includes Industrial (Trawler Fishing) and Artisanal. In 1983-84, the contribution of marine fish production was 0.165 mill.mt and production percentage was 21.38% and in 2013-14, marine fish production was 0.5952mill.mt and was decreased at 19.41%. Finally, in 2020-21, contribution of marine water fish production was 0.6812mill.mt. and total fish production was decreased sharply with a value of 21.88% to 14.74% during the last 38 years (Fig. 4). The regression type was logarithmic and the equation was $y = 0.2451\ln(x) + 0.1697$ and where, R^2 is 0.9223 (FSYB, 2021).

Carp and cat fish hatchling

Carp hatchling production was recorded in different rivers at 2.152 mt and about 1056 government and private carp and cat fish hatcheries produced at 668.801mt hatchlings in the year 2020-21. Finally, total production of hatchling was recorded at 670.953mt in 2020-21 (FSYB, 2021).

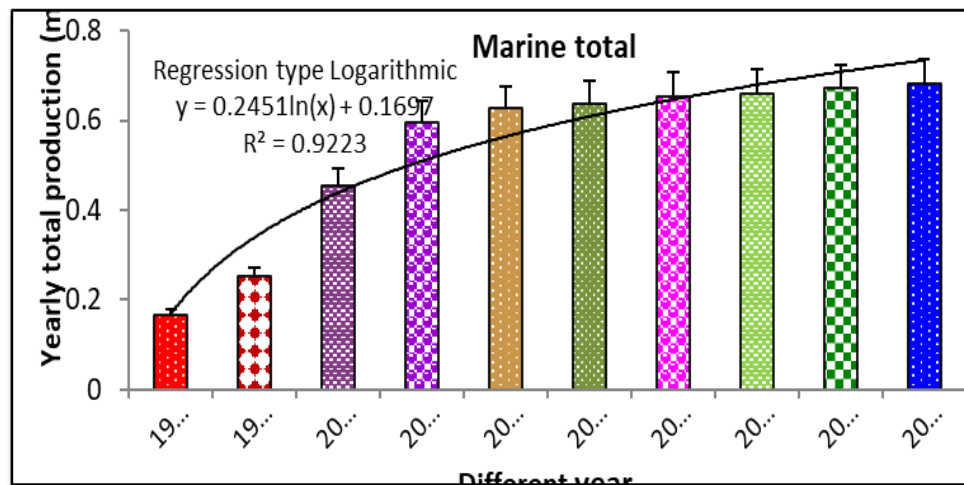


Fig. 4: The fish production of marine water last 38 years in Bangladesh.

Post larvae (PL) production

The number of PL production in government and non-government Galda hatcheries was recorded at 2.37 cores and the number of PL production in government and non-government Bagda hatcheries was noted at 721.04 cores in the year 2020-21. Total production of PL was recorded at 723.41 cores in 2020-21 (FSYB, 2021).

Practice of aquaculture methods in Bangladesh

Cultured Method

Monoculture: Monoculture is practiced for high value, marketable fish species. These are the practice of tilapia, catfish, and carps.

Polyculture

In this system, culture with different feeding habits with catla, rui and mrigal with tilapia and catfish or without other species. To support intensive production, pangas ponds require regular applications of pelleted feed and other inputs.

Small-scale polyculture: Culturing mola and diversify Indigenous fish species with carps are practiced in ponds. Yield up to 7.4 mt. fish/ha/yr. and up to 3.6 mt.fish/ha/yr. in stand-alone ponds (Thilsted, 2014). In extensive culture farmer produces fish <1.5 mt/ha, in semi-intensive method farmer produces fish 1.5- 4.0 mt/ha, in intensive method produces fish 4.0 -10 mt/ha and in highly intensive method farmer produces fish >10.0 mt/ha.

Native Carp species: Cultivable native carp species are Catol, *Catla catla*; Rui, *Labeo rohita*; Mrigal, *Cirrhina mrigala*; Kalbaus, *L. calbus*; Gonia, *L. gbonia*; Sorpunti, *Puntius sarana*; Bata, *L. bata* and cultivable exotic fishes are *Pangasius sutchi* (Thai pangas), *Aristichthys nobilis* (bighead carp), *Hypophthalmichthys molitrix* (Silver carp), *Ctenopharyngodon idella* (Grass carp), *Mylopharyngodon piceus* (Black carp), *Cyprinus carpio* (Common carp), *Puntius gonionotus* (Thai sorputi) and *Oreochromis niloticus* (Tilapia).

Diversification of Indigenous Fish Culture

Diversification of indigenous fish (Fig. 5.a-f) culture practices are discussed below:

1. *Mystus cavasius* (Gulsa)

Habitat of *Mystus cavasius* is fresh water. They inhabit rivers, floodplain and ponds, and fecundity range is at 3,314-63,135. Conservation status is endangered. They attain Maximum length up to 18.0cm. Food and feeding of this species is carnivorous and predator fish. They breed in between April and August in every year. At the length of 10 cm, they gain first maturity for both the sexes. Sexually matured at the age of one year (Bhatt, 1971).

Sex	Dosage	
	1 st (mg/kg)	2 nd (mg/kg)
Male	3	14-18
Female	6	7-8

2. *Ompok pabda* (Pabda)

Habitat of *Ompok pabda* (Pabda) is fresh water. They inhabit rivers, floodplain and ponds, and fecundity range is at 1500-7000. Conservation status is endangered. They attain Maximum length up to 12.4-17.2 cm. Food and feeding of this species is carnivorous and predator fish. They breed in between April and July in every year.

Sex	Dosage	
	1 st (mg/kg)	2 nd (mg/kg)
Male	3	14-18
Female	6	7-8

3. *Mystus tengra* (Tengra)

Habitat of *Mystus tengra* is fresh water and they inhabit rivers, floodplain and ponds. Their fecundity range is 6770-21708 and conservation status is endangered. They attain maximum length up to 18.0 cm. Food and feeding is carnivorous and They are basically predator fish. They breeds between April and August.

Hormone	Dosage	
	Male	Female
PG (mg/kg)	20	40
Ovatid (ml/kg)	1.5	1.5



Fig. c: *Mystus tengra* (Tengra).

4. *Heteropneustes fossilis* (Shing)

Habitat of *Heteropneustes fossilis* is fresh water and they inhabit rivers, floodplain and ponds. Fecundity range is at 2800-4500. Their conservation status is endangered. The maximum length is up to 16-30cm. Food and feeding is omnivore. They breed between April and October.

Hormone	Dosage	
	Male	Female
PG (mg/kg)	14-18	60-70



g. d: *Heteropneustes fossilis* (Shing).

5. *Clarias batrachus* (Magur)

Their fecundity range is 6,770-21,708. Their conservation status is endangered. The length is recorded at 16-35 cm. Food and feeding of this species is carnivorous and predator. Their fecundity range is at 1800-13400. They breeds May to July.



Fig. e: *Clarias batrachus* (Magur).

6. *Anabas testudineus* (Koi), Climbing perch

Habitat *Anabas testudineus* is fresh water, and they inhabit floodplain and ponds. Their conservation status is endangered. The length is recorded at 10-18 cm. Food and feeding of this species is carnivorous and predator. Their fecundity range is at 16832 - 46186. They breed April to July.

Sex	Dose PG (mg/kg)	Remarks
Female	8-10	Ovulate after 6-7 hrs.
Male	4	



Fig. f: *Anabas testudineus* (Koi).

7. *Channa striatus* (Striped snakehead), Vietnami Shoal

Habitat *Channa striatus* (Vietnami Shoal) is fresh water, and they inhabit floodplain and ponds. This species is exotic species. The length is recorded at 25-55 cm. Food and feeding of this species is carnivorous and predator. They breed May to July by building nest.



Fig. g: *Channa striatus* (Koi).

8. *Amblypharyngodon mola* (Mola)

Habitat *Amblypharyngodon mola* (Mola) is fresh water, and they inhabit River, canal, floodplain and ponds. Their fecundity range is at 1280-13679. Their maximum length 90 mm and weight 1.2 -10.5 g. Food and feeding of this species is herbivores. They breed May to October. Pituitary gland (PG) is used in artificial breeding.



Fig. h.: *Amblypharyngodon mola* (Mola)

9. *Notopterus chitala* (Chitol)

Habitat Chitol, *Notopterus chitala* is fresh water, and they inhabit River, canal, floodplain and ponds. Their maximum length up to 82 cm with maximum body weight of 9 kg. Food and feeding of this species is carnivorous and predator. They breed May and July by building nest.



Fig. i. *Notopterus chitala* (Chitol).

10. Pangas, *Pangasius hypophthalmus*

Pangasius hypophthalmus is an exotic fish and in the year 2020-21, total contribution of total production was 23.24%. The weight of pangas was recorded at maximum body weight 3-4kg. Food and feeding habit is omnivorous. It breeds in between May to July. The pangas production of Bangladesh was belongs to 0.3711mill.mt in 2013-14 and the contribution of highest pangas production was recorded at 0.5101mill.mt in 2016-17. Finally, in 2020-21, the decreased pangas fish production was recorded at 0.4023mill.mt (Fig. 6). The regression type was Polynomial and

the equation was $y = -0.0088x^2 + 0.0795x - 0.306$ and where, R^2 is 0.7214 (FSYB, 2021).

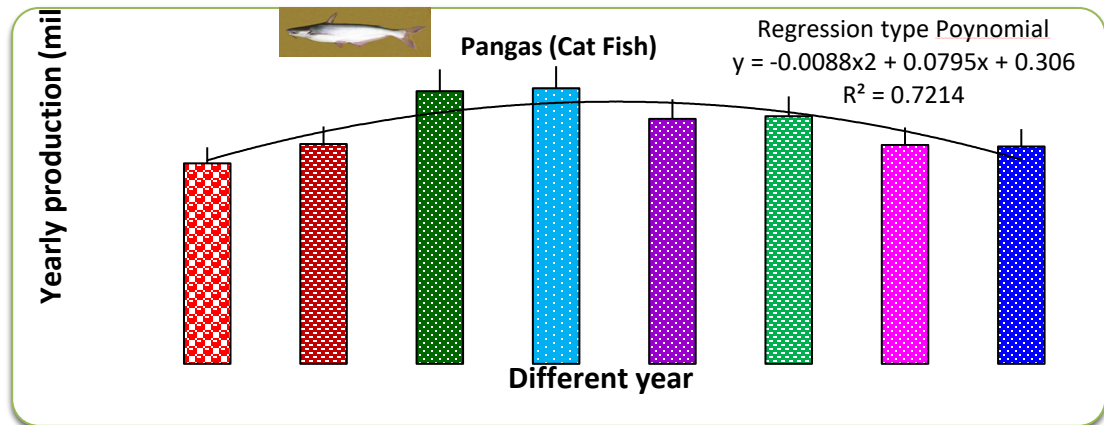


Fig. 6: The production of *Pangasius hypophthalmus* in between 2013-14 to 2020-21.

11. Tilapia, *Oreochromis mossambicus/niloticus*

Tilapia, *Oreochromis mossambicus/niloticus* is an exotic fish and total contribution of total production was 16.64%. The length and weight of pangus was recorded at maximum body length 60 cm and body weight 2-3kg. Food and feeding habit is herbivores. In breeding technology, Tilapia laid their eggs in nests made by the males and then carries the fertilized eggs in their mouths until they hatch. It breeds in between May to July. The tilapia production of Bangladesh was belongs to 0.2981mill.mt in 2013-14 and the contribution of tilapia production was 0.37002mill.mt in 2016-17. Finally, in 2020-21, the increased tilapia fish production was recorded at 0.3921mill.mt (Fig. 7). The regression type was Polynomial and the equation was $y = -0.003x^2 + 0.0371x + 0.2763$ and where, R^2 is 0.8457 (FSYB, 2021).

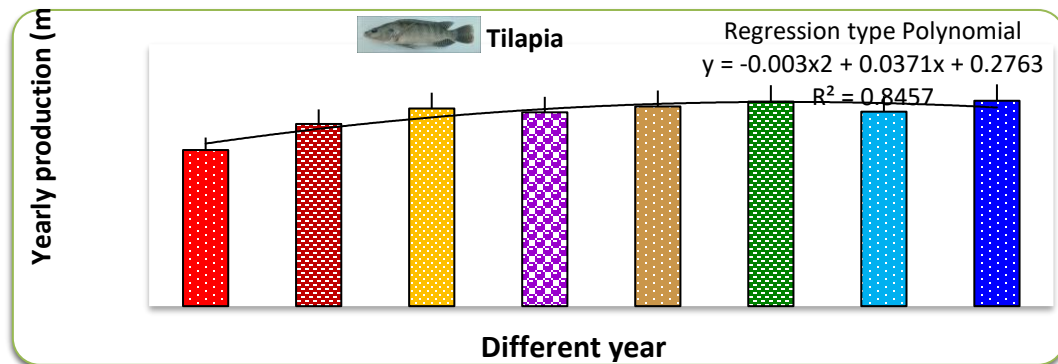


Fig. 7: The production of *Oreochromis mossambicus/niloticus* in between 2013-14 to 2020-21.

Integrated Fish Farming

Integrated Fish Farming system (Fig.8a-f) is one of the important ecological balanced sustainable technologies. Fish species are Indian major carps, *Channa spp*, *Oreochromis mossambicus*, *Clarias batrachus*, *Anabas testudineus*, silver carp, common carp and Thai sarpunti. Total production is 2000 kg/ha.

8. Agro-based fish farming

1) Paddy-cum-fish culture

This farming is practised in the in the paddy fields. The paddy fields retain water for 3-8 months in a year.

Type of practice -

i) Perimeter type

Paddy grows in the middle. Rice fields also serve as fish nurseries. Produced fingerlings are to be sold or stocked in ponds.



Fig.8a: Perimeter type culture.

ii) Central pond type

Paddy growing area is on the perimeter.



Fig.8b: Central pond type culture.

iii) Lateral trench system

Trenches are provided on either one or both sides of the moderately sloping field.



Fig.8c: Lateral trench type culture.

2) Horticulture-cum-fish farming
(d) Horticulture-cum-fish farming

This system includes the culture of fruits, vegetables and flowers on the embankment of the pond. Fruits and vegetables contain various nutritive elements. A Research has recommended 85g of fruits and 300g of vegetables to consume daily.



Fig.8d: Horticulture-cum-fish type culture.

3) Live-stock fish farming

(e) Duck-cum-fish farm

Duck are reared on the dyke of the pond in a low-cost house. About 300-500 no./ha of ducklings Khaki campbell are reared to fertilize the 1 ha. pond. The duck acts as live aerator and control the aquatic weed (Lemna, Azolla etc.), aquatic insects, molluscs, tadpoles etc. Total production is about 3500-5000 kg fish, 18000-18500 eggs and 600 kg of duck meat. The duck droppings are used as manure for primary production of fish.

Fig.8e: Duck-cum-fish type culture.

(f) Cattle-cum-fish culture

Cow-shed should be built close to fish pond to simplify handling of cow-manure. A healthy cow may excrete over 4000-5000kg dung. About 5-6 cows can provide adequate manure for 1 ha pond. Produces 9000 kg milk and about 3000-4000 kg of fish annually. The BOD of cow manure is lower than other livestock manure.



Fig.8f: Cattle-cum-fish type culture.

9. Culture of cuchia (*Monopterus cuchia*)

Develop two technology on eel culture:

a. Aquaculture method (Fig.9a)



Fig.9a: Aquaculture method culture

b. Natural resource management (NRM) System (Fig.9b)



Fig.9b:Natural resource management (NRM) System

10. Shrimp culture n Bangladeshi

Practice of *P. monodon* and *P. indicus* culture in medium to high saline water and *Macrobrachium rosenbarje* culture in fresh and saline water. In 2006-07, the production was 0.2211mmt and in 2020-21, the production was 0.252 m.mt (Fig.10).



Fig.10: *P. monodon* and *Macrobrachium rosenbarje*.

Some other latest modern technologies are applied in the field of aquaculture sector of Bangladesh.

11. Biofloc fish farming

Bio-floc aquaculture is an advanced technique of fish farming system where waste materials derived from unused feed, faecal mass and others are converted into microbial protein as food for cultured stocks (Fig.11).



Fig.11: Biofloc fish farming

12. Re-circulatory Aquaculture System (RAS)

Water is recycled and reused after mechanical and biological filtration and removal of suspended matter and metabolites. This method uses for high-density culture of various species of fish, utilizing minimum land area and water (Fig.12).



Fig.12: Re-circulatory Aquaculture System (RAS)

13. Bottom Clean race way Pond culture

The pond area of Bangladesh is belongs to 0.408 (mill.ha). In 1983-84, the contribution of pond culture sector's fish production was 0.10794mill.mt and in 2013-14, the production of pond culture was 1.72mill.mt. Finally, in 2020-21, the increased fish production of pond culture was 2.091mill.mt (Fig. 14). The regression type was Polynomial and the equation was $y = -0.0361x^2 + 0.6259x - 0.6306$ and where, R^2 is 0.9629 (FSYB, 2021).



Fig.13: Bottom Clean race way Pond culture

Livelihood of Fisheries sector

There are 162.18 million peoples live in Bangladesh. Near about 17.84 million (11%) people are somehow directly or indirectly related with different sectors of fisheries. Now a day's women participation is an important and hopeful in fish drying activities, pond aquaculture, crab culture, shrimp culture, fishing gears, fish feed and fish processing sectors. During harvesting season or net changing period, extra labors are needed from casual or occasional laborers (Ahmed and Garnett, 2010). This is traditionally an area of work done by rural women. They invest small amount of money and produce salted dry fish and non-salted dry fish indifferent fish species near their house and yard. In this way they can self-dependent in the society.

Conclusions

The population of Bangladesh will be risen up and would be a great challenge to secure the future dietary demand of the increasing population according to the report of FAO, 2009. Three fundamental aspects stand out to ground the importance of fish for food security and nutrition: (i) the protein and nutrient content of fish as food; (ii) the role of fisheries and aquaculture activities as a source of income and livelihoods; and (iii) the relative efficiency of fish to produce proteins (FAO, 2014). Aquaculture helps the nation in earning valuable foreign exchange, increases the food production, and later in diversifying the economy and results in job creation in the countryside. Institutional and infrastructure aid are urgent in need from the government for diversification of production and trade. The sustainability in aquaculture and fisheries in Bangladesh is under tremendous threat due to increasing population growth, changing climatic conditions, continuous decline in water area, vulnerable to the hazards of climate change-flood, drought, salinity, depleting water resources, declining production through indiscriminate use of agro-chemicals and poor research. So, environmental-socio-economic friendly technology is needed for sustainable fish, fisheries and aquaculture development.

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Alternate Livelihood Options for Coastal Fisher Folk Through Small Scale Enterprises

Dr. S. Athithan

Department of Aquaculture (DAQ), Fisheries College & Research Institute (FC&RI), Tamil Nadu Dr. J. Jayalalithaa Fisheries University (TJFU), Thoothukudi - 628 008, Tamil Nadu, South India

Abstract

Fishing has been considered as a primary livelihood option since time immemorial for the occupants of the coastal belt in India. Alternative livelihood as a solution to overfishing has been proposed for more than two decades. The dwindling catch rates in capture fisheries and rampant unemployment in the coastal region focus towards the development of mariculture and coastal aquaculture as a remunerative alternate occupation. The potentially cultivable candidate species in India include about 20 species of finfishes, 29 crustaceans, 17 molluscs, 7 seaweeds and many other species of ornamental and therapeutic value. Many mariculture technologies are very simple, eco-friendly, free from pollution and use only locally available infrastructure facilities for construction of farm, feed and seed and hence the entire farming can be practiced by traditional fishermen. Coastal aquaculture and mariculture offers one of the best and secondary livelihood options especially in coastal areas. Out of several existing major mariculture species and farming technologies available in India, the following alternative livelihoods options are well suited for coastal communities and small-scale fishers through small scale enterprises such as seaweed farming, lobster fattening, crab fattening, edible oyster farming, mussel farming, marine ornamental fish rearing in hapa, pearl spot cage farming, Integration of *Artemia* in salt pans and farm made fish feed preparation, which deserve prime attention. These available technologies can be popularized by effective extension mechanisms. This paper highlighted the different livelihood options available in India to augment income generation among coastal fisherfolk through small scale enterprises. Further, this paper also discussed iron frame cage culture practice for lobster fattening in the open sea under Institution-Progressive farmer tie up method, which was adopted at Tharuvaikulam of Thoothukudi coast, Tamil Nadu.

Introduction

Fish Production / Capture & Culture (India)

- 0.75 million tonnes (1950 – 1951)
- 14.164 million tonnes (2020 – 2021)
(Inland – 10.437 / Marine – 3.727 million tonnes)
18.885 fold increase in just 8 decades
- India Ranks II (Both Culture & Capture)
- Agri. GDP (5.43 %)
- Fish. GDP (0.90 %)
- Per Capita Fish Consumption / Annum (9 kg)

Justifies Country's Economy & Livelihood Security

Livelihood Options (Primary & Secondary)

Fishing (Primary livelihood)

(Since time immemorial for occupants of coastal belt in India)

Alternative livelihood to overfishing proposed for more than two decades

Coastal Aquaculture & Mariculture

Offers Best & Secondary Livelihood Options Especially in Coastal Areas

Reasons

- To focus towards Development of Mariculture & Coastal aquaculture as remunerative alternate occupation
- Dwindling catch rates in capture fisheries
Rampant unemployment in coastal region

Many Mariculture Technologies (Open / Off Shore & Closed / Inshore)

Very simple / Eco-friendly / Free from pollution
/ Use only locally available infrastructure facilities for construction of farm, feed & seed. Hence, entire farming practiced by traditional fishermen

Potential aquatic species for mariculture in India

Common name	Scientific name
Asian seabass	<i>Lates calcarifer</i>
Grouper	<i>Epinephelus</i> spp.
Milkfish	<i>Chanos chanos</i>
Flathead mullet	<i>Mugil cephalus</i>
Silver pomfret	<i>Pampus argenteus</i>
Cobia	<i>Rachycentron canadum</i>
Tunas	<i>Thunnus</i> sp., <i>Euthunnus</i> spp.
Mud crab	<i>Scylla serrata</i>
Rock lobster	<i>Panulirus</i> spp.
Edible oyster	<i>Crassostrea</i> spp.
Pearl oyster	<i>Pinctada fucata</i> , <i>P. margaritifera</i>
Mussels	<i>Perna viridis</i> , <i>P. indica</i>
Clams	<i>Anadara granosa</i> , <i>Paphia malabarica</i>
Sea cucumber	<i>Holothuria scabra</i>
Seaweeds	<i>Gracilaria</i> , <i>Gelidium</i> , <i>Kappaphycus</i> , etc.

Livelihood Options through Small Scale Enterprises (India)

- Lobster Fattening
- Crab Fattening / Farming
- Mussel Farming
- Seaweed Farming
- Pearl spot cage farming / Seed Production
- Marine Ornamental Fish Rearing in Hapa
- Integration of *Artemia* in Salt Pans
- Farm Made Fish Feed Preparation

Lobster Fattening



- Fattening Methods
- Ponds / Tanks
- Sea Pens
- Cages (Floating Cages / Submersible Cages)

Tank



Floating Cage



FRP (Floating Cage)



Iron Frame Cage



Livelihood Options Through Small Scale Enterprises (adopted at Tharuvaikulam of Thoothukudi Coast, Tamil Nadu)
Iron Frame Cage Culture Practice for Lobster Fattening in open sea under Institution-Progressive farmer tie up method Revolving Fund.

2 Farmer (Thruvaikulam) / Mr.S.Francis / Mr.G.Joseph Raj

- Study carried out with spiny lobster (*Panulirus homarus*) Tharuvaikulam Village (Thoothukudi, South India)
- Juveniles procured from private company at Kanyakumari Collected juvenile lobsters kept in FRP tank (300 litres) containing seawater with continuous aeration and transported to Tharuvaikulam, Thoothukudi by truck vehicle
- Reared in Iron Frame Cage (8 x 8 ft) Installed at open sea of Tharuvaikulam Village
- Before starting, juvenile's lobsters conditioned for 2 days
- Stocking Density (900 numbers / Cage)
- FR @ 5 % of TBW
- lobsters fed with live clams (*Donax* sp) by hand twice daily
- Feed intake checked daily
- Uneaten clams along with shells were removed manually once in week
- Fattening done for 240 Days



Sl. No	Parameters	I year	II Year	III Year	IV Year
1	Purchase of undersized lobster for 2 cages	90,000	90,000	90,000	90,000
2	Feed Cost 2 cages	50,000	50,000	50,000	50,000
3	Cage Construction Cost (For 2 cages)	50,000	--	--	--
4	Total Financial Assistance from University	1,90,000	1,40,000	1,40,000	1,40,000
Income generated from 2 Iron frame cage					
1	Total weight from cage (I and II)	142.00 kg	175 Kg	175 Kg	189 Kg
2	Total income generated	2,13,000	1,83,750	1,89,000	1,89,000
Repayment particulars to the University					
1	Total Financial Assistance from University	1,90,000	1,40,000	1,40,000	1,40,000
2	Total interest @ 8 %	7,600	10,267	10,267	11,200
	Sub Total	1,97,600	1,50,267	1,50,267	1,51,200
3	Net Profit Total Revenue – Total repayment Rs. 2,13,000 - Rs. 1,97,600	15,400	33,483	38,733	37,800.00
4	Sharing to Farmer @ 80% out of Rs. 15,400 Sharing to University @ 20% out of Rs. 15,400 (As per proposal)	12,320 3,120 15,400	26,786.40 6,696.60 33,483.00	0,986.40 7,746.60 38,733.00	30,240 7,560 37,800
Abstract on Mode of Repayment to the University					
1	Repayment on total investment	1,90,000	1,40,000	1,40,000	1,40,000
2	Interest on total investment (@ 8% for Rs. 1,90,000 for six months)	12,670	10,267	10,267	11,200
3	Net profit (20 % for University share)	3120	6,696.60	7,746.60	7,560.00
4	Total Repayment (total investment + Interest)	2,00,720	1,57,000.00	1,58,014	Rs.1,58,760

Crab Fattening / Farming

Fattening of Mud Crab

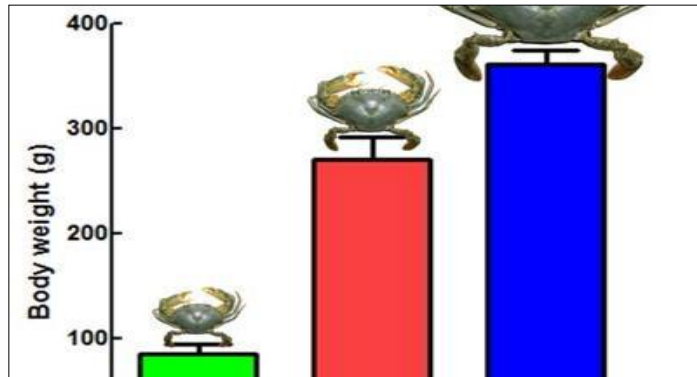
Indoor Cement Tanks

Ponds Direct stocking / Bamboo or wooden boxes

Cages (Bamboo / FRP / PVC) / Crabs tied in Bamboo Poles

Three Tier Modular Farming Systems (Multi-Phased Culture System) for Mud Crabs, Scylla Serrata By Ciba

- Hatchery produced juveniles to marketable size takes Long Period (10-12 months)
- Long DOC hinders production efficiency, survival rate, Increased disease
- To circumvent these issues, 3 tier modular farming systems (multi-phased culture system) comprising
 3 months nursery (4 days old / 10 per m2 / 46 % SR / 85 g / 280 kg in 1 ha)
 4 months of mid grow (3 months old / 0.1 per m2 / 270 g / 1110 kg in 1 ha)
 3 months of final grow (6 months old / 0.01 per m2 / 80 % SR / 270 g / 1168 kg / ha)



Seaweed Farming

Common methods are

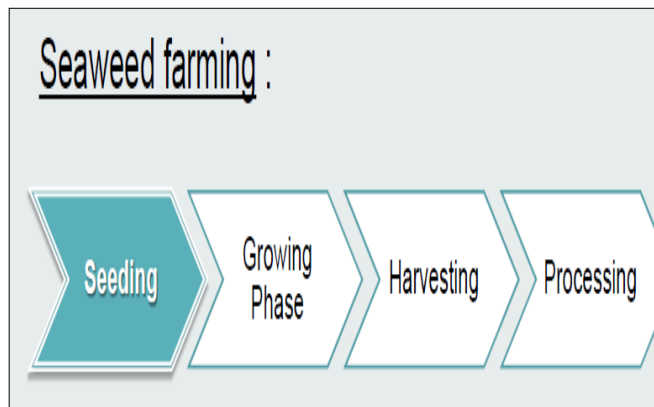
- Bottom Farming
- Broadcast Method
- Floating Bamboo Method (Tie-Tie Technique-TT)
- Monoline & Net Method (Tie-Tie Technique-TT)
- Tubular Net Method (TN)

Seaweeds potential & markets (TN)

Palk Bay & Gulf of Mannar Abundant in Seaweeds

GOM Well suited for indigenous seaweed farming Dominant varieties of indigenous seaweeds *Gracilaria edulis* / *Gelidiella acerosa* / *Sargassum* / *Turbinaria* / *Hypnea*

Palk Bay (Pepsi pasi / *Kappaphycus alvarezii*)



Cost for establishing 45 numbers of seaweed raft for one SHG beneficiary (45 x Rs. 1500)	Rs. 67,500
Bio mass of seaweed obtained after 45 days / raft	300 Kgs

Total quantity of seaweed harvested excluding the requirement of 60 kg for implantation	240 Kgs
Available seaweed quantity on dry weight basis (10 %)	24 Kgs
Interest on bank loan (12 %)	Rs. 8100
Insurance	Rs. 1000
Total Cost (Rs. 67,500 + 8,100 + 1000)	Rs. 76,600
Revenue 24 kgs x Rs. 35 x 45 rafts x 6 crops	Rs.2,26,800
Net profit (Rs. 2,26,800 - (Rs. 67,500 + Rs.8,100 + Rs. 1000))	Rs. 1,50,200

Cost for establishing 10 mm size 104 m length for 20 members SHG beneficiary (10 lines x @ Rs. 5000 / 1 line)	Rs. 50,000
Bio mass of sea weed obtained after 45 days / 10 lines @ 400 kg / line x 10 for every day	4000 Kgs
Total quantity of sea weed harvested excluding the requirement of 1000 kg for implantation	3000 Kgs
Available seaweed quantity on dry weight basis (10 %)	300 Kgs
Interest on bank loan (12 %)	Rs. 6000
Insurance	Rs. 1000
Total Cost (Rs. 50,000 + 6,000 + 1000)	Rs. 57,000
Revenue 300 kgs x Rs. 35 x 10 lines x 6 crops	Rs. 63,000
Net profit (Rs. 63,000 - (Rs. 50,000 + Rs. 6,000 + Rs. 1000))	Rs. 6,000
Net Profit / member / day (Rs. 6000 / 20 members)	Rs. 300
Net Profit / member / month (Rs. 300 x 30 days)	Rs. 9,000
Net Profit / member / month (Rs. 9,000 x 10 months)	Rs. 90,000

Pearl Spot Cage Farming & Seed Production

Why Cage Culture is preferred?

- Pond culture not recommended (large scale)
- In Pond - Even spawn at 110 g
- Brood Stock development through cage
- Cage culture offer good potential for Monoculture & Polyculture
- Pearl Spot Production 2 m Dia Cage / Volume (7.85 m³)
- Stocking Density (1000 Numbers)
- Feed Requirement (150 Kg / 6 months)
- Production (200 Kg)
- Total Expenditure (10,000)
- Gross Income (30,000)
- Net Income (20,000)



Pearl Spot seed Production (1000 pairs)

- Area for Brood stock Rearing (0.265 ha)
- Egg 4000 / pair / year (4 millions)
- Larvae 95 % HR (3.8 millions)
- Juveniles 60 % SR (2.28 millions)
- Area stocked @ 10,000/ha (228 ha)



- Harvest 75 Survival Rate (1.71 million fish)
- Production 200 g ABW (342 t / year)
- Total Revenue @ 150 / kg (51.3 millions)

6) Mussel Farming

Brown Mussel



Green Mussel



Culture Method

- A) Deep Water Culture
 - Raft Culture / on-line Culture
- B) Intertidal & Shallow Water Culture
 - Rack Culture
 - Hanging Method
 - Stake (tulos) Method
 - Tray Culture
 - Wig-wam Culture
 - Rope-web Culture
 - "Bouchot" Culture / Pole culture / Stake culture

C) Bottom Culture

Growth & Production

- Seeded Mussels grow to 36 g / 5 months
- Each rope yield (5.1 - 12.3 Kg / m)
- 100 ropes 6m length in raft (8 x 8 m)
- Yielding 4800 Kg / raft @ 8 Kg / m of rope

Marine Ornamental Fish Rearing in Hapas by CMFRI

Grow-out in hapas

Grow out of ornamental fishes can be effectively practised in *hapas* installed in protected calm nearshore areas. The growth was found to be much faster. The major advantage is that the colour is much brighter in fishes grown in *hapas* due to natural light and good exchange of water.

Selection of site

The site should have at least 2 m depth of water, good dissolved oxygen content, free from industrial contaminants, low anthropogenic pollution and easy accessibility from land. A protected area is generally preferred.

Construction of floating hapa

- Rectangular shaped floating *hapa* (2.5 m x 1.5 m x 1.5 m) with PVC frames (dia 1.5 inch) for supporting the net bag structure and to retain the shape are used for the grow out phases of juvenile to marketable size within 2 months. Here the advantage is that it provides better water exchange and natural environment to the fishes.
- Good quality HDPE net having 0.5 mm and 1 mm mesh size could be used to make the net bag. Double layered net bags are stitched in the dimension 2.5 x 1.5 x 1.5 m depending upon the design and requirement of the frame. The *hapa* can be moored properly at the suitable site.
- Morning and late evening hours are better for stocking, as the temperature is comparatively low and chances of mortality will be less. A stocking density of 1000 fishes in optimal in the *hapa* of the dimension mentioned.

Survival of 90 – 95 % is obtained through proper feeding with different wet feeds like boiled sardine flesh, chopped clam meat, mussel meat and formulated dry feed, 2 times a day *ad libitum*. Fouling was a regular phenomenon and regular monitoring is advisable. Cleaning the net with coir brush has to be carried out on daily basis.

- Floating hapa reared marine ornamental juveniles grow faster with increased survival rate and good colouration, thereby fetching better price in the market.



Integration of *Artemia* in Salt Pans

India (12,000 salt producers)

Profitability of seasonal salt farms

Improved by integrating *Artemia* with solar salt

Production / ha

180 to 200 Kg ww cysts (18 – 20 kg dry cysts)

300 to 500 Kg ww biomass

Proper pond modification

Good biological managements

Salt Works Involved in Integrated Artemia Farming

- TATA Chemicals (Gujarat)
- Balarpur Industries (Gujarat)
- Dolphin Aqua Salt (Thoothukudi, Tamil Nadu)
- DCW (Sahapuram, Tamil Nadu)
- NI Salt Works (Puthalam, Tamil Nadu)

Salt Workers Go for Integrated Farming (Reasons)

- Salt quality So Poor (82 to 96 % NaCl)
- Toxic Chemicals in sea water > heavy metals Hg Pb, Cu etc
- Organic materials also high
- Income - Very low due to Mono Salt Farming
- Awareness after 1992 for Integrated Aquaculture & Salt Farming

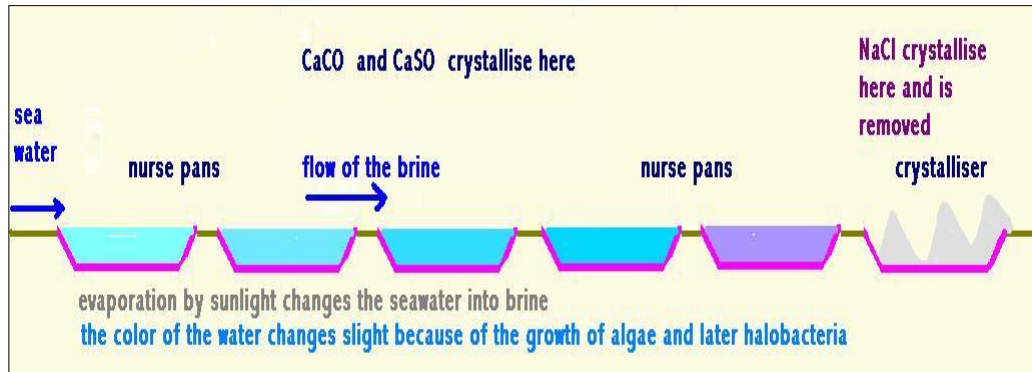
Normal (Favourable) conditions

- Sexual reproduction / Ovoviviparous
- (80 to 150 ppt)

Extreme conditions

Asexual reproduction resulting with dormant eggs

Oviparous (150 to 200 ppt)



- India salt production (2013-14)
- Total Area (2, 49, 011 ha)
- Area Utilized (1, 45, 308 ha / 58.40 %)
- Area Unutilized (1, 03, 703 ha / 49.60 %)

Salt producers encouraged to take up *Artemia* Biomass & Cyst in Unutilized area (1,03,703 ha) to meet entire requirement in Hatchery (India)

Though Potentials & good extra income (Rs. 1, 50, 000 / ha / year). Some of Hurdles are

- Additional Investment
- Institute – Industry Integration
- Establishing Units for Cyst Processing
- Establishing Units for fast freezing *Artemia* Biomass
- TOT by Effective Extension Programmes

Trigger activity in India

Alternative Livelihood to shrimp farming

Farm Made Fish Feed Preparation

According to New & Savas (1993), In Asia, 10 % Fish production using commercial feed and 90 % Fish production - farm based feed). 80 % Fish - freshwater and non predatory fishes

Several factors to be considered in farm made fish feed preparation are

- ✓ Market price of a fish
- ✓ Capital Investments
- ✓ Traditional farm techniques
- ✓ Period of fish culture
- ✓ Availability of labour
- ✓ Ingredient availability & its rate
- ✓ Feeding habits of fish
- ✓ Fish feeding behavior & nutrient requirements
- ✓ Water quality

Uses of farm based fish feeds

- Locally available all types of ingredients
- Reduction feed cost for small scale fish farm
- Best one if no feed mill available nearby farm

Mini Equipments required for Farm Made Fish Feed Preparation

- ✓ A simple balance to weigh ingredients)
- ✓ grinding machine
- ✓ Ingredient mixer
- ✓ Pellet machine (mincer)
- ✓ Sieves
- ✓ Steamer
- ✓ Small cooker
- ✓ Drying machineries
- ✓ Air tight containers

As much as possible, aqua feeds should be based on locally available feedstuff, simple and cheap methods of increasing their nutritional value with particular reference to digestibility, removal of toxic substances (antinutritional

factors) and palatability. In addition, efforts should be made towards the development and improvements of simple and cheap machinery for aqua feed production as well as improve the techniques for processing and storage; without compromising environmental quality.

Outline of Fish Feed Preparation

Summary & Conclusion

- 3.9 Million Hectares (Estimated)
- 1.2 Million Hectares (Potential Cultivable Area)
- 0.18 Million Ha (Current Cultivable Area / 15 %)
- Available technologies popularized by effective extension mechanisms such as participatory demonstration programmes
- TOT depends on 3 systems
 - Knowledge Generating System (KGS)
 - Knowledge Disseminating System (KDS)
 - Knowledge Consuming System (KCS)

Initiation and Expansion of Small Scale Coastal Aquaculture & Mariculture Practices Lead to Increased Production & Augment Income Generation of Coastal fisher folk in the Country

- Fishing considered as Primary Livelihood Option since time immemorial for coastal fisher folk in India.
- Alternative livelihood as solution to overfishing has been proposed for > 2 decades and act as Remunerative Alternate Occupation
- Coastal Aquaculture & Mariculture offers - Best & Secondary Livelihood Options especially in coastal areas
- The list existing major mariculture species and farming technologies available in India is also well suited for coastal communities and small-scale fishers
- These available technologies can be popularized by effective extension mechanisms
- All are alternative livelihood and sustainable farming for them in a sustainable practice

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Antimicrobial Resistance and Alternatives to Antibiotics

Pani Prasad Kurcheti

ICAR – Central Institute of Fisheries Education Versova, Mumbai - 400061

Abstract

Antimicrobial resistance (AMR) is recognized as one of the complex problems and bacteria have acquired resistance to a wide range of antimicrobials used due to its abuse in growth promotion, treatment of diseases etc. An unsolved and growing problem nowadays is known to be an antimicrobial resistance which have created a worldwide health crisis. Identifying the alternatives and bringing out comprehensive alternatives to antibiotics is the need of the hour, to further reduce the impacts. Strong commitment from all the stakeholders, researchers, and the policy makers are essential for limiting the rapid spread as well as emergence of new strains which are resistant to available antibiotics. Antibiotic prudence could be a nebulous concept that is difficult to define when the health of the individual, not the population, is of immediate importance. Nonetheless, central to executing antibiotic prudence is the availability of efficacious alternatives to antibiotics. Numerous alternatives to antibiotics exist for treating specific diseases, including bacteriophage therapy, predatory bacteria, bacteriocins, and competitive exclusion of pathogens. Novel studies are focussed on compounds with antimicrobial activity with antimicrobial properties of natural or synthetic compounds and development of nano particle based agents. Bacteriophages have been used for therapy in some parts of the world. The new arena has been making the antibodies as therapeutic agents in which the specificity of antibodies, and the inability of bacteria to develop resistance against them, make them attractive, albeit expensive, alternative therapeutic agents. Antimicrobial peptides have long been considered as potential replacements for antibiotics but with limited success. Synthetic peptides and synthetic membrane-active agents might cause a shift. For the purpose of stimulation or microbial enhancement, probiotics and faecal transplant therapy can be employed. The use of oligonucleotides for silencing resistance genes and re-sensitizing resistant bacteria to antibiotics are limited to in vitro experiments and haven't progressed to clinical evaluation. Several alternatives already exist in nature and are being researched on. Still, the challenge is to implement them in clinical use. Advancements within biotechnology, genetic engineering, and synthetic chemistry have opened up new avenues towards the search for therapies that can substitute antibiotics. Whilst the use of bacteriophages and antibodies has been partly implemented, other promising strategies, such as probiotics, lysins, and antimicrobial peptides, are in various stages of development.

Approaches

Strategies of the novel approaches have been arranged in three categories:

- (i) Naturally occurring alternatives,
- (ii) Synthetically designed strategies, and
- (iii) Biotechnology-based strategies.

The strategies are discussed in the light of the available literature.

Constraints and Strategies for Improvement of Domestic Post-Harvest Fisheries Sector of India

Prof. R. K. Majumder

Former HoD, Dept. of Fish Proc. Technol. & Engg. Central Agricultural University, Imphal, India

1. Introduction

With the growing population of the country and the increasing requirements for fish protein, the need for sustainable development of the post-harvest fisheries sector is now felt much more than ever before. Fish and fishery products serve as a part of a balanced diet because fish is known to be an excellent source of proteins, long-unsaturated chains of omega-3 fatty acids (EPA and DHA), vitamin D, vitamin B12, and many useful trace elements such as selenium and iodine. Over the years the demand for fish is on the rise all over the world due to such health benefits. The harvest and post-harvest handling, processing and distribution of fish provide livelihood for millions of people as well as provide valuable foreign exchange earnings. However, the disadvantage with the fish is that it is highly perishable though it is an inexpensive protein source. Due to this, the fish and fish products suffer 50-60% higher postharvest losses (PHL) compared to other subsectors of agriculture.

Post-harvest fisheries is considered a critical sub-sector and plays a very significant role in contributing to national food and nutrition security, livelihood of the people, and the national economy. Post-harvest technology serves to make fishery products available at the place, at the time and in the form required. One attractive way to help fishing communities is to improve the technology they use by introducing new or better ways of processing, handling, and packing fish. As spoilage of fish starts right from the time it is caught, proper storage, preservation and prompt disposal or transport services are essential. Various studies have pointed to the high levels of wastage in the Indian fish and fishery products due to spoilage. This is particularly acute during the monsoon, when up to 15-20 percent of the catch reported to be lost. Major technological advancements in post-harvest aspects of fish over the last six decades are in method of fish preservation, processing, packaging, improved attention for quality and improvements in processing machineries. The consumption of fish particular, in India is increasing significantly due to lifestyle changes and the higher relative cost of meat. In addition, the perception of fish as a healthy food with high levels of digestible protein, PUFA and lowering cholesterol capability constitutes a major factor for its increased consumption. *While the country has the most modern processing infrastructure catering to the export market, the same is not the case for domestic marketing.*

2.0. Key constraints

Fishermen are the key actors, as playing a pivotal role in keeping the quality of fish in the distribution chain. Because the spoilage of fish initiates at their hand and if adequate handling practice is not adopted, the entire lot is ruined. Therefore, strengthening of post-harvest infrastructure such as creation of chilled storage facilities, ice plants, cold chains and freezing/processing units, roads and transportation, modern and hygienic wholesale and retail fish market outlets etc., as well as effective marketing network in identified areas are the key requirements for the development of this sector. This would ensure higher profit margins to the producers enabling faster fisheries development. This will also promote quality assurance and better food safety standards for fish food for domestic consumers and also for the export markets.

The key issues and challenges that are currently faced by the post-harvest phase of Indian fisheries in the domestic sector includes:

2.1. Low per-capita consumption of fish

Consumption of fish creates a driving force for development of fisheries sector. However, fish also has export value but consumption in domestic market plays an important role in creating the demand for fish in the market. The national average of per-capita fish consumption is around 6.45 kg a year, this remains below the global average per capita of 16 kg and below the WHO recommended level of 12 kg per capita. Top five fish consuming states are Tripura (29.29 kg), Kerala (19.41 kg), Manipur (14.1 kg), Odissa (13.79 kg) and Assam (11.72 kg). In case of all other states, these figures are ten or less. Therefore, increasing per-capita consumption rate of fish becomes a challenging task.

2.2. Lack of adequate marketing infrastructure for hygienic handling of fish

The present condition of the infrastructure in the identified markets is in very bad shape with no drainage, highly congested, with poor or no water provision, many are without power connection and some are even functioning under open places. The existing markets are presently under the ownership of Municipality, Zila Parishads, Gram Panchayats. In most of the village markets, there is no ice-plants near the fish auctioning centres (Aratdar). There is need of developing proper marketing facilities for wholesale/retail marketing of fish including creation of modern fish market complex and modernisation of existing fish markets in industrial belt/cities/District HQs and towns in association with the municipal/local organisations.

2.3. Lack of infrastructure for proper fish distribution chain (supply chain)

Lack of technical knowledge, recurrence of natural disaster, decline of catch in natural waters, lack of ice box to carry fish by paikers (non-fisher traders) in distant places or to preserve unsold fish by retailers overnight, unavailability of ice during glut, high price of ice, lack of cold store to preserve ice block or iced fish, lack of potable water supply in arat (wholesale market), lack of insulated van or portable ice box for vending, money lending from aratdars (wholesellers) and mahajons (money lenders) at high rate of interest and also selling of fish at prefixed low price, huge unskilled workers involved in each step of fish value chain and undue toll taken by local mufias, etc. are the common constraints in wet fish distribution chain. Traditionally, local fishes are transported in normal vehicle, packed with insufficient ice and kept either in bamboo baskets or thermocol box. Even the traders collect fish from the farm gate and bring to the market without ice. Sometimes, imported fishes are repacked with already used ice for transportation from the main wholesale market to the suburban or rural markets. This mode of transportation results loss of the quality of the fish when it reaches to the market and fetch low price.

2.4. Lack of prior information regarding market forces, i.e., demand, supply and price

Presently, the inter linkages between various markets are poor leading to opacity in market information, i.e., demand, supply and price. This affects the consumers, traders and farmers adversely by creating pockets of over and under supplies preventing an appropriate demand supply match. As a result, the information regarding price, demand and supply are not available to the fish farmers/traders in appropriate time, which sometimes results financial loss to the traders. Sometimes it so happens that heavy loss is incurred by the farmers due to sudden excess market landings as there is no effective system of communication or harvesting schedule amongst the producers.

2.5. Lack of modernized fish landing/fish collection centres

Landing centres are quite inadequate with virtually no definite structure existing, thus the government is losing revenue. Freshwater harvest lands to some specific locations closure to principal fishing spots. Most of the reservoir or riverine fish landing centres are devoid of proper infrastructural facilities including ice plants and fish packing arrangements, even without provision of electricity and water supply. True recording of catch/distribution/market data at landing centres and markets at local, district or regional level is completely lacking. Further, there is lacking of maintaining proper database in the major landing /marketing spots.

2.6. Lack of adequate cold chain infrastructure

The cold chain concept, which again is in rudimentary stages, calls for provisions of integrated facilities to retain the quality of refrigerated or frozen fish from the time of harvesting till it reaches the consumers in distant parts of the country. The programs and strategies for fisheries and aquaculture development in the country under the Blue Revolution along with development of modern hygienic fish markets and cold chain will improve the acceptability of fish and also increase its consumption in the country. There are hardly any cold storages dedicated for fish. Benefits arise from the development of cold chain infrastructure across the supply chain of fish includes improvement of the nutritional status and food security by augmenting national fish production, reduction of post-harvest losses, improvement of quality and safety of fish products to acceptable standards, making fish available almost round the year and lastly to develop high profit margins to the producers.

2.7. Lack of clustering of fish producers

Agglomeration of fish producers improve economies of scale in producing, processing and marketing of fish. This includes Fish Farmer Producers Organizations (FFPOs), Fish Production Clusters (FPCs), Common Service Centres (CSCs). Fish value chain action plans can be developed and implemented through strengthening of farmers' societies and cooperatives for both production and marketing. Cluster specific business plans utilizing the innovative communication and information tools (e.g. production of small sized fish for marketing in live condition) can be developed to support the functioning of FFPOs and FPCs. Fish collection centres can be created in the Common Service Centres within FFPOs and FPCs supported with relevant infrastructures (such as ice plants, cold rooms, refrigerated/insulated vans etc.), so that fish from multiple producers can be properly packed with ice for transportation to the distant markets based on the prior market information.

2.8. Lack of adequate fish processing and value addition for the domestic market

With the rapid and continual changes in work cultures and life styles, especially of the urban population, demand for value-added fish products are in increasing trend. Moreover, value addition to fish can improve the socio-economic condition of the unemployed youths and also create employment opportunities. The conventional products are gradually replaced by the hygienically prepared and attractively packed products in the form of 'ready-to-cook', 'ready-to-serve' convenience foods. Rather, people have become more selective in their food choices and are ready to spend more on convenience food such as assembled meals, rather than preparing from base ingredients. Most of the fish

processing units of our country are export oriented and utilize high value fish. There is scope for utilization of low-priced fish for processing and value addition, which through attractive packaging can have a promising market in the domestic sector.

2.9. Lack of adequate measures to address quality and safety issues

Sanitation Standard Operating Procedure (SSOP) are not maintained anywhere during fish handling, processing, preservation, transportation, distribution and marketing systems. Hygienic conditions in the existing fish landing centres and local processing units are very poor and minimum standards wherever existing are hardly followed. Lack of proper drainage facilities in the markets, non-disposal of the fish market wastes, non-use of ice during transportation, poor personal hygiene of the fish handler, etc. are some of the aspects need proper attention to maintain edible quality of fish and to prevent contamination/infection from the fish. Fish Moreover, use of formalin in fresh fish or other harmful chemicals in dried fish appear in news on and often. There is lacking of adequate measure to sensitize and warn retailers and consumers regarding quality and safety issues of fish and fish products. Lastly, there is no proper vigilance in the retail and wholesale fish markets by the food safety officials.

2.10. High post-harvest loss

Very high levels of post-harvest loss occurs during pre-processing, processing, storage and transportation of fishery products. It also means that less fish is available to consumers, or consumers are supplied with poor quality fish and fish products. And these translate into losses in nutritional contribution of fish to the total diet and health of the population. It is also very difficult to estimate the losses in the sector due to its unorganised nature. According to Times of India (issue, March 15, 2020), the annual post-harvest fish loss of India was 61,000 crores as revealed by the Parliamentary Committee. The direct impact of increasing PHL across the value chain is loss of profit margin. Indirectly, decreasing product on the market affects food security, food safety, and livelihood. Some important factors that affect post-harvest loss includes high ambient temperature, long and unreliable transport with lack of adequate preservation, long storage time and also lack of proper awareness regarding market behaviour and dynamics.

2.11. Lack of judicious utilization of fish waste

Simple disposal of fish wastes either to open areas or municipal garbage is a great economic loss and also an environmental concern, since these could be recycled or utilized for beneficial purpose. Fish wastes especially generated in the markets, consists of guts, scales, skins, frames, etc. contribute about 30% of the whole fish. About 70% of the fish is dressed before final sale. Fish waste is a potential source of high-quality protein enriched with essential amino acids, oil rich in unsaturated fatty acids and essential minerals, could be an important protein and lipid source for fish feeds. Judicious utilization of fish wastes for beneficial uses which would not only reduce the amount of bio-waste going to disposal route, but would also substantially increase the economy of the fisheries sector.

2.12. Lack of entrepreneurship in post-harvest fisheries sector

Entrepreneurship in post-harvest fisheries sector is essential for creating self-employment for rural youth. But so far, this has not been developed upto a satisfactory level mainly due to want of motivation, technical and financial support, hand-holding, etc. Moreover, it is perceived that there is a lack of skilled trainers to disseminate information and assist in developing skills in marketing and management for fisheries entrepreneurs. The other major bottleneck in entrepreneurship development and self-employment is the credit requirement, which is not met by the formal lending institutions.

2.13. Production of dried and fermented fish are not organized

Drying, smoking and fermentation of fish is a traditional practice of fish preservation especially in the northeast and other states from time immemorial. Fermented fish products of northeast India have been reported to have excellent nutritional qualities, due to presence of lot of health beneficial microbes and nutraceuticals. Excess fish and mainly which are not preferred in fresh condition are usually dried for long-term preservation and export to other states. At present, such traditional products are made in a very unhygienic conditions without any effort of quality control and this sector is totally unorganized. Although, proper showcasing of these would create a great demand in SE Asian markets due to similar food habits.

2.14. Lack of skilled manpower to support different actors of the value chain

Skill development with an objective to create an employable workforce is the new mantra of the policy makers to promote the economic growth and equitable development of the country. In recent years the fisheries sector has witnessed many transformational changes in technology use; production, processing, and marketing; sectoral composition of the output and labour force. In the post-harvest fisheries, there is a dire need for skilling in this sector for doubling the production and farmers' income. Skilled manpower is *sine qua non* for quality conscious activities,

particularly for post-harvest fisheries sector for efficient utilisation of fish. It is a challenge to convert the mindset of the institutions and capacity building providers to bring them to a skill-based training program. As of now, they indulge only in knowledge—based, theoretical learning with minimum focus on skills. Most of the institutions lack quality trainers, infrastructure and environment for long-term skill-based training.

3. Strategies

In order to overcome the constraints mentioned, following strategies may be adopted.

- Mass awareness program on nutritional value of fish and fish products
- Provision of minimum requirement of a fish market, i.e., raised cemented platform, proper washing and drainage facilities, regular waste disposal and periodical sanitation.
- Establishment of modern hygienic fish markets in strategic locations.
- Large capacity ice plants, chilled rooms and stand-alone cold storages will be established at strategic locations.
- Promotion of door-to-door vending of fish in live condition.
- Modernization of the wholesale fish markets with loading and unloading facilities, hygienic auctioning platforms, availability of ice and cold storage facility.
- Information related to the availability of ice and ice box, cold storage facility, quality of ice and method of icing be made available to all the actors of value and supply chain.
- Development of a proven system for better information exchange between markets and producers.
- Modernization of the fish landing/collection centres
- All the FFPOs/FPCs/Fishermen Cooperatives and SHGs need to be connected through mobile app to get updated status of price, demand and supply of all big fish markets.
- Encouragement for processing and value addition of low-priced fish.
- Periodical inspection of fish sample from retail and wholesale markets as well as from dry fish markets for the presence of harmful chemicals like formalin, pesticides etc.
- Aggressive training for the farmers, traders and retailers including field staff on SOP/SSOP of hygienic fish handling, processing, preservation, transportation, distribution and marketing systems including personal hygiene to provide safe fish to the consumers.
- Capacity building/skill development programmes of the fish sellers in hygienic fish handling, sanitation, processing and marketing.
- Cured, fermented and value-added fish products should meet the standards enforced by BIS/FSSAI.
- Encouragement of youths for production of valuable products such as, fish feed, manure, foliar spray, collagen, gelatin, chitosan, chitin, pearl essence, etc. from fish waste on entrepreneurship mode.
- Cohesive and coordinated entrepreneurial training programmes, creation of more business incubators, etc.
- Promotion of Govt.'s role as catalyst in self-employment through developing private entrepreneurship in different post-harvest fisheries activities.

Conclusions

Improvement of the post-harvest fisheries management in the domestic sector needs proper and planned programs. This will supplement our aim of nutritional security with increase of per-capita fish consumption. In addition, this will minimize post-harvest loss, maximize employment opportunities. Further, interstate distribution of fish from low consumption-high production state to high consumption-low production state would be beneficial for the fishers to get optimum price for their produce.

Ecobiotechnological tools for reservoir fisheries management

Dr L.L.Sharma

Retd. Dean, College of Fisheries, Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur

Abstract

Reservoirs offer great opportunities for fisheries development due to their large water spread and huge catchment areas. These are often considered as the 'sleeping giants'. For harnessing the full potential of available aquatic productivity of a reservoir, a scientific management strategy has to be worked out for individual reservoirs. Based on this, suitable policies on stocking need to be worked out for selection of species, stocking number, stocking ratio and other related aspects. Obviously, for such an approach understanding and analyzing the basic aspects of the ecosystem of a particular reservoir are essential. Therefore, studies pertaining to water quality, available food resources, linkages of food chains and related aspects need to be investigated for the formulation of suitable scientific management strategy for the reservoir. With the increasing time span, the reservoir undergoes changes with respect to their trophic status and sometimes these alterations may be undesirable and deleterious due to various anthropogenic factors operating in and around the reservoir. For achieving the objective of sustainable fisheries, there is also a need for considering various aspects of conservation of fisheries resources. Unless the water body itself is conserved and maintained properly to ensure desirable water quality and available food resources, fisheries management may be posed with various problems leading to lower yields and may adversely affect sustainable fisheries. Use of various Ecotechnological methods can be adopted for the conservation of fisheries resources. The selection of a particular method or a combination of more than one ecotechnological methods, depends on the characteristics of the ecosystem and related issues of a particular water body. With the use of suitable ecotechnological methods it is possible to achieve twin objectives to reap the full potential of any reservoir for higher fish yields and ensuring sustainability in fish production. The most desirable scientific approach for reservoir management would be to conduct systematic limnological studies of reservoirs for the development of location specific suitable management plans. In this presentation problems of reservoir fisheries and management related aspects are discussed in the light of various Ecotechnological and management techniques.

Biotechnology Interventions for improving Fisheries and Aquaculture Production

Dr. Shiva Dhar Singh
Former ADG-Inland Fisheries (ICAR) New Delhi

Introduction

The development of improved fish seed stocks that can contribute to increased fish production is one of the key solutions to meet the future food demands of the growing world population. Biotechnology has opened a new window for development of genetic resources in aquaculture. Genetic Engineering Technologies can be utilized in aquaculture for a variety of reasons, not just to improve production but also marketability, cultivability and the conservation of natural aquatic resources. Research in aquaculture and fisheries genetic biotechnology has steadily grown since early 1980s, and now further investigations in this area are extremely active in many organisations of our country. Cultured fishes are being improved for a variety of traits, including growth rate, feed conversion efficiency, disease resistance, tolerance of low water quality, cold tolerance, body shape, dress-out percentage, carcass quality, fish quality, fertility and reproduction and harvest ability. The main vision of aquaculture biotechnology is to achieve improvements of aquaculture stock, preservation of genetic resources, disease diagnosis and control of microbial/micro algal genetic engineering. In broad terms, biotechnology can be defined as any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products or processes for specific use. This ranges from the use of synthetic hormones (GnRH) in induced breeding, hybridization, production of monosex, uniparental and polyploid population, molecular biology, transgenic fish to gene banking. Biotechnology has the potential to enhance reproduction and the early developmental success of culture organism. This technology is used in several different ways in aquaculture and its application benefits both producers and consumers of aquaculture food products.

World Scenario

Globally, total fisheries and aquaculture production reached an all-time high record of 214 million ton in 2020, comprising: 178 million ton of *aquatic* animals and 38 mt of algae. Despite the decline in capture fisheries, aquaculture continued to demonstrate growth in the last two years, albeit at a slower yearly rate. As a result, the production of aquatic animals directly used for human consumption reached 157 million tons in 2020, the second highest on record. The prevalence of moderate to severe food insecurity has been rising since 2014, exacerbated by the COVID-19 pandemic. Globally, over 800 million people now suffer from hunger and 2.4 billion people have severely limited access to adequate food. As we enter the Decade of Action to deliver the Global Goals, the challenge to feed a growing population without exhausting our natural resources continues to increase. In this context, aquatic food systems are increasingly in the spotlight for their potential to provide a larger proportion of humanity's nutritious food requirements.

In 2021, the FAO Committee on Fisheries (COFI) unanimously endorsed the COFI Declaration for Sustainable Fisheries and Aquaculture (FAO). This Declaration recognized the contributions of the sector in combating poverty and hunger since the endorsement of the 1995 Code of Conduct for Responsible Fisheries. Blue Transformation is the vision and the process by which FAO, its members and partners can use existing and emerging knowledge, tools, and practices to secure and maximize the contribution of aquatic (both marine and inland) food systems to food security, nutrition, and affordable healthy diets for all. Blue Transformation has three main objectives: 1) Sustainable aquaculture intensification and expansion 2) Effective management of all fisheries 3) Upgraded food chains. Climate and environment-friendly policy and practices, as well as technological innovations including biotechnology, are critical building blocks for Blue Transformation. Therefore, FAO and its partners must focus on the urgent demand for the development and transfer of innovative technologies including Biotechnology and Standard Best Practices to generate efficient, resilient, and sustainable operations for boosting both fish production and productivity.

Cryopreservation of Fish Germ Plasm: NBFGR, Lucknow has established a facility for cryo preservation of carp milt on large scale. This consists of Liquid Nitrogen Vapour Storage System (8000 numbers of 2.0ml cryovial), Dry shippers for air transportation of cryomilt, 1000L Liquid Nitrogen Storage Tank (1 no.), 11L transportation can (40 nos). Ten in-house training programs (hatchery operators/ progressive farmers from 21 states) at NBFGR and 13 fields training at 4 states (Odisha, West Bengal, Bihar and Uttar Pradesh) were completed. Total 353 prospective farmers were trained and manual in English and Hindi were distributed to the trainees during in-house and on farm demonstrations. During the year 2019, NBFGR distributed cryopreserved Indian major carp milt to 13 hatcheries located at 4 states (Uttar Pradesh, Bihar, West Bengal and Odisha), for fertilization of eggs collected from the female IMC brooders of hatchery origin and fertility trials were evaluated. A total of 37.2 lakh spawn was produced using frozen sperm under this demonstration.

An Innovative Project on backyard Re-circulatory Aquaculture System for High Density Fish Culture by NFDB in collaboration with Cochin University of Science and Technology was implemented. Further, 64 units were sanctioned to 34 beneficiaries in Telangana and 77 nos. of Backyard RAS units were set up in Kerala.

National Surveillance Programme for Aquatic Animal Diseases (NSPAAD). The aims of this programme are to (i) improve the collection of information on the distribution and occurrence of aquatic animal diseases, (ii) Quick Detection of new and emerging pathogens and (iii) implementation of national information management system for

fisheries diseases of national concern. A National Aquatic Animal Diseases Diagnostic Manual has been published on behalf of DoF under NSPAAD which has information on prioritized diseases including 22 finfish, 13 crustaceans and 6 molluscan diseases. For augmenting the passive surveillance system in our nation, a total of 518 awareness programmes have been arranged involving about 26104 stakeholders. A total of 67 trainings involving 1591 officers /research scholars have been held to strengthen their diagnostic capability. To observe the occurrence of endemic pathogens, a total of 1780 disease cases have been observed by various collaborating centres. Monitoring of about 2000 farms located in 151 districts have been undertaken twice per crop. Seven new/emerging diseases have been reported for the first time from India. These are (I) Goldfish haematopoietic necrosis disease, (II) Koi sleepy disease, (III) Infectious myonecrosis, (IV) Tilapia Lake Virus Disease (V) Infection with *Enterocytozoon hepatopenaei*, (VI) Epitheliocystis and (VIII) Red Sea bream Iridovirus disease. Besides, Infection with *Perkinsus olseni* has been detected in a new host i.e., farmed *Perna viridis*. Thus, this programme has succeeded in developing a strong network of aquatic animal health laboratories and scientific manpower with basic skills in surveillance and aquatic animal epidemiology tools. This activity has led to significant improvement in diagnostic capability for detection of OIE/NACA-listed and emerging aquatic animal pathogens. NSPAAD has helped in more understanding of fish diseases in the country and has come to the stage where it can easily identify diseases whether present or absent.

HRD: Biotechnology Departments established under several fisheries colleges and NFDB have collaborated with various Central Fisheries Research Institutes, other Central Organisations, State Fisheries Universities and KVKs for providing training to researchers, fishers, fish farmers, women, State Fisheries officials on various aspects of fisheries. Many types of training such as 3-day skill development programmes, 5-day Training of Trainers programmes, one day awareness programme on preventing usage of antibiotics in shrimp farmers etc have been organized. On an average, about 19800 fishery farmers including Departmental officials were trained on various aspects such as fish seed production, composite fish culture, RAS, brackish water aquaculture, Deep Sea fishing, ornamental fisheries, seaweed cultivation etc.

NFDB funded and established an Aquatic Quarantine Facility at Chennai, the first of its kind in the country, by MPEDA-RGCA to ensure the SPF status of imported brood stock of shrimp *Litopenaeus vannamei*. (Handbook on Fisheries Statistics: 2020).

Aquatic Animal Health Labs are supported by NFDB in 7 States namely Bihar, Andhra Pradesh, Tamil Nadu, Manipur, Assam, Tripura and Telangana; they act as main centres for collecting and furnishing information on disease outbreaks to the National Surveillance Programme for Aquatic Animal Disease (NSPAAD). Both conventional and molecular DNA based technologies are being developed and used in diagnosis of fish diseases and microbial contaminants.

Aquatic Animal Health & Quality Testing Laboratory (AAH&QTL): As in other farming systems, diseases are main threats leading to severe economic losses. Often, fish farmers use prohibited antibiotics, pesticides and toxicants to control various types of diseases and also use some preservatives. These practices violate the 'Food Code' or 'Codex Alimentarius' and accumulation of their residues not only adversely impacts consumers' health but also results in rejection of export consignments. NFDB established an in-house 'Aquatic Animal Health and Quality Testing Laboratory' (AAH&QTL) at Hyderabad to analyse and monitor the residues of aquaculture drugs, environment contaminants, etc. in shrimp, scampi, freshwater fish, hatchery seed and feed samples received from fish farmers and other stakeholders and provide them molecular and microbiological diagnostic services following standards protocols.

Biotechnological Interventions

Biotechnology has immense role in enhancing both quality and quantity of fisheries and fishery products. There has been considerable research in the developments of its tools and methods having applications to boost both fisheries and aquaculture. In order to achieve above, biotechnological tools and methodologies shall have to work in synergy with best and standard practices of both traditional and modern management strategies. These combined efforts of both traditional and biotechnological practices in aquaculture and fisheries will certainly add value in following activities.

- To improve production both in quantity and quality, processing, storage, transport and marketing of the products of capture and culture fisheries
- To achieve sustainable management and conservation of natural aquatic resources including the fish stocks/ ecosystem/environment
- To apply modern tools of research and development for optimizing production and productivity from fisheries and aquaculture
- To provide modern infrastructure mechanisms for fisheries & aquaculture and ensure their effective management and optimum utilization
- To train and generate substantial competent and skilled HRD leading to employment /livelihood
- To enhance contribution of fishery towards food, nutrition, economic, environmental and social security.

In fact, biotechnology and its related tools have already initiated their applications in following activities of fisheries and aquaculture through R&D programmes of different ICAR fisheries institutes, State and Central Agriculture Universities sponsored Fisheries Colleges and Govt of India, CSIR, DBT, MPEDA / Department of Fisheries

institutions/projects like National Fisheries Development Board etc. To be more precise, work on following areas has been initiated by ICAR and other Government organizations to augment fish production and productivity in this country.

Induced Breeding

The artificial propagation methods constitute a major practicable means of providing enough quality seed for rearing in confined enclosure such a fish lakes, reservoirs, and tanks. Fish culture today is hardly possible without the artificial propagation of fish seeds of preferred cultivable fish species. Apart from being able to obtain quality seed the artificial propagation technique can also be used to develop strains superior to their ancestors by the methods of selective breeding and hybridization. Hormonal stimulation with Ovotide and Ovaprim allows year-round production of gametes and fry of economically valuable species. Hormone therapy is applied to improve and control of reproductive cycles during the domestication. The induced breeding of fish is now successfully achieved by the development of Gonadotropin releasing hormone (GnRH) technology. GnRH is the key regulator and central initiator of reproductive cascade in all vertebrates. It is a decapeptide with the ability to induce pituitary release of luteinising hormone (LH) and follicle stimulating hormone (FSH).

Genomics and Genetic breeding techniques

The recent advances in genomics techniques and availability of chromosome level genomes have revolutionized the field of genetics and breeding by providing meaningful insights into the genetic basis of traits, identifying genetic variations and expediting the improvement of aquaculture fish species. The whole genome availability offers the means to develop high density genetics maps, Qualitative trait loci (QTL) and molecular markers associated with QTL's. These powerful tools allow for more efficient and precise selection of desirable traits in aquaculture species. It enables the identification of genomic regions associated with important traits such as growth rate, disease resistance, tolerance to environmental stress conditions, and product quality. This facilitates in identifying superior candidates for breeding, accelerating genetic gain, and reducing the generation interval. The genetic diversity and population structure can also be better elucidated by genomic studies which are vital for the preservation and ethical management of genetic resources, conservation initiatives and sustainable breeding programs (Su et al 2023).

Gene-editing

Gene editing is a powerful technology that enables us to make precise changes to the DNA of an organism. It involves modifying specific genes to introduce desired traits or remove undesirable ones. Some of the most widely used gene editing tools include CRISPR-Cas9 (Clustered Regularly Interspaced Short Palindromic Repeats and CRISPR-associated protein 9), RNAi (RNA interference), ZFN (Zinc Finger Nucleases), and TALEN (Transcription Activator-Like Effector Nucleases). Doudna and Charpentier (2020) shared the Nobel Prize in Chemistry for their above work. Some major applications of gene editing tools involve studying the function of a gene, improving growth and performance, and imparting disease resistance. It is crucial to remember that applying gene editing to aquaculture necessitates careful consideration of ethical, regulatory, and environmental issues. The potential advantages and risks of gene editing must be weighed against societal concerns. For aquaculture to use gene editing technologies responsibly and sustainably, adequate research, risk analysis, and disclosure are crucial and prerequisite.

Transgenics:

The transgenic involves the transfer of certain preferable traits from one species into another species in this case of fishes. These traits may include improvement of growth rates (Sekhar et al 2015), larger size, more efficient feed conversion and control of sexual maturation. The technology offers an excellent opportunity for modifying or improving the genetic traits of commercially important fishes, molluscs and crustaceans for aquaculture. It is a short cut to achieving genetic change for fast growth, disease resistance, tolerant to low level of dissolved oxygen in the water and fish resistant to freezing temperature.

Electroporation is considered as an efficient and versatile massive gene transfer technology. An increased resistance of fish to cold temperatures has been another subject of research in fish transgenic for the past several years. Coldwater temperature is a stressor to many fishes, and few are able to survive water temperatures much below 0-1°C. This is often a major problem in aquaculture in cold climates. Interestingly, some marine teleosts have high levels (10- 25 mg/ml) of serum antifreeze proteins (AFP) or glycoproteins (AFGP) which effectively reduce the freezing temperature by preventing ice-crystal growth. The isolation, characterization and regulation of these antifreeze proteins particularly of the winter flounder, *Pleuronectes americanus*, has been the subject of research for a considerable period (Marshall et al 2004). The introduction of AFPs to gold fish also increased their cold tolerance, to temperatures at which all the control fish died. Similarly, injection or oral administration of AFPs to juvenile milkfish and tilapia led to an increase in resistance from a 26 to 13 °C drop in temperature. The development of stocks harbouring this gene would be a major benefit in commercial aquaculture in countries where winter temperatures often border the physiological limits of these species. The use of biotechnology to create transgenic fish, such as the genetically altered Atlantic salmon AquAdvantage involving Growth Hormone gene and promoter, is the most recent of these interventions (Yaskowiak, et al 2006). We have cloned, characterized and expressed growth hormone gene from Pangasianodon hypothalamus in Escherichia coli. The product of which after purification when injected into Labeo rohita has increased their growth

(live weight basis) within almost 3 months of nursery rearing by about 18% in comparison to controls fishes (Sekar et al 2014, 2015). We also believe that the use of transgene elements homologous to both the structural gene and promoter region sequences are more effective and useful than heterologous ones for growth hormone (GH) transgenesis in farmed fish species (Nam et al 2008). In fact, very recently Kim et al (2018) have decoded a draft genome of *P. hypophthalmus* and performed comparative analyses for marker-assisted breeding.

Host pathogen interaction

Host-pathogen interaction studies play a crucial role in aquaculture by enhancing our understanding of the interactions between aquatic organisms and disease-causing pathogens. By investigating the mechanisms of host-pathogen interactions, scientists can identify key factors that contribute to disease susceptibility and resistance in aquaculture species which may result in the development of strategies to control and prevent disease outbreaks, leading to improved survival rates, reduced economic losses, and increased production efficiency in aquaculture operations. The knowledge of biology and behaviour of these pathogens can help develop targeted interventions such as vaccines, antimicrobial treatments, and biosecurity measures to prevent and manage diseases and also contribute to the sustainable development of aquaculture by promoting environment friendly practices. Host-pathogen interactions studies also help in assessing the impact of diseases on wild populations, identify potential risks associated with the introduction of non-native species, and develop protocols for responsible aquaculture management that minimize the spread of diseases and prevent negative ecological consequences. To be more concise, research on host-pathogen interactions in aquaculture has a significant impact on disease management, prevention, and sustainable production. They offer vital insights into the biology of pathogens, host immune responses, and disease resistance, leading to improved health and welfare of aquatic organisms, increased productivity, and the overall sustainability of the aquaculture industry.

Aquaculture health management

Biotechnology plays a crucial role in the animal health management by contributing innovative solutions for disease diagnostics (Adams, and Thompson 2011), prevention and treatment. the utilization of molecular diagnostic tools like PCR, qPCR, multiplex PCR (Sahu, et al, 2019), DNA probe-based in-situ hybridization, microarray, ELISA and DNA sequencing, enables us to identify the various pathogens rapidly and accurately facilitating a prompt treatment and initiating preventive measures to limit the spread of infections. The vaccination development procedures and vaccination programs impart enhanced immune response and protection against pathogens and reduce the incidence and severity of the diseases (Adams. and Thompson, 2008). Vaccines developed by using recent advanced molecular techniques can be considered as an effective way of treating disease causing pathogens in aquatic organisms (Mondal and Thomas 2022). In conclusion the implementation of the above methods in animal health management, aquaculture producers can enhance disease control, improve animal welfare, and ensure sustainable and profitable operations, ultimately leading to a healthier and more resilient aquaculture populations. The application of PCR detection of viruses of brood stock and larval stages is now practised in most of the countries in all commercial sectors.

Environmental Management & Bioremediation

Aquaculture farms generate diverse waste, including residual food, fecal matter, metabolic by-products, biocide residues, fertilizer-derived wastes, and waste from moulting and algal blooms. Bioremediation improves water quality by applying microbes or enzymes to ponds and eliminate undesirable waste compounds (Jasmin et al 2020). Effective bioremediation requires microbes capable of clearing carbonaceous wastes. *Bacillus* species are suitable for organic detritus bioremediation. *Lactobacillus*, used with *Bacillus*, breaks down organic detritus, reducing water turbidity. Excess nitrogen applications lead to ammonia and nitrite accumulation, harmful to fish and shrimp. Nitrification via bio-filters with ammonia oxidizers removes ammonia. Denitrifying filters convert nitrate to nitrogen gas, but many ponds lack these filters, accumulating nitrate. Phosphorus limitations in freshwater influence nitrification rates. Microbes like *Bacillus*, *Aeromonas*, and *Pseudomonas* are screened for bioremediation efficacy. Commercial bio remediators include nitrifiers, sulphur bacteria, and *Bacillus* or *Pseudomonas* species. Phosphorus is typically limited in freshwater environments, and any imbalance in the NO_3/PO_4 ratio is thought to depend on factors influencing nitrification rates or bacterial regeneration of phosphorus. Within organisms, phosphorus is predominantly present as phospholipids and nucleoproteins. Certain bacteria produce enzymes like phosphatases and phytases that convert organic compounds into PO_4 , the inorganic form of phosphorus. The solubility of inorganic phosphates is mainly influenced by pH. Bacteria can release PO_4 from these compounds by producing organic and mineral acids.

Nutrigenomics

Nutrients are important signals that affect genes, proteins, and metabolites, ultimately impacting the overall health of aquatic species. Understanding how diet and nutrition influence molecular processes is crucial in aquaculture. In aquaculture, studying gene expression related to muscle growth helps determine the right amino acid requirements for different fish species. Similarly, analysing genes associated with immunity provides insights into the health of fish. However, it's challenging to comprehend how the composition of fish feed, their gut bacteria, and resulting metabolites interact. Different diets can affect fish health and their ability to fight off diseases. Despite advances in

studying fish gut bacteria, we still need to understand how it relates to fish health and immunity. In recent years, aquaculture has shifted towards using more plant-based proteins in fish feed. This change poses new challenges for fish health and product quality. For example, mycotoxins found in wheat, soy, and peas can reduce fish growth and weaken their immune system. Phytoestrogens in soy affect the development and genes of vertebrates. To better understand the effects of plant protein-based fish feed, this study used zebrafish as a model. They examined how these feeds affect gene expression and overall health at a molecular level (Singh et al 2008).

Nanotechnology

Nanotechnology has become increasingly influential in aquaculture, finding applications in sensors, drug delivery, pathogen control, and more (Shah and Mraz 2019). Nano biosensors, for instance, are utilized to detect extremely low concentrations of pathogens like bacteria, viruses, and pollutants in water. These sensors enable early identification and monitoring of potential threats to aquatic organisms. Furthermore, nanotechnology has facilitated the development of diagnostic sensors and controlled drug release systems based on nanoparticles. These systems can respond to changes in environmental parameters such as temperature, pH, and dissolved oxygen levels. By leveraging nanotechnology, these advancements enable precise and targeted drug delivery, enhancing the effectiveness of treatments and minimizing potential side effects. An interesting development in aquaculture is the use of colloidal silver nanoparticles, which exhibit antimicrobial properties. These nanoparticles have demonstrated efficacy against a wide range of pathogens, including viruses, fungi, and bacteria. Their broad-spectrum action offers potential solutions for mitigating diseases and improving overall health in aquatic species. While nanotechnology's applications in aquaculture extend beyond water treatment, it is worth mentioning that nanomaterials have shown promise in addressing water pollution concerns. Through photo-catalytic and adsorption mechanisms, nanomaterials can efficiently remove contaminants and pollutants from water sources. This approach presents cost-effective and sustainable solutions for water purification in aquaculture settings.

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Ornamental Fisheries: A Promising Employment Creating Sector Post COVID-19 in Both Rural and Urban India.

Dr. Atul Kumar Jain

Ornamental Fisheries Training and Research Institute, Udaipur-313001, Rajasthan

Introduction

The entire world came to a standstill during the COVID-19 pandemic and people were bound to stay in confinement either at home, in hospitals, or elsewhere. Everyone underwent a difficult time and the wheel of economic growth slowed down considerably. The post-COVID effects are still visible at many frontiers as nations are trying hard to emerge out of the adversity. India has set an example to the world in such a difficult situation by effectively managing the pandemic at home and extending support to other nations. The economic growth of the country has revived as GDP grew by 6.6% during 2022 and is estimated to be 7.2% by the end of 2023 while it is much less for numerous other developed nations. The total value of the Indian economy is presently valued at US\$ 3.75 trillion with only USA, China, Japan, and Germany, ahead of India (Business Today, 2023).

When all the economic activities slowed down during the pandemic except those related to essential commodities and services, there was one business activity though very small in magnitude that kept rolling. It was the pet industry including fish keeping. It was the period when hobbyists could spend time with their loving pets. These pets provided company to the housemates during this phase of solitude, acted as a stress buster and helped to energise the ambience. The pets and aquarium shop dealers in all parts of the country have played an important role. They helped sustain the hobby by managing the supply of fish feed, medicines, aquarium equipment and live fish to aquarium hobbyists. It was during this period when many people realized the importance of fish keeping and large numbers of youth felt that ornamental fisheries could be a promising business activity. The ornamental fish farming, aquarium trading and other allied activities that were earlier being operated by less and moderately qualified people, now attract highly professionally qualified youths. The number of aquarium shops and ornamental fish production units has relatively grown speedily post-COVID-19 with many other emerging activities. The Pradhan Mantri Matsya Sampda Yojan 2020 of GOI with a proposed investment of Rs. 576 crores (MOFAHD, 2020) and financial assistance of Rs. 500 crores from the world bank for the development of ornamental fisheries in India was appropriate timely support. The current scenario and potential of different ornamental fisheries activities for entrepreneurship development are briefly discussed.

Indian ornamental fisheries Pre COVID-19

The pre-COVID phase was the transition period for the Indian ornamental fisheries sector. It was during this period when the juvenile phase that began at the start of the 21st century was coming to an end (Jain and Jain, 2019). A few of the salient characteristics of the Indian ornamental fisheries industry pre-pandemic can be summarised as follows:

- The total value of domestic aquarium trade was Rs. 500 crores during 2019-20. The number of aquarium shops crossed the mark of 5000 with the existence of aquarium shops almost at all district headquarters and even large towns. The ornamental fish production farms which were earlier limited to a few villages of West Bengal, Maharashtra and Tamil Nadu extended to Kerala and Karnataka as well as to inland states of Rajasthan, Madhya Pradesh, Bihar, and even north-east states of the country.
- The first-ever schemes of financial support were launched by the Marine Products Export Development Authority (MPEDA), Ministry of Commerce and Industry, Government of India establishing 579 ornamental fish production units in the coastal states of Karnataka, Kerala, Maharashtra, Tamil Nadu and West Bengal as well as inland states of Himachal Pradesh, Madhya Pradesh, and Rajasthan.
- National Fisheries Development Board (NFDB), Ministry of Fisheries, Animal Husbandry and Dairying, GOI launched another pilot project with a proposed investment of Rs. 61.98 crores. The scheme supported many ornamental fisheries developmental activities in the states of Karnataka, Kerala, Maharashtra, Tamil Nadu, West Bengal, Odisha, Gujarat, Bihar, and Assam including the setting up of an ornamental fish brood bank at the University of Guwahati, Assam.
- NFDB organised several workshops for policy formulation, funded organising large numbers of skill development training and publication of literature on ornamental fisheries development.
- The National Skill Development Corporation (NSDC), Ministry of Skill Development and Entrepreneurship, identified ornamental fisheries as one of the important livelihood support activities and formulated training modules for skill enhancement in ornamental fisheries.
- The ornamental fisheries-based vocational courses were introduced at many UGC-approved degree colleges in the country.
- Several numbers of Public Aquarium Galleries were established in different parts of the country in private as well as in government institutions.

- In addition to all the above one of the noticeable changes in the Indian ornamental fisheries sector was the increasing interest of professionally qualified youth of the country to set up ornamental fisheries-based startups.

A major turning point

The year of pandemic 2020 and 2021 proved to be a "Blessing in disguise" for the Indian ornamental fisheries industry. The implementation of Pradhan Mantri Matsya Sampada Yojna 2020 at the same time further supported the development of the sector.

Blessing in disguise

The two lockdowns in combination with the implementation of the "work from home" policy played an instrumental role in promoting the hobby of aquarium keeping. It was during the lockdown period that many family members other than the key hobbyist at home realised the importance and benefit of aquarium keeping. The key hobbyists enjoyed setting up their aquarium the way they wanted to do it for a long time while the other family members developed a bonding with their aquarium fishes which was lacking earlier. A few of the hobbyists even upgraded their hobby to breed the ornamental fishes with appreciable success and shared their produce with other hobbyists. All these circumstances, motivated many highly qualified youths in the country to take up ornamental fisheries to become self-employed. It includes fisheries graduates, IT professionals, engineers, MBAs, NRIs etc.

Implementation of PMMSY

The Ministry of Fisheries, Animal Husbandry and Dairying, Government of India announced Pradhan Mantri Matsya Sampada Yojan 2020 with a proposed investment of Rs. 20,050 crores to develop fisheries, aquaculture, and fishermen. The ornamental fisheries were identified as one of the major activities for livelihood support, entrepreneurship development and doubling the income of farmers with a proposed investment of Rs. 576 crores. At the same time, financial assistance of Rs.500 crores was extended by the world bank for the development of ornamental fisheries in the country. Under the PMMSY scheme, a beneficiary is provided financial assistance to set up a backyard ornamental fish production unit, integrated freshwater ornamental fish production unit, marine ornamental fish production unit, brood bank, aquatic ornamental plant culture unit etc (Table-1). A total of 1689 ornamental fish production units have been established in the country with financial assistance under PMMSY since its inception in 2020 (MOFAHD, 2023).

S.No.	Name of Scheme	Total Project Cost	Financial Assistance*
1.	Backyard ornamental fish-rearing unit (Both marine and freshwater)	3.00	0.75
2.	Medium-scale ornamental fish-rearing unit (Both marine and freshwater)	8.00	2.00
3.	Integrated ornamental fish unit (Breeding and rearing of freshwater fish)	25.00	6.25
4.	Integrated ornamental fish unit (Breeding and rearing of marine fish)	30.00	7.50
5.	Establishment of freshwater ornamental fish brood bank	100.00	25.00
6.	Construction of fish kiosks including ornamental fish	10.00	2.50
7.	Promotion of recreational fisheries#	DPR	25%

* 25% of the total project cost in the case of the General category and 40% for SC, ST, Women, and NE regions.
Limited to approved project cost

Others-A few other factors that are contributing to the fast progress of aquarium fish keeping in the country are;

- Changes in spending behaviour including expenses on pursuing a hobby,
- Increasing annual income and number of middle-income group families
- The increasing number of nuclear families with the work-from-home concept
- Easy availability of aquarium fish and equipment,
- Decreased cost of aquariums and fish,
- Easy access to information on social media on aquarium keeping,
- Visibility of aquarium at many public places including aquarium galleries.

Entrepreneurship opportunities in ornamental fisheries

The ornamental fisheries is not the culture of ornamental fishes and setting up of an aquarium. It embraces several activities for entrepreneurship development under the current market demand as follows:

- Culture of freshwater ornamental fishes
- Culture of marine ornamental fishes
- Culture of aquatic ornamental plants
- Breeding of indigenous ornamental fishes



Fig.1: Entrepreneurship opportunities in ornamental fisheries

- Culture of live fish feed
- Setting up an aquarium shop
- Export of ornamental fishes
- Manufacturing of aquarium and aquarium accessories
- Manufacturing of ornamental fish feed and medicines
- Aquarium servicing and maintenance unit
- Establishing a fish pedicure spa
- Setting up of public aquarium gallery or aquapark

Readers are advised to scan the QR code in Fig.1 to learn more about the entrepreneurship development opportunities and potential in the ornamental fisheries sector.

Entrepreneurship promotion

The organizing of entrepreneurship promotion and skill enhancement activities are very essential for entrepreneurship development in any sector for sustainable growth. It may include skill development training, awareness campaign, organisation of other extension activities etc. at different levels. It will include aspiring entrepreneurs, existing ornamental fish producers and aquarium traders as well as aquarium hobbyists in case of ornamental fisheries. The Ornamental Fisheries Training and Research Institute (OFTRI) is contributing to all these requirements through various training programs and activities. OFTRI is a recognised training partner with the National Skill Development Corporation, Ministry of Skill Development and Entrepreneurship and National Fisheries Development Board, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India.

Programs for aspiring entrepreneurs

OFTRI regularly organises "Entrepreneurship development and management training" on ornamental fisheries for aspiring entrepreneurs at their farm in Village Veerpura, Tehsil Sarada, District Udaipur, Rajasthan. It is a 5 days duration training program on self-finance mode. The training module consists of practical demonstrations, hands on-training, classroom lectures and the screening of films on ornamental fisheries. The training program helps participants learn about the status and potential of the sector, entrepreneurship opportunities, culture and breeding of ornamental fishes, aquarium fabrication and maintenance, fish feed and health management, institutional support, DPR preparation etc. Many youths have already undergone this training and established their farms, aquarium shops and aquarium galleries. College students from different parts of the country are also regularly visiting our centre for an exposure visit. On completion of the training, participants are assessed by the Agriculture Skill Council of India (ASCI) and awarded a certificate of "Ornamental fish technician" on qualifying for the assessment.

Programs for existing ornamental fish producers

Skill enhancement training on freshwater ornamental fish breeding and culture is another training module organized by OFTRI for existing ornamental fish producers. The objective of this specific program is to help update the knowledge and skill of existing ornamental fish producers. The training contents are delivered through on-farm demonstrations, hands-on training and classroom lectures. On completion of the training, participants are assessed online by ASCI and awarded a certificate of "Ornamental fish technician" on qualifying for the assessment. Both institutionally sponsored and self-finance programs are organised from time to time.

Programs for existing aquarium traders

The domestic aquarium trade will grow if the number of hobbyists will increase. The aquarium traders in the domestic market are playing a very important role to promote the hobby of ornamental fish keeping as they are the first guide to a new hobbyist. Many of the new hobbyists discontinue keeping the fish as they do not get proper advice from their aquarium suppliers. Many times, it is because of the lack of their knowledge. It was learned that many aquarium traders were willing to update their knowledge and enhance their skills but could not because of the long distances of training centres and the duration of training programs. To solve this problem, OFTRI requested permission from ASCI to organize online training programs for existing aquarium traders only. It helps them to understand basic concepts of aquarium keeping as they already have practical knowledge of the subject. The training module consists of 12 lectures of 45 minutes each followed by 15 minutes discussion at the end of every lecture. On completion of training, participants are assessed online by ASCI and awarded a certificate of "Aquarium technician" on qualifying the assessment. More than 100 aquarium traders all over the country have already become certified aquarium technicians under this program. OFTRI is also organizing free webinars from time to time for aquarium traders and ornamental fish producers and inviting subject experts to deliver a lecture and interact with the participants.

Programs for aquarium hobbyists- As stated earlier the domestic aquarium trade will grow if the number of fish-keeping hobbyists also grows. Hence, there is a need of organizing activities to promote the hobby of fishkeeping and help the hobbyists to know the art and science of aquarium keeping. OFTRI has published 50 one-page e-bulletins at a weekly frequency during 2019-20 on the following subjects of ornamental fishkeeping:

- Basic lessons of freshwater aquarium keeping (Fig.2)
- Guidelines for water quality monitoring of a freshwater aquarium (Fig.3)
- Guidelines for selecting fishes for a freshwater aquarium (Fig.4)
- Diagnosis and treatment of freshwater aquarium fish diseases (Fig.5)



Fig. 2: Basic lessons of freshwater aquarium keeping



Fig. 3: Guidelines for water quality monitoring of a freshwater aquarium keeping



Fig.4: Guidelines of selecting fishes for a freshwater aquarium



Fig. 5: Diagnosis and treatment of freshwater aquarium fish diseases

OFTRI has also developed an e-course on “Freshwater aquarium keeping” to help learn the basic science and art of aquarium procurement, installation, and routine maintenance. The course contents will be delivered through text material as well as pre-recorded audio-video lectures and films. It will be a paid training program and launched shortly online.

Conclusion

The ornamental fish-keeping hobby is growing very fast in the country. Consequently, a large number of jobs and entrepreneurship development opportunities are being created. The developmental agencies have also realised the potential of ornamental fisheries for livelihood support, employment generation and economic development hence, launched many schemes of financial assistance and skill development. The PMMSY is targeted to increase the value of domestic aquarium trade to Rs. 3000 crores, export of ornamental fishes to Rs.100 crores and the number of fish hobbyists to 5% of the urban household population. The value of ornamental fish export increased from Rs. 10.84 crores (US\$ 1.55 million) in 2019-20 to Rs. 33.32 crores (US\$ 4.53 million) during 2021-22 being the highest ever (MPEDA, 2023). The FOREX of US\$ 4.53 million may appear very meagre in terms of the total export earnings of the country. But it is a three times increase in the export of ornamental fish from India post-COVID-19. It is an indication of the growing size of the ornamental fish industry in India. However, there is a need of implementing activities to promote the hobby of aquarium keeping. OFTRI is working with the same objective and mission.

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Fishery Resources and Its Management

Dr. Sushanta Kumar Chakraborty

ICAR-Central Institute of Fisheries education, Off Yari road, Panch Marg, Versova, Mumbai - 400061

Abstract

India is endowed with rich natural freshwater, coastal and marine fish resource. The estimated catch of India in 2021-22 is around 16.24 mmt and the catch from marine capture resource is 3.49 mmt (Handbook of Fisheries Statistics, 2022). Total number of people who are engaged in fishing and allied activities from inland sector is 23 million and in the marine sector is around 4 million (Year book of Fisheries Statistics, 2021). The total catch of World is around 177.8 mmt of which 90.3 mmt is from capture and 87.5 mmt from culture (SOFIA, 2022). The resources of fishery importance are fish, crustaceans, molluscs and echinoderms. The total number of fish reported from the world is around 35100 (Froese and Pauly, 2023). As per NBFGR India is native to 3193 fish belonging to 1036 genera of 254 families and 53 orders (NBFGR, 2023) and About 324 exotic species - 291 ornamental, 31 aquaculture and 2 larvicidal taxa have been recorded from the Indian waters (Kumar and Pandey, 2013). At least 200 of them are commercially important. The overall fish consumption per capita in India averaged 6.31 (Handbook Fisheries Statistics, 2022). Almost all these species exhibit faster growth rate attaining maturity at about one year of age, are highly fecund and are multiple spawners.

The development of fishery science started in a systematic way with the advent of Europeans in India. However, it must be mentioned that as quoted by Nikolsky (1963) that the earliest mention of fishing pressure reducing the catch of fish in the Indus River can be traced back to the ancient scripture of Mahabharatha in India. A good number of taxonomists like Russell (1803) Cantor (1839) MacClland (1839), Hamilton (1826), Bleeker (1840), etc. made huge contribution towards taxonomy of Indian fish. But the "MAGNUM OPUS" to quote Silas (2003) came from a veterinary surgeon Francis Day who published his books in the years as *Fishes of Malabar* (1865), *Fishes of India* in two volumes (1875-78), *Fauna of British India* (1889) describing 1418 species of fish. These are still the most indispensable work of fish taxonomy in India till date (Silas, 2003). Indian Fisheries Act came into existence in 1897 and fisheries was made a state subject so that depending on made for their protection and management. This sector has seen sea of changes in the last 150 years in fisheries research, education, extension and development necessitating change in the Act. The Britishers also made several Surveys catering to specific needs like ZSI, BSI, GSI, ASI etc. The ZSI became one of the major centre for research on fish. Director of ZSI emphasised the need for special institutions for doing research in fisheries. On his recommendation as Fisheries Development Advisor the Marine Fisheries Research Station was established in Zoology Dept. of Madras University which was shifted to Mandapam Camp in 1949 and to Cochin in 1972. On March 17, 1947 CIFRI station was started which was subsequently named as Central Inland Fisheries Research Institute. Presidencies of Madras, Bengal and Bombay too contributed to the development of fisheries sector. Most of the Universities in India were impairing education in fishery science. Later specialised colleges teaching fishery science came into existence with COF Mangalore being the first.

The concept of Fish resource being infinite was an established norm, however later it was discovered that this is not true. As the number of boats went up it was found that rate at which they reproduce far exceed the rate at which we fish them. Thus fishery scientists started research as to how much should be harvested out of water in order to sustain the resource. The precursor to the Sustainable Yield was given by Kyle (1905) as Rational Fishing. Reproductive biology of fish including length/age of maturity, seasons and periods of spawning, age, growth and stock assessment studies including MSY etc. were worked out. Scientist in fishery science were trained by FAO/DANIDA / ICLARM in India by analysing their own data. This made the study of population dynamics easy for them. This was followed by tremendous development in computer based stock assessment programmes like, LFSA (Sparre, 1987), ELEFAN (Gayaniilo *et al.*, 1988) and FiSAT (Gayaniilo *et al.*, 1995) were easily made available. This made the task of estimating population parameters easy. Further development in this field was the Ecosystem based models where the study of the whole ecosystem from primary producers to top level predators can be done taking all the individuals /groups in the food chain and food web. Trophic levels were assigned depending on their position in the food chain and the status of mean trophic level was determined to assess the health of the fish/ecosystem. Studies on the Large Marine Ecosystem (LME) and Marine Protected Area (MPA) was initiated to study the species in situ and assess biodiversity. MPA's protect marine life and allows systematic and continuous monitoring of the area. Systematic and continuous monitoring sea and atmospheric parameters it's processing, analysis, interpretation and dissemination is going on. Satellite remotely sense information on SST, OC and current patterns and supplied by PFZ advisories from INCOIS gives forecast in Indian seas. NOAA gives seasonal forecast of Oceans from California to Vancouver especially on sardined and Salmon. Japanese Information Centre give information on fish to Japan. FAD's are very important for fish assemblages like tuna, groupers etc. It apart from giving protection to predator's gives abundant food and protection of juveniles and larvae. Acoustic devices have also evolved in a long way. Silicon Diode Intensified Target (SIT), Laser Line Scan System (LISS), SONAR (Chu, 2011) are routinely used. A number Institutions World over as well as Indian and many researchers from different countries including India have made management of fish resource a success.

Aquatic Animal Bio-security in Aquaculture Production Systems

Dr. Ratan Kumar Saha, Tanmoy Gon Choudhury
College of Fisheries, CAU (I), Lembucherra, Tripura 799210

Introduction

A significant challenge to the expansion of aquaculture production is the outbreak of disease. Potential economic losses from disease outbreaks are significant, and can affect the survival of the industry. The occurrence of disease is a combination of the health of the animal, the condition of the environment, and the presence of a pathogen. The poultry industry has implemented a bio-secure production system to prevent the spread of infectious disease among farms. It serves as a model to aquaculture as a reliable source of animal protein worldwide. This paper briefly highlights some of the major points and practices of biosecurity for various aquaculture production systems, prawn farming finfish culture and mollusks culture as well as regulations and policies to prevent and control the spread of aquatic animal diseases are provided. The key elements of biosecurity are:

- A reliable source of stocks,
- Adequate detection and diagnostic methods for excludable diseases,
- Disinfection and pathogen eradication methods,
- Best management practices, and
- Practical and acceptable legislation.

To meet the world's demands for high quality aquaculture products necessitates the importance of disease control. Good biosecurity measures are vital to maintaining healthy animals, to reducing the risk of acquiring diseases in aquaculture facilities and to harvest high quality yield.

What is Biosecurity?

Biosecurity can be defined as 'the measures and methods adopted to secure a disease-free environment in all phases of aquaculture practices (i.e., hatcheries, nurseries, grow-out farms) for improved profitability'. Bio-security protocols are intended to maintain the "security" of a facility (i.e., prevent entry of, or reduce overall numbers prior to entry) with respect to certain disease-causing organisms (parasites, bacteria, viruses, and fungi) that may not be present in a particular system.

Good Biosecurity Measures

Good biosecurity measures reduce the exposure to disease causing organisms with, **External Barrier**– preventing the spread of disease-causing organisms onto and off a farm or hatchery and **Internal barrier**- preventing the spread of disease-causing organisms within a farm.

Biosecurity Management Protocols

Biosecurity involves many strict management protocols to prevent specific pathogen from entering a system or reducing the numbers. A good understanding of pathogen reservoirs is important. Quarantine, sanitation, and disinfection are all important components of biosecurity.

Aquaculture Biosecurity Policy

Aquaculture biosecurity policies vary from farm-level to the international level, and between areas at each of these levels, but several characteristics are essential if aquaculture biosecurity policies are to be successfully implemented (Scarfe, 2003). These common characteristics include:

- a) Science-based decision making,
- b) Economical and sociopolitical rationales,
- c) Standardized and uniform methods,
- d) Relative ease of application,
- e) Wide recognition,
- f) Vertical and horizontal integration, application, and agreement,
- g) Consistent enforcement, and
- h) A primary focus on prevention, but with contingencies in place for control and management, or eradication.

Conclusion

Biosecurity can be applied to aquaculture production systems through a variety of management strategies and by following internationally agreed upon policies and guidelines. In addition, there are a variety of risk assessment that can be used for aquatic animal diseases of finfishes and shellfishes. The key element of biosecurity can be summarized as reliable sources of stock, adequate diagnostic and detection methods for excludable diseases, disinfection and pathogen eradication methods, best management practices, and practical and acceptable legislation.

Aquacultural activities of Dr. Naseem's Farm and Modern Hatchery for sustainable aquaculture development

Dr. M. Naseem

*Dr. Naseem's Farm and Modern Hatchery
Kathaun, Rajaun Dist.-Banka (Bihar)*

Abstract

The Sustainable Livelihood approaches (SLA) through National Conference on Fisheries At College of Fisheries Kishanganj for the Development of Rural Small Scale Fish Farmers Combines a conceptual frame work with an infrastructure of genuine operational guidelines to Cater Day to Day demands of the quality Fish Seed (Fingerlings) to the Rural Fish Farmers is the immediate need for many Districts of Bihar Specially Bhagalpur, Banka, Purnea, Katihar, Araria and Kishanganj.

Observing the present situation and Lack of Knowledge in the farmers Dr. Naseem's Modern Hatchery and Research Farm Situated at Kathaun, Rajaun Dist.-Banka. Set a Goal and Established in the Year 20th April 2020 to fulfill the High Demand of Healthy Fish Seed and to provide Proper Training on Pond Water Management for aquaculture through Pilot Project.

Background

This is an integrated Fish Farm constituted with various ideas comprising an area of 12 acres near Chanand River with the determination to educate Farmers.

(a) To support the potential Fish culture to contribute to increase production of Livelihood, employment, income generation of rural areas small scale farmers.

(b) To access the possible environmental and socio-economic impact

(c) To scaling up the modern technologies to optimize the benefits on a sustainable manner.

Achievements in the year 2022.

Seed production

In the Year of 2022-23 produced fingerlings (Rohu- 2 Million) , (Catla-1.5 M) (Mrigal- 2.5 Million), (Common Carp 5 Million), and (Grass Carp-0.5 Million)

First ever brooder bank

(Rohu-500 Numbers, Age- 2-3 Years), (Catla-200 Numbers, Age-3 Years), (Mrigal 200 Numbers, Age 3 Years), (Grass Carp - 100 Numbers, 3 Years) and (Panagasuis-200 Numbers, Age 3-5 Years).

(Training Given to be Farmers)

155- Rajoun, Banka Year 2021

58- Katyama Banka Year-2021-22

112-District Munger Year-2022-23

50-Rajoun Banka, Year 2022

100-Sabour Naugachia Bhagalpur Rural Year 2022-23

(Production of Market Size Fishes)

Rahu - 7 MT- 202

Catla - 9 MT- 2022

Mrigal - 3 MT - 2022

Grass Carp- 1 MT- 2022

Common Carp - 2 MT- 2022

Pargasius - 2 MT - 2022

Dr. Naseem's Farm and Modern Hatchery is Compassionate and sensitive towards all our related Farmers and Treat them with way we would expert to be treated. It provides equal and fair opportunity for other associates for the Laborers to learn them our techniques and to feel them Confident.

Theme I: Priming Indian Aquaculture for Boosting Rural Economy

TRPSF-AQUA-O-1

Comparative growth performance of major and minor carp of genus *Labeo* in lesser Himalayan region, India

Ashutosh Mishra*, Lovdeep Sharma, Vipul Gupta, Akansha Khati and M. Das Trakroo
College of Fisheries, G.B. Pant University of Agriculture & Technology, Pantnagar- 263149, Uttarakhand

*Corresponding author: ashutosh36in@yahoo.co.in

Abstract

The present study aimed to evaluate the growth performance of Indian Major Carps (*Labeo catla* and *Labeo rohita*) and Minor Carp (*Labeo gonius*) in captivity from Lesser Himalayan region, an experiment was conducted for 90 days. Three different treatment sets (T₁, T₂, and T₃) in FRP tanks (Size. 2.5 m diameter with 4 m³ water volume) in triplicate with experimental fishes (*L. catla*, *L. rohita* and *L. gonius*) @ 25 fingerlings m⁻³ in each treatment with uniform combinations of 1:1 ratio (T₁- *L. catla* and *L. gonius*; T₂- *L. catla* and *L. rohita*, T₃- *L. rohita* and *L. gonius*) were maintained indoor in the polycarbonate house of College of Fisheries, Pantnagar. Over the course of the experimental period the growth parameters viz. weight gain, length gain and specific growth rate were observed and analyzed. In addition, the important water quality parameters viz. water temperature, total dissolved solids, conductivity, dissolved oxygen and pH were recorded fortnightly and found optimum throughout the study period. The statistical analysis of the result shows that there is a significant difference (p<0.05) in the weight gain of experimental fishes among treatments. The highest weight gain was observed in the experimental fishes of T₁ as compared to T₂ and T₃ treatments. The specific growth rate ranged between 0.1 to 0.35% day⁻¹. Significant difference (p<0.05) in survival rate was observed among treatments in which T₁ and T₃ fishes showed better survival than T₂. Overall results showed that the growth performance of *L. gonius* in combination with *Labeo catla* was best among all while *Labeo gonius* performed excellent with *Labeo catla*. The findings of this research could provide valuable insights into the development of improved aquaculture practices for these species, leading to enhanced production and economic upliftment in the aquaculture sector.

Key words: Minor carp, Growth Performance, Specific Growth Rate, Survival Rate, Economic Upliftment

TRPSF-AQUA-O-2

Changes in digestive enzyme activities during the early ontogeny of milkfish, *Chanos chanos* larvae

T. Sivaramakrishnan*, K. Ambasankar, Sandeep, K.P, Aritra Bera, K.P. Kumaraguru Vasagam, M. Kailasam^b
ICAR-Central Institute of Brackishwater Aquaculture, Chennai-600028, Tamil Nadu, India

*Corresponding author: sivaraman.fish@gmail.com; sivaramakrishnan.t@icar.gov.in

Abstract

Knowledge of the developmental ontogeny of the digestive system and nutritional requirements of marine fish larvae is a primary requisite for their successful rearing under an optimal feeding regime. In this context, we assessed the activity profile of key digestive enzymes viz., trypsin, chymotrypsin, leucine aminopeptidase, lipase, amylase and alkaline phosphatase during the early ontogeny of milkfish, *Chanos chanos* (0, 3, 6, 9, 12, 15, 18, 21, 25 and 30 days post-hatch). Larvae for this study were obtained from fin fish hatchery of ICAR-Central Institute of Brackishwater Aquaculture, Chennai, India. The growth curve (length and weight) of the larvae during the study period indicated a positive morphological development, under a standardized feeding regime that comprised of *Chlorella salina*, *Brachionus plicatilis*, *Artemia salina* nauplii and commercial weaning feed, for different larval stages. With respect to protein digestion, the specific activity of pancreatic enzymes trypsin and chymotrypsin, and intestinal brush border leucine aminopeptidase showed two peaks at 3 and 15 dph, following the introduction of rotifer and *Artemia nauplii*. Similar bimodal peaks were observed for alkaline phosphatase and amylase, with first peak at 3 dph, and second peak at 18 and 21 dph, respectively. Whereas in the case of lipase, high activity levels were observed at 0, 3 and 18 dph, with subsequent decrease and showing fluctuating trend. This study revealed that the most of the enzymes were found to have peak activities at 15 to 21 dph, indicates this period can be potentially considered as the starving period for weaning milkfish larvae from live to formulated feeds in milkfish larval rearing.

Keywords: Milkfish larvae, *Chanos chanos*, Digestive enzyme, Weaning, Larval feed

TRPSF-AQUA-O-3

Food & nutritional security improvement and income enhancement through a climate resilient farming system

Lopamudra Sahoo¹, Anup Das², Chandan Debnath³, Vinay Singh¹, H. Bharati¹, H. Lembisana Devi¹

¹ICAR RC for NEH Region, Tripura Centre

²ICAR RC for Eastern Region, Patna

³ICAR RC for NEH Region, Umiam

*Corresponding author: lucy2311@gmail.com

Abstract

This technology is targeted for the low lying flood prone zones. During unprecedented heavy rainfall, the extent of damage to crops is to the tune of 50-100%. A floodplain farming system was evaluated for 4 years to address this problem. In this system, the area of 0.15 ha was divided to raised and sunken bed system. All the beds were used for paddy cultivation during rainy season. In addition, lowland were used for fish culture where in high demand small indigenous and self recruiting species like Puntius, Mola and Kanla along with carps can be cultured. In addition, the raised beds were used for vegetable cultivation during winter and summer season. This system will be very beneficial to the farmers because if the flood destroys the paddy crop in the lowland, there will be an additional upland paddy for overcoming distress. In addition, the fishes will generate household nutritional security as well as additional income. The system generated a gross income of Rs.2,60,000/ha/annum with a rice equivalent yield of 13t/ha/annum. Thus the system has a potential to enhance productivity by about 3 times compared to conventional monocropping of paddy in flood prone areas. Since field crops, vegetables and fish are integrated in the system, it also generates year-round income and employment making the system climate resilient.

Key words: Climate resilient, Farming system, Paddy, Vegetable, Fishes

TRPSF-AQUA-O-5

Effect of different weaning strategies on growth and survival of *Clarias magur* larvae (Hamilton 1822)

Pravesh Kumar*, Shivendra Kumar, Roshan Kumar Ramand, P. P. Srivastava
College of Fisheries, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar- 843121

*Corresponding author: pravesh.cof@rpcau.ac.in

Abstract

The catfishes have high market demand for its good taste, high protein and iron content as well as therapeutic applications. *Clarias magur* is the preferred medium sized catfish for pond culture. But the major constraint is the non-availability of quality seeds due to higher larval mortality. In the current study, we breed the magur and try to optimise the larval rearing techniques by using different weaning strategies. We raise the brood stock at our farm by using good quality feed and maintaining optimum water quality parameters. During the month of July-August 2021-22 the breeding trials were conducted by using mature female (140-160 gm) and male (120-135 gm). The average breeding parameters from more than 30 pairs and 2 years of breeding trails were recorded. The gonadosomatic index (GSI) during the breeding season for female was $10.4 \pm 1.7\%$ and for male was $0.5 \pm 0.1\%$ while fecundity was 420 ± 20 eggs/gm ovary weight. The average fertilization rate of $79 \pm 5\%$, average hatching rate of $68 \pm 8\%$ and the deform larvae percentage of $13 \pm 4\%$ was obtained. For 4 weeks weaning experiment, we used three thousand larvae (4 dph, 4.0 mg in wet weight) in fifteen plastic crates (200 no./crate) of 160 litre capacity, containing 40-lit water. The five types of diets namely; Powdered feed (T1), mix-plankton (T2), Artemia nauplii (T3), Milk powder (T4) and Egg custard (T5) in different combinations and in triplicates were used during the experiment. In all treatments, larvae were fed to apparent satiation four times a day (08:00, 12:00, 16:00 and 20:00 h). All the uneaten food and faecal residues were siphoned out after 2 hours of every feeding. The larval survival after 4 weeks trial was highest in T3 group (43%) but not significantly different from T2 group (40%) and lowest in T4 group (0%). The daily growth rate and specific growth rate were also higher in mix plankton and artemia nauplii fed groups compared to others. So, we can conclude that mix plankton (T2) and Artemia nauplii (T3) fed group larvae have higher survival and growth compare to other treatments.

Keywords: *Clarias magur*, Weaning strategies, Artemia, Mix plankton, Survival

TRPSF-AQUA-O-6

Effects of starvation and re-feeding regimes on the growth and selected digestive enzymes activity of Nile tilapia, *Oreochromis niloticus*

Raj Kamal Mishra, Pravesh Kumar, Ankur Jamwal, P. P. Srivastava, Bhumika Gamango, Roshan Kumar Ram, Adita Sharma

College of Fisheries, Dr.Rajendra Prasad Central Agricultural University, Dholi-843121, Bihar, India

**Corresponding author –pravesh.cof@rpcau.ac.in

Abstract

In aquaculture adjusting feeding frequency and reducing the amount of feed can reduce working cost and prevent deterioration of water quality. In this study we used *Oreochromis niloticus* juveniles (Avgwt. 9.34 ± 0.9 g) and examined the effects of starvation and re-feeding on compensatory growth performance, blood glucose level, Hepatosomatic index (HSI), and digestive enzyme activity for 60 days period. The fish were divided in 5 treatment groups: a control group (fed continuously) and 4 fasting groups- T₁ (1 days fasting), T₂ (3 days fasting), T₃ (5 days fasting) and T₄ (7 days fasting) and re-feeding was done for 7 days to each group in a repeated cycle (cycles; 7, 6, 5, 4) immediately after starvation. The growth rate was significantly ($P < 0.05$) decreased from T₃ group onwards during these 60 days fasting and re-feeding cycles. i.e., the re-feeding groups showed a compensatory growth up to T₂ group as control. Further, the feed conversion ratio, feed efficiency ratio, and specific growth rate up to T₂ group were same as control. The activities of digestive enzymes like Amylase, Protease and Lipase during the initial cycle of fasting decreases dramatically as the number of fasting days increases but rises and reached to almost control level after different cycles of fasting and re-feeding at 60th day. The serum glucose levels were also significantly dropped during starvation, but after re-feeding, it back to control. The Hepatosomatic index was not significantly change during the experiment period. The Growth rate, digestive enzyme activity of selected enzymes, blood glucose level and Hepatosomatic index (HSI) in Nile tilapia recover positively after re-feeding up to T₂ group. Taken together, the present findings suggests that 3days fasting and 7days re-feeding in multiple cycles can be a strategy for reducing the input cost in Tilapia farming.

Keywords—*Oreochromis niloticus*, Fasting, Refeeding, Compensatory growth, Blood glucose

TRPSF-AQUA-O-7

Investigation of Potassium Supplementation in Aquaculture Wastewater and Its Impact on Growth Performance of Pangasius (*Pangasianodon hypophthalmus*) and Basil (*Ocimum basilicum* L.) in NFT-Based Aquaponics

Neerudu Harika, Ajit Kumar Verma*, Kishore Kumar Krishnani, Chandrakant Mallikarjun Hittinahalli, Ramakrishna Reddy, Manjulesh Pai

ICAR-Central Institute of Fisheries Education, Off Yari Road, Versova, Andheri (W), Mumbai-400 061, India

*Corresponding author : akverma@cife.edu.in

Abstract

An experiment was conducted for 120 days to optimize the potassium dose and investigate its effects on the growth performance of basil (*Ocimum basilicum* L.) and pangasius (*Pangasianodon hypophthalmus*) in a nutrient film technique-based aquaponics. Potassium was supplemented as four different dosages assigned as T₁ (90 mg/L), T₂ (120 mg/L), T₃ (150 mg/L), and T₄ (180 mg/L) and compared with unsupplemented (control). The basil and pangasius (12.66 ± 0.08 g) were stocked at the rate of 24 plants/m² and 3.00 kg/m³, respectively in each aquaponic unit. The basil was harvested four times and the highest yield was observed during the 3rd harvest in T₄ (390.50 ± 4.25 g) followed by T₃, T₂, T₁, and control. No significant difference in plant yield was observed between T₄ and T₃. Similarly, highest plant height, leaf length, leaf width, SFW, SDW, RFW, and RDW was recorded in T₄ and T₃ compared to control and other treatments. Potassium supplementation resulted in increased uptake of macro-micro nutrients in basil. The physico-chemical parameters and nutrient profile of culture water were found to be within the permissible limits for aquaponics. The body weight of fish didn't show any significant difference in control, T₁, T₂ and T₃ while significantly lower body weight was recorded in T₄. Significantly higher serum cortisol and glucose levels were found in T₄. Considering the water quality, basil yield, plant nutrient content, body weight of fish, and fish stress parameters, supplementation of 150 mg/L (T₃) of potassium was found to be the optimum dose for basil and pangasius culture in NFT-based aquaponic system.

Keywords: Aquaponics, Basil, Pangasius, Potassium

TRPSF-AQUA-O-8

Physiological and Metabolic responses of Amur carp (*Cyprinus carpio haematopterus*) reared at different salinity using inland saline ground water

Shashank Singh^{1,2,*}, A. K. Reddy¹, P. P. Srivastava^{1,3}, Munish Kumar^{1,2} and W.S. Lakra¹

¹ICAR- Central Institute of Fisheries Education, Mumbai, Maharashtra

²College of Fisheries, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh

³College of Fisheries, Dr. Rajendra Prasad Central Agricultural University, Dholi, Muzaffarpur, Bihar

*Corresponding author: drssaqua@gmail.com

Abstract

A 90 days experiment was conducted to evaluate the effect of different salinity of inland saline ground water on physiological and metabolic responses of Amur carp (*Cyprinus carpio haematopterus*). The experiment was conducted in the 12 circular FRP tanks (500 L capacity each) with 400 L water. Two hundred forty fish (avg. wt. 3.48 ± 0.27 g) were equally distributed in 12 FRP tanks in four experimental groups such as C (<0.5 ppt), T₁ (5 ppt), T₂ (10 ppt), and T₃ (15 ppt) following Completely Randomized Design (CRD). Serum biochemical indices like serum glucose and serum cortisol level showed a significant difference and recorded highest at higher salinity. Digestive enzyme activity showed no significant difference between control and T₁ whereas decreasing trend and significant difference was recorded with T₂ and T₃. Aspartate aminotransferase (AST) and Alanine aminotransferase (ALT) activities in the liver and muscle of Amur carp reared at different salinity depicted significant difference in T₁, T₂, and T₃ while no significant difference was observed between control and T₁ group. Lactate dehydrogenase (LDH) and Malate dehydrogenase (MDH) activities showed increasing trend with increase in salinity. Superoxide dismutase (SOD) and Catalase (CAT) activity of the gills and liver in different treatment groups showed significant difference with control and higher values were recorded in T₃ group. Thus, the findings of the present study revealed that the inland saline ground water of upto 5 ppt can be used for the culture of Amur carp without any alteration in physio-metabolic responses of the fish.

Keywords: Amur carp, Inland Saline Ground water, Cortisol, AST, ALT, Glucose

TRPSF-AQUA-O-9

Potential of Elephant Foot Yam (*Amorphophallus paeoniifolius*) Leaf as a Potential Non-conventional feed ingredient for grass carp (*Ctenopharyngodon idella*): Converting waste into valuable resource

Devarshi Ranjan¹, Shivendra Kumar^{1*}, P. P. Srivastava¹, Pankaj Kishore², Ankur Jamwal¹, Roshan Kumar Ram¹, Maneesh Kumar Dubey¹

¹College of Fisheries, Dr. Rajendra Prasad Central Agricultural University, Dholi, Muzaffarpur - 843121, Bihar, India

²ICAR-Central Institute of Fisheries Technology, Cochin-682029, Kerala, India

*Corresponding author: shivendra@rpcau.ac.in

Abstract

Elephant foot yam leaf is commonly directly discarded resulting in a waste of resources and environmental pollution. However, elephant foot yam leaf contains effective nutrients is far from being fully realized, hence it has potential to be a safe and effective feed ingredient in aquaculture. To investigate the impacts of elephant foot yam leaf meal (EFYLM) on nutrient utilization, growth performance and digestive enzyme activities of grass carp (*Ctenopharyngodon idella*), juvenile (initial weight 2.01 ± 0.02 g) were fed *ad-libitum* with five isoproteinous (crude protein 30%) and isolipidic (crude lipid 6%) semipurified diets supplemented with 0% (control), 10%, 20%, 30% or 40% of elephant foot yam leaf meal for 45 days. At the end of experiment, it was recorded that inclusion of EFYLM upto 20% in the diet did not affect the growth performance (weight gain percentage & specific growth rate) and nutrient utilization (FCR, FER, and PER) of juveniles, compared to control (0%) and significantly decreased ($P < 0.05$) in 30%, and 40% inclusion level. Digestive enzyme (amylase, protease, and lipase) activity were also significantly decreased ($p < 0.05$) in the juveniles fed with diet having inclusion of more than 20% EFYLM. Finding of the present study concluded that EFYLM can be include in feed upto 20% in place of major energy sources ingredients (Protein and carbohydrate as in control). Accordingly, the waste leaf of elephant footyam, after harvesting the yam crop, can be doubly beneficial as removing menace of waste leaves and also its utilization as non-conventional feed ingredient in fish feed.

Key Words: *Ctenopharyngodon idella*, Digestive Enzyme, Elephant Foot Yam Leaf, Growth, Nutrient Utilization

TRPSF-AQUA-O-10

Preparation of Crude Extracts from Pod Meal of Khejri, *P. cineraria*, and their *In-vitro* Evaluation of Antioxidant and Antimicrobial Activities

Rohitash Yadav^{1*}, Manish Jayant², Gulshan Kumar¹, N.K. Chadha², V.P. Saini³, Paramita B. Sawant², M.L. Ojha⁴

¹College of Fisheries Sciences, Gumla, Jharkhand-835207

²ICAR-Central Institute of Fisheries Education, Mumbai-400061

³College of Fisheries Kishanganj, Bihar-855107

⁴College of Fisheries, Udaipur, Rajasthan-313001

*Corresponding author: draquayadav093@gmail.com, rohitashyadav093@gmail.com

Abstract

An increase in the transition from semi-intensive to intensive culture practices of modern aquaculture has triggered oxidative stress and immune suppression. Thus, the fish raised in a high stocking density system requires a well-balanced feed supplemented with nutraceuticals that can support the fish's immune system. An attempt was made to search the suitable, commonly available native medicinal plant that can be used to improve an aquatic animal's growth performance and health. Khejri, *Prosopis cineraria* is a commonly available medicinal plant in India. In this study, three extracts, viz. aqueous, ethanolic, and methanolic extracts, were prepared from khejri pod meal (KPM), and their antioxidant and antimicrobial properties were evaluated using *in-vitro* assays. 65% ethanolic extracts prepared from khejri pod meal (KPM) exhibited higher dry matter recovery of 16.07 ± 0.57 than 80% and 95% ethanolic extracts. Similarly, higher dry matter recovery was observed in 65% methanolic extracts of KPM (16.43 ± 0.8) than in 80% and 95% ethanolic extracts. Whereas dry matter recoveries were 6.71 ± 0.24 in aqueous extracts prepared from KPM. KPM-based-ethanolic extracts exhibited maximum 2,2 diphenyl 1 picrylhydrazyl inhibition (74.71 %), followed by methanolic (48.53 %) and aqueous (37.65%) extracts. Ethanolic KPM extracts exhibited higher ferric-reducing antioxidant power activity ($4407.00 \mu\text{mol Fe (II)/g}$) than methanolic ($3574.00 \mu\text{mol Fe (II)/g}$) and aqueous ($3174.00 \mu\text{mol Fe (II)/g}$) extracts. DPPH inhibition and FRAP activity of KPM extracts showed a positive relationship with total phenolic contents ($P < 0.05$). Ethanolic KPM extracts exhibited maximum bacterial inhibition (mm) against *Edwardsiella tarda* (11.67 mm) and *Aeromonas hydrophila* (10.50mm), followed by methanolic and aqueous extracts. Based on the results of the *in-vitro* study of antioxidant and antimicrobial activities, ethanolic 65% extract exhibited significantly higher antioxidant properties (DPPH inhibition (%), FRAP activity, TPC contents) and antimicrobial against *E. tarda* and *A. hydrophila* than aqueous and methanolic extracts ($P > 0.05$); hence it could be used as an antioxidant (nutraceutical) in the diet of different cultivable fish species.

Keywords: KPM, Pod Extract, Antioxidant, Antimicrobial, *Aeromonas hydrophila*

TRPSF-AQUA-O-11

Total Replacement of Soybean meal by Rice Distilled Dried Grain Soluble (DDGS) and Lysine Supplementation in Diet for *Cirrhinus mrigala*

Aditi Banik¹, Shivendra Kumar^{1*}, P. P. Srivastava¹, Pankaj Kishore², Sujit Kumar Nayak¹, Pravesh Kumar¹, Abhishek

Kumar¹, Maneesh Kumar Dubey¹

¹College of Fisheries, Dr. Rajendra Prasad Central Agricultural University, Dholi, Muzaffarpur - 843121, Bihar, India

²ICAR-Central Institute of Fisheries Technology, Cochin-682029, Kerala, India

*Corresponding author: shivendra@rpcau.ac.in

Abstract

The increased availability and potential price advantage of rice distiller's dried grains with solubles (DDGS), there is considerable interest in utilizing this product in aquaculture diets. To investigate the response of rice DDGS on nutrient utilization and growth performance, *Cirrhinus mrigala* juveniles (initial average weight 14.00 ± 0.10 g) were fed *ad-libitum* for 45 days with twelve isoproteinous (crude protein 30%) and isolipidic (crude lipid 6%) practical diets containing 0, 6, 12, 18, 24, 30% of rice DDGS replacing up to total dietary soybean meal with and without lysine supplementation (0.1%). At the end of feeding trial, treatment fed with diet having 18% or more rice DDGS without lysine supplementation recorded a significant decrease ($P < 0.05$) in growth performance and nutrient utilization in juveniles compared to treatments fed with diet having 12% or less rice DDGS. However, supplementation of lysine (0.1%) in the diet showed an improved growth performance of juveniles as compared to the non-supplemented counterpart diet containing at least 30% of rice DDGS. Activities of digestive enzymes (protease, amylase, and lipase) were also significantly ($P < 0.05$) higher in the lysine supplemented group compared to the non-supplemented group.

Considering all the factors, a negative trend was observed with nutrient utilization, growth performance and digestive enzymes activity and signalled that more than 12% inclusion of DDGS in practical diets without supplementation of lysine recorded negative physiological effect, however supplementation of lysine nullify the negative effect of total replacement of soybean meal by rice DDGS. Overall, the present study demonstrated the high potential of rice DDGS as an alternative to the soybean meal feedstuffs for mrigal and rice DDGS can be increased to at least 30% (highest level evaluated) if lysine is supplemented.

Keywords: *Cirrhinus mrigala*, Rice DDGS, Lysine, Growth, Nutrient Utilization

TRPSF-AQUA-O-12

Transforming rural poverty to prosperity: The makhana (*Euryale ferox* Salisbury) cum fish culture system in Bihar, India

Shailendra Raut¹, Jaspreet Singh², Vinod Kumar Padala¹, S. K. Ahirwal², Ravi Kumar³, Tarkeshwar Kumar², Rahul Kumar Rout¹, Kamal Sarma², I. S. Singh¹, Manoj Kumar¹, B. R. Jana¹

¹ICAR-National Research Centre for Makhana, Darbhanga- 846005, Bihar, India

²ICAR Research Complex for Eastern Region, Patna-800014, Bihar, India

³ICAR Mahatma Gandhi Integrated Farming Research Institute, East Champaran 845429, Bihar, India

*Corresponding author: shailenmraut10@gmail.com

Abstract

The study focused on evaluating the performance and economic feasibility of semi-intensive integrated makhana-fish farming, to promote sustainable livelihoods and alleviate rural poverty. The experiment was conducted in an 800 m² pond with a depth of 1.2 m in triplicates in Bihar, India, comparing makhana (*Euryale ferox* Salisbury) cultivation alone with makhana-fish integrated culture. Fish fingerlings of various species were stocked in makhana-fish integrated ponds, including catla (*Gibelion catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*), bata (*Labeo bata*), kawai (*Anabas testudineus*), and snakehead (*Channa striatus*). Results revealed that the integrated makhana-fish culture system yielded a significant production of makhana seeds (1500±170 kg/ha) and fish biomass (1596±201 kg). Among the fish species, rohu and catla showed higher average weights and biomass. The water parameters remained within acceptable limits in both experimental ponds. The integrated system not only enhanced resource utilization but also resulted in increased income (>55%) and improved nutritional sustainability compared to monoculture methods. These findings highlight the potential of the makhana cum fish culture system in Bihar, India, to transform rural poverty into prosperity while promoting sustainable livelihoods.

Keywords: Makhana, Fish, Livelihood, Integrated aquaculture, Bihar, India

TRPSF-AQUA-O-13

Use of Azolla in Diet of Common Carp Fry (*Cyprinus carpio*)

Vivekanand Bharti*, Kamal Sarma, Tarkeshwar Kumar, Surendra Kumar Ahirwal and Jaspreet Singh

ICAR-Research Complex for Eastern Region, Patna. 800014

*Corresponding author: vivekanandbharti15@gmail.com

Abstract

Aquaculture production of crustaceans and finfish, relies on farm-made or industrial diets. About two-thirds of the protein in aquatic diets comes from fish meal and with the expansion of the aquaculture industry, demand for fish feed has increased with rapid hikes in prices which ultimately affected feed cost, thereby increasing in operational cost of fish farming. Several attempts have been made by researchers to partially or totally replace fish meals with less expensive, locally available protein sources. In recent years, aquatic plants have taken a new dimension in producing the much-required animal protein at a low cost. The present study was conducted on the growth performance of common carp fry with the incorporation of Azolla (*Azolla pinnata*) in its feed ingredient. Azolla powder, mustard oil cake (MOC), maize powder (10%), rice bran (20%), wheat bran (17%), maida (8%), vitamins (1.5%), oil (3%) and salt (0.5%) were used for the preparation of fish feed. The fish feeds namely T₁, T₂, T₃ and T₄ were prepared by adding Azolla powder as 10%, 20%, 30%, and 40%, respectively. Azolla powder was not added to the control diet, where 40% MOC was used. The result of the study indicated that the significantly highest weight and length were found in T₃. The weight gain and percentage weight gain in common carp were also found in T₃. However, the feed conversion ratio was lowest for T₁. The trend-wise growth pattern of common carp also showed a higher weight and length for T₃ as compared to other treatments. The water quality such as temperature, pH, alkalinity, hardness, DO, ammonia and nitrite did not show any significant difference among the treatments. To observe the feed quality the proximate composition of feed such as moisture, protein, and fat ash content was analyzed, and found that there are no

significant differences in protein content in feed in all treatments, resulting in no significant difference in protein content in the fish carcass also. Similarly, to observe the health condition of fish, haematological parameters were analysed and found that there are no significant differences in haematological parameters except WBC.

Keywords: Azolla, Common Carp, Feed Quality, Water Quality, Carcass Quality

TRPSF-AQUA-P-1

Utilizing Tannery Solid Waste (TSW) as a protein source for fish feed

Revathi A, Manish Jayant, A*, Shiv kumar, Husian Nottanalan

Fish Nutrition, Biochemistry and physiology Division, ICAR-Central Institute of Fisheries Education, Mumbai

*Corresponding author: manishj@cife.edu.in

Abstract

The leather processing industry is a major contributor to environmental pollution, with significant amounts of waste being generated and improperly disposed of worldwide. In India alone, the presence of around 3,000 tanneries results in the daily production of 50 million liters of liquid waste and 305 million kilograms of solid waste. This issue is particularly prominent in West Bengal and Tamil Nadu. On a global scale, the annual production of fresh hides from various animals accounts for 8 to 9 million tonnes, leading to approximately 1.4 million tonnes of waste during processing. This waste includes keratin waste, skin trimmings, chrome shaving waste, buffing waste, and fleshing waste. To address the environmental challenges posed by the leather processing industry, urgent action is needed to embrace the zero-waste concept. This involves minimizing the use of these materials and implementing effective recycling methods. Currently, only 25.5% of the processing waste in the leather industry is utilized to produce leather products, while the remaining 74.5% is indiscriminately dumped into the environment, causing severe environmental damage. Furthermore, the leather processing industry requires significant amounts of water and process chemicals. For every 1000 kilograms of wet salted hides or skin, approximately 40 cubic meters of water and 452 kilograms of process chemicals are necessary. Out of this, only 72 kilograms of chemicals are retained in or on the leather, while a substantial 380 kilograms are wasted and discharged in various forms. One method to address this issue is the use of chrome tanning to remove chromium from tannery solid waste. The recovered chromium can then be repurposed as a valuable ingredient in the fish feed industry, offering an innovative way to utilize waste material. In conclusion, it is essential to adopt sustainable practices in the leather processing industry to mitigate its environmental impact. This includes reducing waste generation, maximizing recycling efforts, and exploring innovative methods for waste utilization. By implementing these measures, the industry can move towards a more eco-friendly and responsible approach, ensuring a more sustainable future for the leather industry.

Keywords: Tannery Solid Waste, Zero-waste concept, Fish feed, Protein

TRPSF-AQUA-P-2

Utilization of shrimp shell waste-derived natural astaxanthin in synergistic combination with its commercial variant enhanced steroid hormones profiling and upregulates vitellogenin gene expression of *Symphysodon aequifasciatus*

Ramjanul Haque*, Paramita Banerjee Sawant, Parimal Sardar, Tincy Varghese, K.A. Martin Xavier, Narinder Kumar Chadha, Jitendra Kumar Sundaray, Subam Debroy

ICAR-Central Institute of Fisheries Education, Mumbai

*Corresponding author: ramjanul.aqcpa903@cife.edu.in

Abstract

A study was performed to evaluate the efficacy of shrimp shell meal derived natural astaxanthin (SSM), supplemented with its commercial variant on steroid hormone profiling and vitellogenin gene (Vtg.) expression in reproductively active adults high value ornamental cichlid discus (*Symphysodon aequifasciatus*) reared under captivity. Four isonitrogenous (50 % crude protein), isolipidic (9% ether extract), and isocaloric (400 kcal digestible energy/100 g) experimental diets viz. control (commercial grade astaxanthin, without SSM), T1 (150g SSM /kg diet + commercial astaxanthin), T2 (200g SSM /kg diet + commercial astaxanthin), T3 (250g SSM /kg diet + commercial astaxanthin) were prepared and fed to satiation level twice daily for the entire experimental period of 90 days. Results revealed significant ($p < 0.05$) linear, quadratic, and overall trends, wherein, GSI, HSI, Cholesterol, FSH, LH, 11-KT, 17 β -Estradiol, and 17 α -20 β DHP increased with an increase in the proportion of SSM in the diet, with higher GSI recorded in T2 and T3 treatment groups (testis and ovary respectively), which were significantly ($p < 0.05$) different from other groups. Histology of the female gonads in T2 and T3 showed majority of the oocytes in the vitellogenic phase, i.e., primary, secondary, and tertiary yolk stages. Higher number of spermatids were visible in testicular tubules

in T₂, followed by T₃ and T₁. Abundance of Vtg. mRNA was significantly ($p < 0.05$) evident in T₂ followed by T₁, than in control. Further increase in SSM inclusion caused a downregulation in expression of this gene in the T₃ group. The dietary combination of SSM @200g/kg diet with its synthetic/commercial variant exhibited optimum performance at combination levels of 77.5 and 22.5 mg/kg respectively, evidenced in terms of changes in steroid hormone profiles, gonadal maturation and vitellogenin gene expression in comparison to the control, which contained the dietary synthetic/commercial variant of astaxanthin alone. These inferences are presumably a milestone in the captive broodstock development of this high value ornamental cichlid *Symphysodon aequifasciatus*, with an added advantage of cost-effectiveness, thus justifying the use of economically important bio-waste in combination with commercial variants for effective value addition in high value ornamental fishes, since robust breeds command higher prices.

Keywords: Shrimp waste in Aquaculture, Environment sustainability, Astaxanthin, Steroidogenesis, Vitellogenesis

TRPSF-AQUA-P-3

Standardization of Stocking Density of *Labeo rohita* (Jayanti rohu) in Aquaponics System

Preeti Maurya* and Ashutosh Mishra

College of Fisheries, GBPUA&T, Pantnagar-263145, Uttarakhand, India

*Corresponding author: preetimaurya070297@gmail.com

Abstract

To standardize the stocking density of *Labeo rohita* (Jayanti rohu) in fish aquaponics system with four aquaponic plants i.e. Tomato (*Solanum lycopersicum*), Cucumber (*Cucumis sativus*), Coriander (*Coriandrum sativum*) and Chilly (*Capsicum annuum*), the present study was conducted for four months from December, 2022 to March, 2023. The experiment was carried out in FRP tanks (2.5 m diameter, 4 m³ water volume) kept indoor in polycarbonate house with three triplicate treatments and control, where stocking density of the experimental fish was maintained as 50/m³ (T₁ & C₁), 75/m³ (T₂ & C₂) and 100/m³ (T₃ & C₃), respectively. The selected experimental plants were transplanted in floating raft (1.23 x 0.6 x 0.025 m size) in each tank to purify water by consuming available nutrients. Each of the rafts was planted with 28 experimental plants encompassing seven plants of cucumber, tomato, coriander and chilly, respectively in single floating raft. During the experimental period, the important water quality parameters viz. water temperature, total dissolved solids, conductivity, pH, dissolved oxygen, total alkalinity, free CO₂, ammonia and phosphate was measured weekly which varied from 13.90 to 27.80 °C (water temperature), 170.95 to 356.80 mg/l (total dissolved solids), 6.90 to 8.4 (pH), 1.20 to 8.26 mg/l (dissolved oxygen), 100 to 230 mg/l (total alkalinity), 1 to 2.50 mg/l (free CO₂), 226.19 to 427.50 µS/cm (conductivity), 0 to 0.18 mg/l (ammonia) and 0.02 to 1.30 mg/l (phosphate). The statistical analysis of length – weight relationship of experimental fish in different stocking density shows that the treatment T₂ performed better than T₁ and T₃. The findings of present study suggests that stocking density of 75fish/m³ is best for carp-aquaponics system.

Keywords: Aquaponics, Stocking density, Tomato, Cucumber, Coriander, Chilly

TRPSF-AQUA-P-4

Stress Response of *Cyprinus Carpio* (Linnaeus, 1758) Exposed To Inland Saline Water

Archana Mishra¹*, Utsa Roy¹, Mujahidkhan A Pathan¹, Satya Prakash² and Gopal Krishna¹

¹Fish Genetics and Biotechnology Division, ICAR-CIFE, Mumbai-400061, Maharashtra, India

²ICAR-CIFE, Rohtak centre-124411, Haryana, India

*Corresponding author: am1391994@gmail.com

Abstract

Common carp is the 4th highest produced species in global aquaculture and 3rd most produced species among carps, contributes to 7.7% of total aquaculture production. The common carp stocks in India are originated from two introductions, in 1939 ("German" strain) and 1957 ("Bangkok" strain) which have been subsequently mixed over many generations. It exhibits a wide range of salinity and cold tolerance, so it can be an attractive option for aquaculture during winter months in North India that are currently unutilized. In the present study, common carp fingerlings of 15gm were exposed to the inland saline water of various salinities i.e; 4 ppt, 8 ppt and 12 ppt and 0 ppt as the control group after gradual acclimatization with salinity increase @1ppt/hour. A total number of 216 fishes (18 fishes in each tank with triplicates) were reared for 30 days in FRP tanks of 1000litre capacity at ICAR-CIFE, Rohtak centre. Liver and gill samples were collected for gene expression of stress linked genes at 0hr, 3rd day, 7th day, 15th day and 30th day of the experiment. The blood samples were collected for CBC analysis on the 30th day of experiment.

Serum samples were separated from blood samples at different time points for serum electrolyte analysis. No mortality was observed during the 30 days of rearing period even in the higher saline group (12 ppt). The Red Blood Cell count (RBC), White Blood Cell count (WBC) and Hb values decreased significantly with increase in salinity. No significant difference was observed in serum Na⁺ and K⁺ values at all the time points of sampling. The relative gene expression of SOD, Catalase and HSP 70 was highest at 72 hr of exposure in 12 ppt followed by 8ppt in both liver and gill tissues. However, no significant difference in expression was observed between the control group and 4ppt group. Stress gene expression level normalized after 7th day of exposure. The expression of *gst* and *gpx* was high upto 7th day of exposure and normalized after that. The relative gene expression of Na⁺-K⁺-ATPase was up regulated in gill tissues in the higher salinity groups at all the sampling points. The overall results reveal that common carp can be reared in high saline water (12 ppt) with some mitigation measures.

Keywords: Common carp, Inland saline water, Blood parameter, gene expression

TRPSF-AQUA-P-5

Relevance of Small Indigenous Fish Species Contribute towards Nutrient Security of Northeast India

Anamika Debnath

Faculty of Fishery Science, W.B. University of Animal & Fishery Sciences, Kolkata-700094

*Corresponding author: anamikadebnath1226@gmail.com

Abstract

Small Indigenous Fish Species (SIFS) are found in inland aquatic resources of Northeast India and provide nutrition as well as livelihood opportunities to a large number of fishers. Several researchers have highlighted the economic significance of culturing SIFS in comparison to other cultured fishes. SIFS offers large quantities of nutrients, such as high-quality proteins, fatty acids, particularly polyunsaturated fatty acids, vitamins, minerals, and trace elements. Significant amounts of lysine and other crucial amino acids can be found in the high-quality protein. Due to the abundance of seasonal water bodies in north-eastern India, it is possible to raise numerous SIF, which are crucial to the nation's food and nutrient security. One of the noted advantages of SIFS is that people, even the poor, can buy them in quantities they can afford. Further, these fish species act as health supplement among rural population particularly in the diet of pregnant women and lactating mothers. It is proven that calcium content of SIFS is similar to amount that is derived from milk. Despite of numerous health benefits, there are no major markets where data about the catch of SIFS can be easily collected as large part of the catch is bartered locally or consumed by the fishers' households. Therefore, it is the need of hour to develop an effective marketing channel for documentation of SIFS catch and promoting their culture in inland water bodies towards sustainable management.

Keywords: Small Indigenous Fish Species, Protein, Micronutrient, Sustainable Management.

TRPSF-AQUA-P-6

Scope and Possibility of Breeding of Giant Freshwater Prawn In Coastal Areas Can Be A Boon for Local Fisherfolk to Harness Alternative Livelihood

T. Maity*, T. K. Ghosh and A. Nayak

West Bengal University Of Animal And Fishery Sciences, Kolkata, India

*Corresponding author: taraffsc08@gmail.com

Abstract

In India, where the per-capita intake of meat and milk is poor, fish and prawns play a vital role in supplementing and balancing people's diets. About nine of the 39 species of the freshwater prawn genus (*Macrobrachium*) in India's rivers are also considered commercially important. Two species – the Malaysian or giant freshwater prawn (*Macrobrachium rosenbergii*) and the riverine prawn (*M. malcolmsonii*) – are presently cultured in India. Some inland states are also keen to adopt technologies that utilize the abundantly available saline water for seed production to sustain this lucrative industry. A variety of hatchery systems – including indoor and outdoor, extensive backyard hatcheries, and those using clear water, green saline water, or artificial seawater – have developed and each has specific advantages depending on local conditions. Giant freshwater prawns breed year-round in parts of India where water temperatures range 28-32 degrees C. Animals attain maturity at around six months and breed four or five times during the season. Gravid females are collected from earthen ponds or natural habitats and held in fiberglass tanks or large plastic pools. Recently a simple, inexpensive outdoor system for seed production was developed at the Central Institute of Freshwater Aquaculture. The system uses 11 to 13 ppt seawater, and the main larval diets supplied to the animals are chopped worms and mussels. The optimal protein level for *Macrobrachium* is probably 27 to 35 percent, with somewhat higher

needs for juveniles. Freshwater prawns are among the best species for culture because they can be grown in both fresh and low-salinity waters. They are omnivorous and hardy, and have the maximum growth potential among the cultured prawns. Freshwater prawns are in demand in both local and export markets. To Study, the effect of different stocking densities of berried prawns of *Macrobrachium rosenbergii* on the production & survival rate of post-larvae under brackish water ponds. It was conducted in coastal villages (21°48' N & 87°45' E) in West Bengal, India using three treatment ponds having pond area (0.1 ha). Three different stocking densities of berried prawns were maintained as T₁ (5 kg), T₂ (10 kg), and T₃ (15 kg) having six replicates of each treatment. Medium-sized berried prawns (45-55 gm, 17.8-19.2 cm) were stocked. The larvae were fed with *Artemia* flakes and egg custard. Water quality was maintained by exchanging 20-30 % once a week. Dissolved Oxygen (mg/l), pH, and salinity (g⁻¹) were maintained. The first PL stage (7.69 mm) was achieved in 25 days (T₁) & other treatments varied from 25-29 days. Post larval production (nos.×10⁵/0.1 ha) was recorded (6.0 ± 0.1^a) in T₁, (4.0 ± 0.1^b) in T₂ and (3.2 ± 0.02^a) in T₃. The survival rate of post-larvae was found at 27.21%, 9.1%, and 4.96% in treatments T₁, T₂, and T₃ respectively. Benefit-cost ratios were 3.14 (T₁), 1.36 (T₂) and 0.68 (T₃). Higher stocking density (T₂ & T₃) caused cannibalism and mortality. Low stocking density (T₁) with better management practices increased survival rate and production of post larvae.

Keywords: *M. rosenbergii*, Stocking Density, Post-Larvae Production, Survival Rate, B:C Ratio

TRPSF-AQUA-P-7

Optimizing Growth Performance of Tubificid Worms (*Tubifex tubifex*) in Recirculating Water Systems: Exploring the Impact of Culture Media Variations

Patekar Prakash*, Krupesh Sawant, Siyag Dhere, S. Munilkumar
ICAR-Central Institute of Fisheries Education, Versova, Mumbai-400061, Maharashtra, India

*Corresponding author- patekarprakash476@gmail.com

Abstract

Tubificid worms (*Tubifex tubifex*), are widely used in aquaculture as a source of high-quality protein for fish feed. It is very important live food for most of the ornamental fishes. The optimal growth of these worms is essential to ensure their sustainable production. This study aimed to investigate the effect of three different culture media on the growth performance or biomass production of *Tubifex tubifex* cultured in a recirculating water system. The present experiment was conducted in the plastics tanks (45cm * 30cm * 25cm) in continuous running water through recirculation (0.5hp pump). Three different culture media were tested, including media-1 (45% soil, 10% sand, 25% cow dunk, 20% fermented rice bran), media-2 (45% soil, 10% sand, 25% cow dunk, 20% fermented wheat bran) and media-3 (45% soil, 10% sand, 25% cow dunk, 20% fermented ground nut oil cake). The results showed that in media-1 and media-3 significantly improved the population biomass of *Tubifex tubifex* (weight in gram) compared to the media-2. However, in terms of population number (number/gram) not differ significantly among three media. This study highlights the importance of selecting suitable culture media for optimizing the growth performance of *Tubifex* in recirculating water systems. These findings could be useful for developing sustainable and efficient aquaculture practices that utilize *Tubifex* as a protein source for fish feed.

Keywords: Tubificid worms, Aquaculture, Culture media, Recirculating water system, Growth performance

TRPSF-AQUA-P-8

Millet as Alternative Sustainable Protein Source for Fish Diet

Suparna Deb*, Payel Debbarma, Jham Lal, Shubham Kashyap, S. Khogen Singh, Pradyut Biswas, Gusheinzed Waikhom, and Arun Bhai patel

College of Fisheries, Central Agricultural University, Imphal, Lembucherra, Tripura- 799210

*Corresponding author: debsuparna66@gmail.com

Abstract

Aquaculture has lately acquired popularity as a result of increased protein consumption and the need for sustainable fisheries output. To maximise profits, any fish farm requires low-cost, comparatively higher protein rich, ecologically friendly feed. Traditionally, fishmeal, which is made from wild-caught fish, has been a common ingredient as protein source in fish feeds. However, the increasing demand for fishmeal has put pressure on wild fish stocks and has raised concerns about its sustainability. Due to a variety of reasons, there is an increasing desire for novel, environmentally friendly, alternative protein sources worldwide. Cereal crops are included in this category because they are affordable, accessible, renewable, and a reliable supply of protein. Using plant-based ingredients like millet in fish diets can help alleviate this pressure on wild fish populations. Millet is a highly nutritious grain that can indeed be considered as an alternative sustainable protein source for fish diets. One of the representative grains that yield seeds with health-

promoting features is foxtail millet (*Setaria italica*), an annual grass plant with a high amount of essential amino acids. Due to the high concentration of essential amino acids, including methionine, in foxtail millet flour, protein ranks as the second most important component. Setarin, a proline-rich, alcohol soluble protein (prolamin) that makes up around 60% of the total protein in mature foxtail seeds, is the primary protein found in them. Foxtail millet can also be thought of as a potential choice for substituting animal protein sources due to its inexpensive cost and the great functional qualities of flour and protein concentrate. However, it is important to consider the specific nutritional needs of the fish species and to optimize processing techniques to maximize its benefits.

Keywords: Millet, Protein, Fish meal, Cereal crop, Sustainability.

TRPSF-AQUA-P-9

Integrating Agriculture – Aquaculture For Blooming Rural Economy Sustainably

Siva N and Arunashri A

ICAR -Central Institute of Education, Salt Lake, Bidhan Nagar, Kolkata - 700091

Abstract:

India is an agriculture country which is said to be the backbone of India, is the second largest wheat and rice producing country. The profit generated from unit source can be drastically enhanced by integrating ornamental fish production. The benefits of integrating fish with agriculture is well known. By making minor changes in the farming field, the fishes can be cultivated along with agri-crops enhancing the productivity. Further, the presence of insectivorous fishes in culture system reduces pest attack. The ornamental fishes are preferred because the price of aquarium fishes are 100 times higher than the marine water food fish and 1000 higher than freshwater food fish. The focus on Indigenous fish species can be beneficial from environmental and economic point of view. India records an export revenue of 57, 586.48 crore INR in the FY 2021-22. Of which, shrimp generates highest income of 32,520 crore INR. But the value per unit quantity of shrimp exported is 550 INR. While Ornamental fishes recorded the highest income of 1,500 INR per kg export. Utilizing the resources available with agriculture, integrating ornamental fishes in agricultural crops can increase the profit margin drastically. This will promote a farmer from domestic producer who is earning minimum profit to international exporter earning foreign currency. This can be achieved through availing beneficial schemes under PMMSY and educating the farmers about export value and market chain.

Keywords: Ornamental fish, Agriculture, Integrated fish farming, Productivity

TRPSF-AQUA-P-10

Incorporation of Drumstick (*Moringa oleifera*) leaves for improvement in growth and health status of Amur carp (*Cyprinus carpio haematopterus*)

Priyanka Acharya

College Of Fisheries, Rangeilunda, Berhampur-7205825714

Abstract

The current study was carried out to determine the inclusion of drumstick (*Moringa oleifera*) leaves in the diet of Amur carp (*Cyprinus carpio haematopterus*). The current investigation included five treatments in triplicate. For each treatment, five experimental diets were formulated. T₀ functioned as the control, with no moringa inclusion. All other diets for treatments T₁, T₂, T₃, and T₄ contain 5%, 10%, 15%, and 20% moringa leaves meal, respectively. The experiment lasted 90 days in a FRP tank with a capacity of 200 l, each tank had ten amur carp. The fish were fed twice daily with 5% body weight. Water quality parameters were calculated fortnightly. There was a significant ($p < 0.05$) difference in the total weight gain among treatments. Treatment T₃ with 15 % inclusion shows higher growth performance as compared to other ones. Survival % is not significantly ($p > 0.05$) different among treatments. The highest mortality of amur carp challenged against *Aeromonas hydrophila* was recorded in the control (100%) whereas, in other treatments, mortality decreased with the inclusion of moringa in the diet. These results suggested that the 15% incorporation of moringa leaf meal in a diet enhances the growth performance as well as improves health status of amur carp.

Keywords: *Moringa oleifera*, Leaf Meal, Amur carp, *Aeromonas hydrophila*

TRPSF-AQUA-P-11

Fostering Rural Aquapreneurs through Revitalization of Derelict Water Bodies into Aquacultural Pools

Arunashri A and Siva N

ICAR-Central Institute of Fisheries Education, Salt lake, Bidhannagar, kolkata-700091

Abstract

The inaugural Census of Water Bodies undertaken by Ministry of Jal Shakti in 2018-19 identified a staggering 24,24,540 water bodies across the country. Astonishingly, 97.1% (23,55,055) of these water bodies are situated in rural

areas, with a mere 2.9% (69,485) found in urban regions. Unfortunately, a significant portion of these water bodies, approximately 16.3% (3,94,500) remains unused and neglected. Harnessing pisciculture in derelict water bodies presents a significant opportunity to bolster the rural economy. The amalgamation of the Ministry of Jal Shakti and Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) would pave the way for making this initiative feasible. By means of MGNREGS, revitalization of ponds and the preparatory measures for pisciculture can be carried out during the summer season; with onset of the monsoon in June, fishes like Carps, Cat fishes, Murrels and Tilapia can be introduced into the derelict water bodies. The utilization of derelict water bodies can further be improved through the integration of fish cum duck farming. As ducks, known as "moving carbon machines" offer natural aeration and contribute to pond fertilization through their droppings, this approach also opens avenues for additional income generation through the sale of duck eggs and meat. A study conducted in Odisha has revealed a noteworthy benefit-cost ratio of 3.84 in a 1.24-hectare derelict water area. This manifestation underscores the feasibility of utilizing derelict water bodies for pisciculture in line with the objectives of the Pradhan Mantri Matsya Sampada Yojana (PMMSY) and addressing future fish demand. To promote this approach, awareness programs shall be implemented in rural areas through Krishi Vigyan Kendras (KVKs) and MGNREGS. With minimal investment and effective management practices, these derelict water bodies can be transformed into productive aquacultural ponds, fostering the emergence of a multitude of aquapreneurs and ultimately uplifting the economic status of rural communities.

Keywords: Duck, Fish Farming, Derelict Water, Integrated Aquaculture, Productivity,

TRPSF-AQUA-P-12

Inclusion of organic and inorganic extractive species Improves water quality in Freshwater Integrated Multi-Trophic Aquaculture system.

Sagar Vitthal Shinde*, Kapil Sukhdhane, Kishore Kumar Krishnani, Babitha Rani A.M., Madhuri Pathak.
Division of Aquaculture, ICAR-CIFE, Panch Marg, Off Yari Road, Versova, Andheri (W), Mumbai, 400061

*Corresponding author: shindesagy2@gmail.com

Abstract

The present investigation was carried out to evaluate the production performance of GIFT tilapia in a Freshwater Integrated Multi-Trophic Aquaculture system. The experiment was performed for 60 days by incorporating floating weed *Lemna minor* as an inorganic extractive and bivalve *Lamellidens marginalis* as an organic extractive to assess the growth, survival, water quality, and physiological response of GIFT-fed fishes in 1000 l outdoor tanks. The treatments were assigned as control (C) only GIFT, T1; GIFT and *Lemna minor*, T2; GIFT and *L. marginalis* and T3; GIFT, *Lemna minor* and *Lamellidens marginalis*. The stocking densities for GIFT and *L. marginalis* were 4,00,000 fingerlings ha⁻¹ and 750 kg ha⁻¹ while *L. minor* was transplanted to cover 25% of the tank surface area. The fish were fed with a floating pelleted feed (30% Crude Protein) at the rate of 4% body weight. Among different water quality parameters, pH was found reduced in systems where the presence of *L. minor* was there. and electrical conductivity was lowest in FIMTA System. A significantly low level of dissolved oxygen was observed in the control group compared to the treatments. The presence of *L. marginalis* in T2 and T3 reduced the total hardness levels of water. and Total Dissolved Solids varied significantly ($p < 0.05$) among different treatments and the lowest values were observed in the FIMTA system. The nitrogenous waste content in the control group was the highest and the lowest in the FIMTA system. The results indicate that the FIMTA of GIFT with *L. Minor* and *L. marginalis* can ameliorate water quality and enhance productivity.

Keywords: *Lamellidens marginalis*, GIFT- Tilapia, *Lemna minor*, FIMTA, Water quality

TRPSF-AQUA-P-13

Impact of fish-vegetable composite bio-silage based diet on the growth and survival of iridescent sharks fingerlings

Subal Kumar Ghosh^{1*}, Husain Nottanalan², Nikesh Hajare¹, Nazeemashahul Shamna², Amjad Khansaheb Balange¹,
Martin Xavier¹, Binaya Bhusan Nayak¹

¹Department of Post-Harvest Technology, ICAR-Central Institute of Fisheries Education, Versova, Mumbai-400061, Maharashtra,

²Fish Nutrition, Biochemistry and Physiology Division, ICAR-Central Institute of Fisheries Education, Versova, Mumbai-400061,

*Corresponding author: subalghosh.phtpa705@cife.edu.in

Abstract

The present study develops a novel fish feed using locally available cauliflower, cabbage, and fish processing waste, which will increase the aquaculture feed sector sustainability in terms of both finances and the environment. Composite bio-silage was produced by combining fish and vegetable waste with probiotic proteolytic strain (*E. faecalis*

+ *L. acidophilus*) and jaggery as a carbon source. The composite bio-silage (CBS) was used as a novel feed ingredient in two month feeding trial of iridescent shark catfish's (*Pangasianodon hypophthalmus*) fingerlings. Five iso-nitrogenous (38.0 to 38.50% crude protein/100g) and isolipidic (8.20 to 8.60% lipid/100g) experimental diets with control (100% FM + 0% CBS), Treatment 1 (75% FM + 25% CBS), Treatment 2 (50% FM + 50% CBS), Treatment 3 (25% FM + 75% CBS), and Treatment 4 (0% FM + 100% CBS) were made by replacing fish meal with composite bio-silage (CBS). Two hundred and twenty five acclimated fishes (4.0 ± 0.05 g) were randomly chosen in five treatment groups in triplicate containing 15 fishes per tank and supplied with a test diet until satiated. The observed water quality did not change ($P < 0.05$) across the treatments. T3 (CBS 75%) group had the highest amylase activity, final weight gain (WG), Specific growth rate (SGR), Protein efficiency ratio (PER), and Apparent dry matter digestibility coefficient as compared to rest of the treatment group. The final WG and SGR were obtained in the following trend such as control < T4 < T2 < T1 < T3 whereas FCR was T3 < Control = T4 < T2 < T1. The protease and lipase activities in T1 (CBS 25%) and T2 (CBS 50%) significantly reduced in comparison to the control and T3 (CBS 75%) groups. The liver's SOD and CAT activities significantly increased when T1 (CBS 25%) and T2 (CBS 50%) were added to the experiment. Serum glucose levels were not substantially affected by the addition of T1 (CBS 25%), T2 (CBS 50%), or T4 (CBS 100%) compared to the control group. The T3 (CBS 75%) composite silage supplemented group had the highest level of Haemoglobin (Hb), Total erythrocyte count (TEC), and Total leucocyte count (TLC). The findings suggest fish meal can be replaced with composite bio-silage as a protein-carbohydrate rich feed ingredient up to 75% in *Pangasianodon hypophthalmus* fingerling diet. Additionally the innovative fish-vegetable composite diet can improve probiotic health without affecting catfish fingerling growth, feed utilisation, or carcass characteristics.

Keywords: Fish-Vegetable Waste, Composite Bio-Silage, Diet Formulation, Growth Performance, *Pangasianodon Hypophthalmus*

TRPSF-AQUA-P-14

Evaluation of *Eucalyptus grandis* Leaf Extract as an Alternative Feed Additive for *Labeo rohita*

Bharat Patel*, Shriparna Saxena, Neetu Garg

Department of Aquaculture, SAGE University, Bhopal

*Corresponding author: bharatpatel444@gmail.com

Abstract

The aquaculture sector has become more intensive, which has increased the likelihood of illness and the use of harmful chemicals in farmed fish. *Eucalyptus grandis*, a medicinal plant with antioxidant and antimicrobial properties, has been proposed as a safe alternative to synthetic hormones and chemotherapeutics in fish feed. This study examined the effects of *Eucalyptus grandis* leaf extract on the growth and haematological parameters of *Labeo rohita*. Fish were assigned to four treatment groups and fed diets containing different levels of *Eucalyptus grandis* leaf extract for 45 days. Results showed that the fish fed with 10% *Eucalyptus grandis* leaf extract had the highest weight gain and specific growth rate compared to the other groups. Additionally, the feed conversion ratio was improved in the fish fed with *Eucalyptus grandis* leaf extract compared to the control group. Moreover, the haematological parameters of the fish were positively affected by the addition of *Eucalyptus grandis* leaf extract to the diet. The study suggests that *E. grandis* leaf extract at an appropriate level could be a potential natural feed additive for enhancing the growth and health status of *L. rohita*. However, further research is needed to determine the optimal inclusion level and underlying mechanisms of its positive effects.

Keywords: Aquaculture, *Eucalyptus grandis*, Leaf extract, Chemotherapeutics, Haematological.

TRPSF-AQUA-P-15

Efficacy of proline on growth accomplishment and salinity abidance of *Osteobrama belangeri* (Valenciennes, 1844)

Susmita Barman*, Tapas Kumar Ghosh

Faculty of Fishery Sciences, 5, Budberhat Road, Panchasayar, Chakgaria Campus Near Upobar Complex, Kolkata- 700094

Abstract

The study on efficacy of proline on growth accomplishment and salinity abidance of Pengba (*Osteobrama belangeri*) (Valenciennes, 1844) was carried out in two phases to evaluate the growth performance and salinity tolerance of Pengba through dietary supplementation of proline. In the 1st phase of the experiment, test fishes ($9.8 \text{ cm} \pm 0.21$, $12.5 \text{ g} \pm 0.35$) were acclimatized in 500L FRP tanks. Three different types of proline-fortified formulated diets *viz.* 0.15% (T1), 0.20% (T2), and 0.25% (T3) with 32-33% crude protein content were fed to fishes @ 4% body weight

daily for 12 weeks. All the treatments (T1-T3) in triplicates along with controls were studied for growth performance of test fishes. At the end of the feeding trial, better growth performance in terms of Specific Growth Rate (SGR), Food Conversion Ratio (FCR), Food Conversion Efficiency (FCE), and Protein Efficiency Ratio (PER) were significantly ($p < 0.05$) higher in T2 fed with 0.20% proline supplemented diet. The 2nd phase of the experiment was conducted to evaluate the impact of proline on the salinity tolerance and 8 nos fishes from each of the treatments (T₁-T₃) along with control were exposed to 2, 4, 6, 8, 10, 12, 14, 16, 20, 22 and 24 ppt salinity for a period of 96 hours. Fishes from all treatments were subjected to a tolerance test with a progressive increase in salinity on daily basis. Daily 2.0 ppt salinity was increased until it became 24 ppt. At the end of the experiment, the LC₅₀ value and mortality rate were recorded. Fishes fed with proline at different dietary inclusion exhibited much higher salinity tolerance. Mortality in different treatment was observed and 100% mortality was recorded at 18 ppt in T₁, 22 ppt in T₃ and 24 ppt in T₂. However, 100% mortality at 12 ppt was observed in control.

Keywords: Proline, *Osteobrama belangeri*, Feed Supplement, Growth, Salinity, LC₅₀, Mortality

TRPSF-AQUA-P-16

Enhancement of essential amino acids in plant-based fish feed ingredients by genetic engineering and protein design

Shivkumar*, Manish Jayant, Dhanalakshmi M, Patekar Prakash

Fish Nutrition Biochemistry and Physiology Division, ICAR - CIFE, Panch Marg, Off Yari Road, Versova, Mumbai, India - 400 061

*Corresponding author - shivkumar.fntpb004@cife.edu.in

Abstract

Generally, fish meal is considered a good protein source because of its amino acid profile, high protein, palatability, and high digestibility. Still, with recent fluctuations in the cost, quality, and availability of fish meal, many scientists are approaching an alternative protein source for fish feed preparation. In that concern, plant-based protein sources are majorly selected for their abundant availability and cheap. Nevertheless, the plant-based ingredients are deficient in some essential amino acids, mainly lysine, so to fulfill the requirement of fish, one need to supplement the additional amino acids through feed, which is again affecting the cost of the feed. Therefore, the new approach, like genetic engineering and protein design, with its varied strategies, can be applied to fish feed ingredients so that plants can produce optimum essential amino acids that meet the essential amino acid requirement of fish and helps in the efficient replacement of fish meal with plant-based protein sources.

Keywords: Essential amino acids, Plant-based protein, fish meal, genetic engineering

TRPSF-AQUA-P-17

Effects of bile acid supplemented diets with varying levels of protein and lipid on the nutrient utilization, whole body proximate composition and digestive enzyme activities of GIFT (*Oreochromis niloticus*) juveniles reared in 10 ppt inland saline ground water

Saiprasad Bhusare¹, Parimal Sardar^{1*}, N. P. Sahu¹, Shamna N¹., Tejaswini Karale¹, Sagar Satkar², Ashish Sahu² and Ajeet Soni³

¹*Fish Nutrition, Biochemistry and Physiology Division, ICAR-Central Institute of Fisheries Education, Mumbai*

²*Faculty of Fisheries, Kerala University of Fisheries and Ocean Studies, Cochin, Kerala*

³*College of Fisheries Science, Chaudhary Charan Singh Haryana Agriculture University, Hisar, Haryana*

*Corresponding author: parimalsardar@cife.edu.in

Abstract

The present study evaluated the effects of bile acid supplemented low-protein, high-energy diet on the digestive enzyme activities of GIFT juveniles reared in inland saline water of 10 ppt for sixty days. Three heteronitrogenous (32, 35, 38% CP), heterolipidic (8, 11, 14% lipid) diets supplemented with three levels (0, 0.05, and 0.1%) of bile acids were formulated and prepared. Four hundred and five (405) acclimated GIFT juveniles were randomly distributed in nine treatments in triplicate with a stocking density of fifteen fish per tank. The fish were fed with respective diet at satiation level. The 38% protein, 8% lipid and 35% protein and 11% lipid fed groups showed lower FCR and PER value. However, dietary bile acid (0.05 and 0.1%) significantly reduced the FCR and enhanced the PER values in 35% protein and 11% lipid fed group. Varying dietary protein and lipid levels had a significant ($p < 0.05$) effect on whole body moisture, lipid and total carbohydrate contents, but no effect on crude protein and total ash contents. The levels of bile acid had no any significant effect on body composition. An inverse relationship was observed between body lipid and moisture level. The lowest moisture and the highest lipid level were found in 32% protein and 14% lipid fed group. Higher lipid fed groups showed lower total carbohydrate in the body. The lower protease activity was found in

32% protein and 14% lipid fed group than both 38% protein and 8% lipid and 35% protein and 11% lipid fed groups. The protease activity was similar in later two groups. In contrast, amylase and lipase activities were significantly lower in 38% protein and 8% lipid fed group than other two groups, which did not show significant difference of amylase activity, but the highest lipase activity was found in 32% protein and 14% lipid fed group. However, protease and amylase activities were not affected by the any level of supplemented bile acid, whereas, 0.05% dietary bile acid significantly enhanced the lipase activity of fish in comparison to 0 and 0.1% supplemental levels. The current study concludes that feeding of 35% crude protein, 11% lipid and 0.05% bile acid can enhance digestive enzyme activity with better nutrient and feed utilization for more production of the GIFT tilapia cultured in inland saline ground water of 10 ppt salinity.

Keywords: Bile acid, Protein-lipid diet, GIFT, Nutrient utilization, Inland saline water

TRPSF-AQUA-P-18

Effect of salinity on growth, survival, haemato-biochemical and antioxidative status of *Anabas testudineus* (Bloch, 1792) juveniles reared in inland saline water

Subam Debroy and Paramita Banerjee Sawant

ICAR- Central Institute of Fisheries Education, Versova, Mumbai – 400061, Maharashtra, India

*Corresponding author: subam.aqcpb005@cife.edu.in

Abstract

A 60-day feeding trial was conducted to evaluate the growth, survival, physio-metabolic and haemato-biochemical responses of *Anabas testudineus* reared in inland saline water (ISW) of varying salinity. Fingerlings (initial weight 6.55 ± 0.08 g) were randomly stocked in triplicate in five treatment groups viz., T1 (0 ppt), T2 (3 ppt), T3 (6 ppt), T4 (9 ppt) and T5 (12 ppt) following a completely randomized design (CRD) with 40/m² stocking density. No mortality of fish was recorded in any of the treatments during the experimental period. Growth parameters such as weight gain (WG), percentage weight gain (PWG), specific growth rate (SGR) and protein efficiency ratio (PER) were highest ($p < 0.05$) at 3 ppt salinity followed by 6 ppt and 0 ppt and lowest at 9 ppt and 12 ppt respectively. Lowest ($p < 0.05$) feed conversion ratio (FCR) and highest feed efficiency ratio (FER) were observed at 6 ppt salinity with no significant difference from fishes at 0 and 3 ppt, respectively. Lowest ($p < 0.05$) moisture and highest protein and lipid contents were recorded at 3 ppt salinity. Digestive enzymes (protease and amylase) activities and oxidative stress enzymes (superoxide dismutase, SOD and catalase, CAT) were significantly ($p < 0.05$) higher in high saline groups (T4 and T5). Hemoglobin (Hb), hematocrit (Hct), erythrocytes, and leukocytes were higher ($p < 0.05$) up to 6 ppt (T3) and reduced thereafter. Highest ($p < 0.05$) serum protein and globulin were recorded at 0 ppt salinity. T5 (12 ppt) group exhibited with the highest ($p < 0.05$) serum glucose, aspartate aminotransferase (AST) and alanine aminotransferase (ALT) activity. The present study concluded that *A. testudineus* can be reared in ISW within an acceptable range of 0-12 ppt salinity. However, salinity above 6 ppt had a negative effect on growth, feed utilization and various physiological parameters related to well-being of the fish. Therefore, it can be opined that *A. testudineus* can be safely considered as a potential cultivable species for inland saline aquaculture upto a salinity of 6 ppt.

Keywords: *Anabas testudineus*, Inland Saline Water, Salinity, Growth, Nutrient Utilization, Stress

TRPSF-AQUA-P-19

Effect of plant density on growth and yield of leafy vegetables in farm pond based vertical Aquaponics system

Venkatappa*, Kishor, C., Nagashree, Supreetha, B.U and Nataraju, O.R.

Inland Fisheries Unit, University of Agricultural Sciences, G.K.V.K, Bengaluru, Karnataka

*Corresponding author: drvenkatappazarsvcfm@gmail.com

Abstract

Optimum plant density is important in vertical Aquaponics system to get maximum leafy vegetable yield. Study was conducted with an aim to optimize spinach and lettuce plant density to get better growth and leafy vegetable yield in hydroponic system with vertically and serially hanged 6 inch diameter PVC pipes consisting of 42 net pot holes. Spinach and lettuce plants were planted in different densities viz., 100% planting in net pot holes, 75% planting, 50% planting and 25% planting. Tilapia fish fingerlings were stocked @ 1 number / 20 lit. of Plastic lined farm pond water. Pond water was supplied to the hydroponic system from the top of PVC pipes and allowed to pass through the net pots and sent back to pond. Foliar nutrient spray (Vegetable special from IIHR) @ 5 gm/lit. was given once in fortnight and fishes were fed with pelleted feed (35% crude protein) @ 8% of body weight / day. Growth of plants were recorded once in fortnight and growth of fish was recorded once in a month. Among the different spacing given

to Spinach & Lettuce plants for better growth, the 100% planting has shown the max. average plant height of 21.36 cm in spinach and 18.28 cm in lettuce and an average yield of 193 g/m² in Spinach and 132 g/m² in Lettuce from 3 verticle pipes. The average total length of fish was 15.53 cm and total yield was 17.43 kgs from 20 m² farm pond in 202 days of culture.

Keywords: Aquaponics, Spinach, Lettuce, Tilapia, Foliar Spray, Fish Feed, Growth

TRPSF-AQUA-P-20

Effect of foliar nutrient spray on yield of European cucumber in crushed granite stones grow bed media and farm pond based Aquaponics

Venkatappa*, Kishor, C., Nagashree, Supreetha, B.U and Nataraju, O.R.
Inland Fisheries Unit, University of Agricultural Sciences, G.K.V.K, Bengaluru, Karnataka

*Corresponding author: drvenkatappazarsvcfm@gmail.com

Abstract

Providing of external nutrients is needed in hydroponics to obtain better yield of vegetables. Studies on the effect of different levels of foliar nutrient spray on yield of European cucumber in crushed granite stones grow bed media in FRP tanks and farm pond based Aquaponics. European cucumber plants were planted in 20mm crushed granite stones grow bed media in 30x30 cm spacing. Farm pond water was supplied through settling tank and bio-filter tank to the grow bed media. Tilapia fish fingerlings were stocked @ 1 fingerling / 20 liter of water. Foliar nutrient spray (vegetable special from IIHR in 3 levels i.e. above 25% of Recommended Dosage, Recommended Dosage and below 25% Recommended Dosage) was given once in a fortnight to the cucumber plants & Control (Aquaponics) was maintained. Fishes were fed with pelleted feed (35% protein) @ 8% of body weight daily and reduced to 5% later. European cucumber yield was recorded and fish growth was recorded once in a month. Among the different levels of foliar nutrient spray applied to improve the cucumber yield, the max. total yield of cucumber (6.78kg) was recorded in >25% of Recommended Dosage. The total fish yield from farm pond was 16.66 kgs / 20 m² in 160 days of farming with 96 % survival.

Keywords: Aquaponics, Cucumber, Tilapia, Foliar Spray, Growth

TRPSF-AQUA-P-21

Effect of protein / lipid ratios in diets on growth and feed utilization of *Ompok bimaculatus*

Rohit kumar¹; A.B. Patel^{2*}; Anamika Debnath²

¹ICAR-Central Institute of Fisheries Education, Mumbai, 400061

²College of fisheries, Central Agriculture University, Imphal (I), Lembucherra, Tripura-799210

*Corresponding Author: arun.b.patel@gmail.com

Abstract

A seven month feeding trail was conducted to find out the effect of protein lipid ration on growth performance of *ompok bimaculatus* in outdoor cemented tanks (5m x 4m x1m with soil bed 8-10 cm) under semi-intensive culture conditions. Pabda fingerling (initial mean weight 1.7 ± 0.2g; Stocking density- 4/m²) were fed with six experimental diets involving three levels (on dry mater basis) of dietary protein contents 25 %, 30 % and 35 % and two levels of dietary lipid contents 6 % and 12 % respectively. The diets were prepared using mustered oil cake, fish meal, wheat bran, corn flower, soybean and vegetable oil. The trail commenced with random application of six experimental diets with differing crude protein (%)/crude lipid (%), viz. 25/6 (T1), 30/6 (T2), 35/6 (T3), 25/12 (T4), 30/12 (T5) and 35/12 (T6) pabda fingerling in triplicates (feeding rate 4-1% BW). The non significant difference ($p > 0.05$) was observed among the survival of different feeding group. Final mean weight, weight gain, specific growth rate (SGR), daily growth index, daily weight gain, daily biomass gain and mean net weight gain has significant ($p < 0.05$) higher in T3 than other treatments. Result reveal that diet with 35% protein and 6% lipid content could be sufficient to support optimal growth up to final mean weight of 37.5 g.

Keywords: Protein, Lipid, Growth, Feed Utilization, Survival, *Ompok bimaculatus*.

TRPSF-AQUA-P-22

Effect of Jal Brahmi leaf extract on growth, FCR and digestive parameters of GIFT fingerlings reared in 10 ppt inland saline water under different stocking densities

Potluri Sai Kishore¹, Pankaj Kumar^{2*}, Shamna N. ¹

¹ICAR-Central Institute of Fisheries Education, Mumbai, Maharashtra – 400061, India

²ICAR- Central Institute of Fisheries Education, Rohtak Centre, Haryana – 124411, India

*Corresponding Author: pankajkumar@cife.edu.in

Abstract

Jal Brahmi (*Centella asiatica*), a perennial herb, consists of high amounts of growth promoters in it. A feeding trial for 60 days was conducted by incorporating *Centella asiatica* ethanolic extract in the diet of GIFT fingerlings reared in 10 ppt

inland saline water under different stocking densities and its effects on the growth and digestive parameters were studied. Three types of practical diets (35% CP & 11% lipid levels) with three different levels of *Centella asiatica* ethanolic extract (0, 0.5 and 1%) were prepared. Four hundred and five GIFT fingerlings (ABW of 2.08 ± 0.2 g) were randomly stocked at three levels of stocking densities (10, 15, 20 nos./75L) under nine treatment groups in triplicates. Results indicated that the fishes fed with 1% *Centella asiatica* ethanolic extract showed significantly ($p > 0.05$) higher percentage weight gain (WG%), specific growth rate (SGR), protease and amylase activities and lower FCR values. Whereas, an increase in the stocking density adversely affected the growth parameters. Highest WG%, SGR, protease and amylase activities and lowest FCR values were found in the treatment fed with 1% *Centella asiatica* ethanolic extract at low stocking density (10 nos./75L). The present study implies that incorporating 1% *Centella asiatica* ethanolic extract in the diet of GIFT fingerlings reared in 10 ppt inland saline water under different stocking densities improves growth, FCR and digestive parameters.

Keywords: *Centella Asiatica* Leaf Extract, GIFT, Stocking Density, SGR, FCR.

TRPSF-AQUA-P-23

Effect of foliar nutrient spray on the growth of Lettuce in floating raft based Aquaponics system

Venkatappa*, Kishor, C., Nagashree, Supreetha, B.U and Nataraju, O.R.
Inland Fisheries Unit, University of Agricultural Sciences, G.K.V.K, Bengaluru, Karnataka

*Corresponding author: drvenkatappazarsvcfm@gmail.com

Abstract

Management of nutrients is important in hydroponics to get better yield of leafy vegetables in Aquaponics. Study was conducted to check the effect of foliar nutrient spray on the growth of Lettuce in floating raft based Aquaponic system. Lettuce plants were planted in net pots and allowed to float in Styrofoam sheet with 12x12cm spacing. Tilapia fish fingerlings were stocked @ 1 fingerling / 20 liter of cement pond water and allowed to circulate in the system. Foliar nutrient spray (Vegetable special) at different levels was given to improve the growth of lettuce, among the different raft (26 net pots). The fishes were fed with pelleted feed, the total fish yield from the cement pond was 4.350 kgs /10 m²pond (4350 kgs / ha.) with 63.5% survival in 152 days of culture period.

Keywords: Aquaponics, lettuce, tilapia, nutrients, growth.

TRPSF-AQUA-P-24

Effect of duckweed as feed ingredient on growth performance of *Cyprinus carpio*

Pujadebi Bera*, Barun Kumar Paul, Tapas Kumar Ghosh, Surya Kanta Sau and Hiranmoy Dhara
Department of Aquaculture, Faculty of Fishery Sciences, WBUAFS 5, Budherhat Road, Chakgaria, Panchasayar, Kolkata-700094

*Corresponding author: pujadebi.bera1997@gmail.com

Abstract

Cost of protein is increasing day by day. Inclusion of quality protein in fish feed makes the feed costly. Indiscriminate use of cheap protein sources in fish feed causes serious health hazards of fishes. Duck weed is a good quality low price vegetative source of protein used as fish food ingredients. It provides an easy practical and cheaper fish feedstuff because it requires no processing to destroy any ant-nutrients. Duck weed was incorporated in fish feed as protein source and growth parameters of common carp were studied for a period of 90 days. Feed-1 (Duckweed 85% + Rice bran 15%); Feed-2 (mustard oil cake 78% + Rice bran 22%) and Feed-3 (ground nut oil cake 88% + Rice bran 12%) were tested on growth parameters viz., weight gain, average daily gain, feed conversion ratio, specific growth rate and protein efficiency ratio of experimental fish. Feed containing duck weed (F1) exhibited significantly ($p < 0.05$) higher growth rate than other two feeds (F₂ & F₃) along with better FCR (1.415 ± 0.15), SGR (2.16%) and PER (1.718 ± 0.24). The result exhibited that F₁ feed performed better due to presence of quality protein and this may be an important replacement of oil cakes in fish feed. So, the locally found duckweed, a rich source of protein, can be used as a feed ingredient to reduce the cost of feed as the main source of protein was the cheapest.

Keywords: Fish Feed, Duck Weed, Common Carp, Weight Gain, Oil Cake

TRPSF-AQUA-P-25

Does Investment Influence Growth in Fisheries Sector? Evidence from Inland States in India

Suvetha. V and Ananthan P.S.

ICAR – Central Institute of Fisheries Education, Mumbai, Maharashtra, India – 400061

Abstract

Fisheries is a sunrise sector gaining attention of policy makers for its potential for improving rural livelihoods and economy. It already plays a vital role in nutritional security, foreign exchange earnings, and employment generation. It's not known whether budgetary allocation and expenditure in the fisheries sector (or agriculture sector) is based on the estimated potential of the sector or the contribution it makes to the economy. Therefore, in order to generate evidence to guide rational and efficient resource allocation, a study was done to assess the budgeted public expenditure and GDP contribution of the fisheries sector in five inland states, namely Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh and Uttar Pradesh. Secondary data was collected from multiple sources in the public domain and the state fisheries departments. Union government spent Rs. 882 crores for fisheries (2020-21), of which 99% was revenue expenditure and <1% only was spent on asset creation (capital expenditure). The result shows that Chhattisgarh spent more on fisheries than other states, with an average annual expenditure of Rs.74 crores. Of these states, Uttar Pradesh followed by Madhya Pradesh have the larger inland fisheries resources. Even though Madhya Pradesh has more than 20% of resources, its contribution to fish production was only 2%. Fish Production was higher in UP (7%) followed by Bihar (6%). A declining trend was seen in Madhya Pradesh's expenditure, where the average annual fisheries expenditure was only Rs.62 crores i.e. 0.1% of the state's total expenditure. Of this, a major share of DoF's budget was spent on welfare provisions for fishers. Contribution from the union govt. to the state was highest for Uttar Pradesh (19%). Though the fisheries sector's GVA (12%) was high in Chhattisgarh, the expenditure on fisheries was quite negligible (0.85% of agricultural sector). This study suggests that the fisheries sector should be treated on par with the agriculture sector and the expenditure should be increased. Returns on investment were also found to be quite high in fisheries. In all the states, capital expenditure is almost negligible as compared to revenue expenditure (except Jharkhand). A comparison of unit expenditure on fishers and resources revealed the need to scale up public investment in Bihar and Uttar Pradesh fisheries. In most of the states, public expenditure (except MP), as well as fish production, increased over the years thus the investment influenced growth in the fisheries sector. But the fact that no linear relationship could be discerned between the compound annual growth of fish production and the public expenditure, needs further investigation.

Keywords: Inland fisheries, Public expenditure in fisheries, GDP contribution, Inland fisheries

TRPSF-AQUA-P-26

Dietary Green tea (*Camellia sinensis*) waste extract enhances the fatty acid composition of muscle and viscera in striped catfish, *Pangasianodon hypophthalmus* (Sauvage, 1878)

Jebarson Solomon*, Ganesh Kumar, Tincy Varghese, Layana P, Ashutosh D Deo, Subodh Gupta

ICAR – Central Institute of Fisheries Education, Mumbai, Maharashtra, India – 400061

*Corresponding author: jebarson.fpbpb201@cife.edu.in

Abstract

Excessive fat deposition and its negative impact on the nutritional quality and texture of muscle and total viscera is a persistent concern in striped catfish, *Pangasianodon hypophthalmus* farming. To address this issue, a 60-day feeding trial was conducted to investigate the effect of supplementing the diet of *P. hypophthalmus* with methanolic extract of green tea (*Camellia sinensis*) waste (GTW) on the fatty acid composition of muscle and total viscera. For this, ninety-six *P. hypophthalmus* fingerlings (initial mean body weight of 35.61 ± 0.75 g) were randomly distributed in four experimental groups in triplicates. Four isonitrogenous (32% CP) and isocaloric (around 370 kcal/100g DE) experimental diets were prepared with supplementing graded levels of GTW extract, comprising control (without GTW extract), G1 (0.2% GTW extract), G2 (0.4% GTW extract) and G3 (0.8% GTW extract). The results of the feeding trial showed that supplementing the diet with GTW extract improved the fatty acid composition of muscle and total viscera, with a decrease in saturated fatty acids (SFAs) and an increase in monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs). The highest level of PUFAs was observed in the G3 treatment groups. Thus, the inclusion of GTW extract in the diet resulted in a more favorable fatty acid profile in *P. hypophthalmus* increasing its nutritional value.

Keywords: Fatty Acid Composition, Green Tea Waste, *Pangasianodon hypophthalmus*, Flesh Quality

TRPSF-AQUA-P-27

Effect of Extrusion Parameters on Feed Physical Characteristics Containing Different Protein Levels

Adarsh M.A.*, Anjali Srivas, Aravindaraj, M., Monika, R., Vinoth, K., Chiranjiv Pradhan
Dept. of Aquaculture, Kerala University of Fisheries and Ocean Studies, Panangad, Kochi-682506, Kerala, India

*Corresponding author: cpradhankufos@gmail.com

Abstract

The application of floating feed is increasing in aquaculture due to its several benefits such as high water stability, higher digestibility and nutrient utilization, lower feed conversion ratio and proper feed management. An experiment was conducted to evaluate the effect of same screw condition on different protein levels in a feed formulation on extruded feed physical characteristics. Three feeds were formulated taking fishmeal, soybean meal, groundnut oil cake, DDGS, corn flour, wheat flour to contain 20%, 24% and 28% protein suitable for carp and tilapia feed. The ingredients were processed through two stages grinding in hammer meal. The bigger size meals and oils cakes were ground to 600 to 700 micron then with a fine hammer mill the particles were further reduced below 400 micron suitable for fin fish feed. The ingredients were mixed as per the formulation in the batch mixture and 30% moisture level was maintained in the feed mixture. The feed was prepared using industrial scale twin screw extruder (100 kg/hr capacity) with constant screw speeds (1920 rpm), 2 mm die and extruder barrel temperatures (90, 100, and 120°C). The resulting extrudates were subjected to extensive analyses of physical properties, which included lateral area, surface area, base area, expansion ratio, sphericity, mass flow rate, porosity and water holding capacity. Several extruder parameters, including moisture content at the die, specific mechanical energy mass flow rate, and net torque were measured to quantify the extruder behavior during processing. All the parameters were analyzed following one way ANOVA and did not exhibit significant difference ($P>0.5$) among the treatments. This study highlights the importance of experimentally determining the effects of feed ingredients and process variables when developing aquafeeds from novel materials.

Keywords: Extrusion, Feed Conversion Ratio, Carp, Tilapia

TRPSF-AQUA-P-28

Dandelion: A promising growth enhancer for *Labeo rohita* in aquaculture

Indulata Tekam^{1*}, Sona Dubey¹, S.K. Mahajan¹, Samad Sheikh², Ashutosh Lowanshi³

¹ Aquaculture, College of Fishery Science, NDVSU, Jabalpur, Madhya Pradesh, 482004

² Aquatic Animal Health Management, ICAR-Central Institute of Fisheries Education, Mumbai, 400061

³ Aquaculture, College of Fisheries Science, CCSHAU, Hisar, Haryana, 125004

*Corresponding author: indulatatekam@gmail.com

Abstract

Labeo rohita, (Rohu) is an economically important freshwater fish species with high demand in aquaculture. Improving the growth performance of Rohu is crucial for meeting the increasing demand for fish production. In recent years, there has been growing interest in using natural and herbal additives as potential growth enhancers in aquaculture. Dandelion (*Taraxacum officinale*) leaf extract is one such herbal additive that has shown promising results in enhancing growth performance in various fish species. However, limited research has been conducted on the effects of dandelion leaf extract on *Labeo rohita*. Therefore, this study aimed to investigate the potential of dandelion leaf extract as a growth enhancer in *Labeo rohita* fingerlings. In this study, dandelion leaf extract was obtained using aqueous extract and was incorporated into the diet of *L. rohita* fingerlings and given at different concentrations along with control and observed for 60 days. The growth performance parameters, including weight gain (WG), specific growth rate (SGR), feed conversion ratio (FCR), and survival rate, were measured at the end of the experiment. The results revealed that *Labeo rohita* fingerlings fed with dandelion leaf extract-supplemented diet showed significantly ($p<0.05$) improved growth performance compared to the control group. The fingerlings fed with 2% dandelion leaf extract showed the highest growth performance, with a significantly higher WG, SGR and survival rate than the control group. The FCR was also significantly improved in the dandelion leaf extract-treated groups, with the lowest FCR observed in the 2% treatment group compared to the control group. In conclusion, this study demonstrates that dandelion leaf extract has the potential to be used as a natural and effective growth enhancer for *Labeo rohita* fingerlings. Further studies are needed to elucidate the underlying mechanisms of the growth-enhancing effects of dandelion leaf extract and optimize its use in fish diets for sustainable aquaculture practices.

Keywords: Growth performance, Aquaculture, Dandelion, Herbal additive, Treatment.

TRPSF-AQUA-P-29

Comparative evaluation of growth performance, survival rate and stress enzyme activities of rohu, *Labeo rohita* fingerlings reared at optimal and suboptimal temperatures

Veeramani Maruthi^{1*}, Ashutosh D. Deo¹, Shamna N¹, Manish Jayant¹, Kinnera Tejaswini¹

¹Division of Fish Nutrition, Biochemistry and Physiology, ICAR-Central Institute of Fisheries Education, Mumbai, Maharashtra, India

*Corresponding author: veeramani.fntpb205@cife.edu.in

Abstract

Fishes being poikilothermic animals, their metabolism is directly influenced by the temperature of the water in which they live. As this temperature lowers during winter months, there is a significant decline in the metabolism which in turn leads to reduction in growth and survival rate. In this viewpoint, a preliminary study of 60 days was conducted to assess the growth performance, survival rate and stress enzyme activities of *Labeo rohita* fingerlings at optimal ($28\pm 1.7^\circ\text{C}$) and suboptimal ($18\pm 0.8^\circ\text{C}$) temperatures. Ninety *Labeo rohita* fingerlings with an initial body weight of $7.4\pm 0.2\text{g}$ were randomly distributed in two experimental groups in triplicates. A basal diet with 300g/kg crude protein and 80g/kg crude lipid was prepared with the common ingredients and fed to the fishes to satiation. The results from this study indicates clearly that the fishes reared at suboptimal temperature showed poor growth performance, high FCR and low survival rate. The activities of SOD and CAT were significantly higher ($P<0.05$) in the fishes reared at suboptimal temperatures as compared to those reared at optimal temperatures, indicating stress due to low temperature. Based on these results, it can be concluded that the low/suboptimal temperature has a pronounced effect in fishes and hence, suitable cultural and dietary measures have to be taken in order to mitigate these ill effects.

Keywords: Winter, Suboptimal Temperature, Growth Performance, SOD, CAT, *Labeo rohita*

TRPSF-AQUA-P-30

Climate Smart Technologies for Sustainable Fisheries and Aquaculture

Susmita Rani, Sarvendra Kumar, Showkat Ahmad Dar, Abhiman

College of Fisheries, Kishanganj, BASU, Patna

*Corresponding author: susmita2421995@gmail.com

Abstract

Greenhouse gases are one of the major causative factors that have led to climate change resulting in daily variations of temperature and rainfall patterns. Climate change consternations, impacts the planet in the form of global sea level rise, glacial melting, ocean acidification, changes in precipitation, reduced ground water level, floods etc. which pose a significant threat to the sustainability of fisheries and aquaculture as well as will affect the livelihood of fishing communities and dependents adversely, calling for urgent and effective measures to ensure sustainable development of the sector. Aqua farming may play a pivotal role in ensuring food security through the judicious utilization of aquatic resources ensuring lower carbon footprint. Controlling the environmental deterioration through the seaweed culture practice is a viable option, as they can quadruple the biomass in just one day, and helps remove carbon from the air and nitrogen from wastewater. Fish being poikilothermic, experience the immediate effect of temperature change. Hence, the short and long term impact of climate change on the fish physiological behaviour has to be studied to improve the aquaculture production and also to maintain the natural stock. This will assist the young minds to come out with new eco-friendly technologies based on changing environment to help escalate fisheries and aquaculture production without altering the flesh quality. Sustainability in aquaculture production can be brought about by organic aquaculture which can be achieved with culture of low-trophic aquatic species; disease management and use of natural and alternative medicines; polyculture and multi-species systems; self-filtering systems, implications of using closed containment systems; environmentally sound effluent management systems; and consumer studies related to food preferences and purchasing habits. Fisheries education can promote the organic farming sector through strong support of research and development and awareness among the youths. This can also help in creating awareness among the professionals, farmers and society regarding climate change, and help them to contribute in combating the harmful effects caused by human intervention.

Keywords: Climate Change, Sustainability, Greenhouse, Organic Aquaculture

TRPSF-AQUA-P-31

A Scientometric Assessment of Research on Inland Saline Aquaculture in India vis-a-vis the World (1981-2022)

Shakir Ahmad Mir¹, P. S. Ananthan^{1*}, Dasari Bhoomaiah¹, Neha Wajahat Qureshi¹, Shivaji Argade¹, Sreedharan Krishnan¹, Raj Mukhopadhyay²

¹ICAR-Central Institute of Fisheries Education Mumbai, Maharashtra

²ICAR-Central Soil Salinity Research Institute Karnal, Haryana

*Corresponding author: ananthan@cife.edu.in

Abstract

Soil salinization is a serious ecological threat affecting the agricultural output and human health in arid and semi-arid environments of more than 100 countries across the world, affecting almost 1 billion hectares worldwide. It caused reduction in cultivated land area, crop productivity and quality by rendering significant chunks of land unproductive or less productive. As per some estimates, worldwide 20% of total cultivated and 33% of irrigated agricultural lands are afflicted by high salinity with global economic losses of around US \$ 27.3 billion per year. Many technological interventions to reclaim the salt-affected lands have been developed but their adoption remains low either due to huge expenditure involved or being ineffective. Practicing aquaculture in salt-affected areas, using saline groundwater, has evolved as one of the economically feasible options especially in Israel, USA, India and Australia. The current study maps the global research output on inland saline aquaculture (ISA) during 1981-2022 using the Web of Science (WoS) database. A total of 2725 tags were subjected to a scientometric analysis consisting of various indicators *viz.*, growth, rank and global publications share, research collaborations, total citation counts, average citations per paper, and *h*-Index. India accounted for 13.61% of the global ISA publications, and stood second after Australia among the 15 most productive countries in terms of number of publications in this period. The Indian researchers had networked with 39 collaborating partners across the world of which Australia, the lead collaborating country accounted for 16.35% of the total papers with international collaboration. The study provides quantitative analysis on the leading institutions and individual researchers, significantly contributing to the ISA research in India. The *Journal of Hydrology* carried the maximum number of research papers on ISA (72 papers), followed by *Agricultural Water Management* (58 papers) and *Aquaculture* (37 papers). The analytical results of the present study provide insights into the trends of ISA research globally and in India and calls for focused and concrete efforts to enhance research which has the potential to reverse the fortunes of the farmers suffering from the problem of salinization.

Keywords: Inland Saline Aquaculture; Web of Science; H-Index; Scientometrics; Salinization

TRPSF-AQUA-P-32

Effect of Sodium Butyrate Supplementation on Growth performance, Survival, gut histology and resistance to infection in Amur Common Carp (*Cyprinus carpio haematopterus*)

Walde Swapnil G¹, Manjappa N², Harsha Nayak², Pavan Kumar P¹, Parvind Kumar¹

¹College of Fisheries, Mangaluru

²Fisheries Research and Information Centre (Inland), Hesaraghatta

Abstract

A possible substitute to the antibiotic's growth promoters prevalent in aqua feeds are organic acids, and/or their corresponding salts. The study aimed to assess the efficacy of sodium butyrate (SB) as a dietary supplement in enhancing growth and survival rates of Amur common carp (*Cyprinus carpio haematopterus*). A total of 180 healthy fingerlings, weighing 4 ± 0.5 g (mean \pm SE), were randomly assigned to four treatment groups in equal number: control (no organic acid additive), 1%, 2%, and 3% SB supplementation. The fishes were kept in triplicates for each treatment groups. The group fed with 3% SB exhibited significant improvements ($p < 0.05$) in final body weight (FBW), weight gain (WG), body length (BL), specific growth rate (SGR), and food conversion ratio (FCR) compared to the other groups. Furthermore, no deleterious effects on water quality were observed with the inclusion of SB in the diet. The treatment group showed significant higher disease resistance than control group, effective in the prevention of *A. hydrophila* infection in Amur common carp. Also, it was shown that the intestinal morphology of the treated fish had improved and structural variation. The treatments and controls there was no clear differentiation in the arrangement and numbers of enterocytes and goblet cells, villus thickness, leucocytes from lamina propria and vacuolation in mucosal epithelia. These findings suggest that the growth, feed utilization, and overall health of Amur common carp can be enhanced through the addition of 3% SB as a dietary supplement, without compromising water quality. These results contribute to the understanding of the potential benefits of organic acid supplementation in aquaculture practices and provide valuable insights for optimizing the rearing conditions of Amur common carp.

Keywords: Sodium Butyrate, Amur Common Carp, Organic Acid, Histology

TRPSF-AQUA-P-33

Surgical method of using sensors to evaluate heart rate and temperature (fever) of olive flounder (*Paralichthys olivaceus*)

Showkat Ahmad Dar^{1*}, Sung-JuJung², Sarvendra Kumar¹, Susmita Rani¹, and Tapas Paul¹

¹College of Fisheries Kishanganj, Bihar Animal Science University- 855107

²Department of Aqualife Medicine, Chonnam National University, Yeosu 59626, Republic of Korea

*Corresponding author: showkatdar53@gmail.com

Abstract

The present study was carried to learn the surgical studies in commercially important oliveflounder (*Paralichthys olivaceus*). Further, the experimental trial was carried to know the heart rate and body temperature (fever) in olive flounder using bio-loggers. Two weeks after surgery, all fish survived with normal skin color but inner part of surgery, peritoneum side, revealed hemorrhages. Total six fish were surgically inserted temperature DST micro-HRT logger. After surgery the fish were monitored daily for one week and were kept in circular tanks with round the clock aeration. After 6 days three fishes were given intraperitoneal injection of FCA @ 100µl/kg and kept as treatment group. The results reveal that the temperature recorded by the bio-loggers was absolutely good in comparison to our manual recorder. While the heart rate was found better in 100 htz compared to 80 and 100 htz using the highest quality index (QI).The expression studies reveal that the HSP genes were significantly induced by temperature rise due to treatment of FCA. The results showed that all the immune genes were induced significantly in both kidney and spleen. The immune genes TNF- α , IL-1 β , and IL-8 showed significant fold change with respect to control non treated group. The TNF- α gene showed very high about 12 times fold change and higher induced expression compared to the other immune genes. During the study, the immunogenic high gene expression responses showed the impact of temperature rise along with cytokine role in fever responses. The study paves way to study more in fish fever and related responses in the field of fisheries science to open the new aspects for research and development. This research will serve as guide to help researchers to increase their understanding of the febrile response in fishes and the underlying mechanisms that boost their knowledge of the critical roles that fever plays in the modulation of host immunity.

Keywords: Sensor, Surgery, HSP, Immune Genes, Heart Rate, Fever

TRPSF-AQUA-P-34

Evaluation of red tilapia growth and physiological response at various stocking densities in inland saline biofloc ground waters

S Kumari ^{1*}, Babitha Rani. A. M ², V. K. Tiwari ², A. K. Balange ²

¹College of Fisheries, Kishanganj, Bihar Animal Sciences University, Patna, Bihar, India

²ICAR- Central Institute of Fisheries Education, Versova, Andheri (W), Mumbai, India

*Corresponding Author: sksangeeta93@gmail.com

Abstract

For the rearing of red tilapia, *Oreochromis mossambicus* \times *Oreochromis niloticus*, a biofloc-based intensive system is most preferable. Red tilapia fingerlings were stocked in triplicate at different stocking densities of 150 (SD1), 200 (SD2), 250 (SD3), and 300 (SD4) no. m⁻³ in biofloc-based treatments and 150 no. m⁻³ in control (C clear water) in inland saline ground water of 20 ppt to determine the optimum stocking density over the duration of an experiment lasting 90 days. The Percentage body weight gain (570.02 ± 21.86), Specific growth rate (2.10 ± 0.04) and Protein efficiency ratio (1.90 ± 0.07) were found to be significantly more in the biofloc treatment groups SD1. Feed conversion ratio (1.04 ± 0.02), was found lowest in SD1. The highest amylase and protease activity (units mg protein⁻¹) were recorded in SD1 (0.66 ± 0.05 , 1.28 ± 0.04 , respectively), and the lowest was reported in control. Additionally, the lipase value in SD1 (1.25 ± 0.02) was much higher. The SD1 treatments had the highest rates of survival (95.57 ± 0.53). Total ammonia nitrogen (0.37 ± 0.02 mg L⁻¹), nitrite-nitrogen (0.41 ± 0.03 mg L⁻¹), and nitrate-nitrogen (4.94 ± 0.06 mg L⁻¹) were all below the permissible levels for red tilapia in the SD1 of the present study. The maximum floc volume was found in SD4 (35.09 ± 0.20 ml L⁻¹), and the lowest was in SD1 (32.74 ± 0.37 ml L⁻¹). Consequently, this study revealed that the optimal conditions for red tilapia rearing in inland saline based biofloc ground water are at a stocking density of 150 m⁻³ and a salinity of 20 ppt.

Keywords: Red Tilapia, Stocking Density, Inland Saline Ground Water, Biofloc, Growth, Enzymes

TRPSF-AQUA-P-35

Effect of Ginger (*Zingiber officinale* Roscoe) incorporated diets on biochemical parameters of Juvenile Striped Catfish, *Pangasianodon hypophthalmus* (Sauvage, 1878)

Sagarika Swain*¹, Anil Pawase², Raju M. Tibile², Ravindra Pawar², Abhiman Ballyaya¹, Aditya Pratap Acharya³

¹College of Fisheries, Kishanganj, BASU, Patna, Bihar

²College of Fisheries, Ratnagiri, DBSKKV, Maharashtra

³West Bengal University of Animal and Fishery Sciences, Kolkata

*Corresponding author: swain_sagarika@ymail.com

Abstract

The study was aimed at determining the effects of ginger (*Zingiber officinale* Roscoe) as an immunostimulants on striped catfish, *Pangasianodon hypophthalmus*. Experimental diets containing ginger powder at 5, 10, 15, 20 g/kg of diet were fed to the juveniles of striped catfish and the control group was fed without incorporating ginger powder in the diet. The experiment was subjected to five treatments and four replicates using a completely randomized design (CRD). The fishes were fed @ 5% of their body weight twice a day. The feeding experiment was conducted for a period of 90 days. After 90 days of feeding experiment, experimental fishes were challenged intra-peritoneally with pathogenic bacteria, *Aeromonas hydrophila*. Biochemical parameters such as albumin, globulin and total serum protein were also found to be significantly higher in the fishes of 10g kg⁻¹ ginger incorporated diet in pre- and post-challenge studies (P<0.05). The glucose concentration was significantly higher (P<0.05) in the control group than that of the remaining groups. No significant difference was observed in glycogen content of liver among the various treatments (P>0.05). The results demonstrated that *Zingiber officinale* powder at 10g kg⁻¹ of diet can act as an immunostimulant, potentially improving non-specific immunity and disease resistance in striped catfish infected with *Aeromonas hydrophila*.

Keywords: Feed, Ginger, Striped Catfish

TRPSF-AQUA-P-36

Combinatorial effects of Dietary Genistein and Daidzein modulate sex steroids in Female *Cyprinus carpio* (Linnaeus,1758) nevertheless growth performance

Samikshya Mishra*¹, Subodh Gupta¹, Narottam Prasad Sahu¹, Prem Prakash Srivastava² and Tincy Varghese¹

¹ICAR-Central Institute of Fisheries Education, Mumbai, India

²College of fisheries Dholi, Dr.RPCAU,Samastipur,India

*Corresponding author: samikshya.fpbpb102@cife.edu.in

Abstract

A study was conducted to evaluate the combinatorial effects of soy phytoestrogens, genistein and daidzein on growth and gonadal steroids of female *C. carpio*. The genistein and daidzein contents were estimated as 22.57 mg and 2.156 mg per 100 gram of soybean meal, respectively. A 45-day feeding experiment was conducted to assess the effects of dietary genistein and daidzein supplementation on the broodstock female common carp. Three different treatments were used, namely control (phytoestrogen-free purified diet), T1 (purified diet with 50% genistein and daidzein of 17.5% of soybean meal equivalent) and T2 (purified diet with 100% genistein and daidzein of 35% of soybean meal equivalent). The growth performance of female *C. carpio* was not affected by the addition of genistein and daidzein diets. Sex steroid profiles *viz* estradiol (E2), testosterone (T), progesterone (P), and cortisol were as given to evaluate the functioning of the reproductive system of female common carp. Both 50% and 100% doses of combined genistein and daidzein supplementation showed a significant (p<0.05) increase in serum estradiol levels, whereas there were no significant changes in serum testosterone and progesterone level. There was no difference in cortisol levels when genistein and daidzein were supplemented together. The histology of ovary revealed that the percentage of vitellogenic oocytes increased significantly (p<0.05) after a higher combined dose of genistein and daidzein feeding (T2). There was also a noticeable increase in cortical alveoli oocytes with inclusion of combined genistein and daidzein. The GSI of the female *C. carpio* was not affected by feeding a combination of genistein and daidzein. As a result, the study indicated that the inclusion of both of 50 % dose of genistein and daidzein and 100 % dose of genistein and daidzein has shown no negative impact on the growth and sex steroid profile except female hormone estradiol (E2) in female common carp. There is a need for more research to see whether genistein and daidzein combined feeding has any harmful implications during a long-term administration.

Keywords: Common Carp, Phytoestrogen, Estradiol, Testosterone, Progesterone, Cortisol

TRPSF-AQUA-P-37

Dietary protein improves immunity and oxidative status of juvenile white-leg shrimp, *Penaeus vannamei* reared in inland saline water

Prasanta Jana^{1,2*}, Narottam P. Sahu¹, Parimal Sardar¹, Ashutosh D. Deo¹, Shamna N.¹, Tincy Varghese¹, Mritunjoy Paul¹

¹ICAR - Central Institute of Fisheries Education, Mumbai, Maharashtra 400061, India

²College of Fisheries Science, Gumla, Birsa Agricultural University, Ranchi, Jharkhand 835207, India

*Corresponding author: prasanta.jana93@gmail.com

Abstract

An eight week experiment was conducted with to assess the effect of graded levels of dietary protein on immunity and oxidative status of white-leg shrimp, *Penaeus vannamei* reared in inland saline water of 15 ppt. Seven hetero-nitrogenous (200 to 500 g CP/kg), iso-caloric (396 Kcal DE/100g) and iso-lipidic (60 g/kg) semi-purified experimental diets *viz.*, CP₂₀(200 g CP/kg), CP₂₅(250 g CP/kg), CP₃₀(300 g CP/kg), CP₃₅(350 g CP/kg), CP₄₀(400 g CP/kg), CP₄₅(450 g CP/kg), and CP₅₀(500 g CP/kg) fed to shrimps of respective group in triplicates thrice a day up to satiation level. Stocking density was maintained at 40/m³. Highest ($p < 0.05$) metabolic growth rate, protein growth rate and feed conversion efficiency were observed in CP₄₀ group followed by CP₃₅ and CP₄₅ groups. Transaminases and antioxidant enzyme activities were higher ($p < 0.05$) in CP₄₀ and CP₂₀ groups, respectively. CP₄₀ group exhibited highest ($p < 0.05$) prophenoxidase, respiratory burst and lysozyme activity and lowest in CP₂₀ and CP₂₅ groups. Therefore, it can be concluded that 400 g CP/kg diet is optimum to support immunity and antioxidant status of *P. vannamei* juveniles reared in inland saline water. The outcomes of the study will help to develop a cost-effective feed for ISW shrimp culture of salt-affected regions.

Keywords: *Penaeus vannamei*; Inland Saline Water; Dietary Protein; Immunity; Antioxidant Status

TRPSF-AQUA-P-38

Exploring the possibilities for fish culture in saline tract of Purna river valley in Amravati & Akola District of Maharashtra

Sachin W. Belsare*, Satyajit S. Belsare and Rajiv H. Rathod

College of Fisheries, Nagpur, MAFSU

*Corresponding author: sachinbelsare@mafsu.in

Abstract

This abstract explores the possibilities for fish culture in the saline tract of the Purna River valley in Amravati and Akola districts of Maharashtra, India. While freshwater aquaculture is more common, the utilization of saline water resources for fish cultivation presents an opportunity to diversify and enhance the aquaculture sector in the region. The first crucial aspect is the selection of fish species that can tolerate brackish or saline water conditions. Thorough research and consultation with local experts will help identify the most appropriate species based on their tolerance to salinity levels and market demand. Water quality assessment is another key consideration. Regular monitoring of salinity levels and other parameters such as temperature, dissolved oxygen, and pH is necessary to maintain optimal conditions for fish growth and health. Suitable infrastructure, including ponds or tanks, water supply systems, and wastewater treatment facilities, must be developed to support fish culture in the saline tract. Feed and nutrition strategies play a vital role in successful fish culture. Identifying suitable feed sources and formulating balanced diets are essential for meeting the nutritional requirements of the chosen fish species. A combination of natural feed availability and supplementary feeds may be necessary to ensure proper growth and development. Effective management practices are crucial for the sustainable operation of fish culture in the saline tract. This includes regular monitoring of water quality parameters, disease prevention measures, stocking density management, and proper feeding protocols. Collaborating with local fisheries departments, aquaculture experts, and experienced farmers will provide valuable insights into best practices. Exploring market opportunities is vital for the economic viability of fish culture in the region. Identifying local or regional markets, establishing market linkages, and understanding consumer preferences will help determine the profitability and marketability of the cultivated fish species. Additionally, exploring processing and value-added opportunities can further enhance the economic potential of fish culture. Collaboration with research institutions, universities, and government agencies is essential for accessing the latest knowledge and technical expertise. Research collaborations can help address site-specific challenges, optimize production techniques, and contribute to the overall development of fish culture in the saline tract.

Keywords: Fish culture, Purna River, Water Quality, Feed

TRPSF-AQUA-P-39

Aquaculture Potential of Malguzari Tanks in the Western Vidarbha Region of Maharashtra: An Exploration of Opportunities

Satyajit S. Belsare, Rajiv H. Rathod and Sachin W. Belsare
College of Fisheries, Nagpur, MAFSU

*Corresponding author: satyajitbelsare@mafsu.in

Abstract

Aquaculture has emerged as a promising solution to meet the increasing demand for seafood, alleviate pressure on wild fish stocks, and enhance rural livelihoods. In the western Vidarbha region of Maharashtra, India, the Malguzari tanks, a traditional system of water storage, present a unique opportunity for the development of aquaculture practices. This study aims to explore the aquaculture potential of Malguzari tanks in the region, considering their physical characteristics, socio-economic factors, and ecological suitability. The research employed a mixed-methods approach, integrating qualitative data from interviews with local stakeholders, fisheries experts, and government officials, as well as quantitative data from field surveys and secondary sources. The findings revealed several factors contributing to the aquaculture potential of Malguzari tanks in the region. Firstly, the physical characteristics of Malguzari tanks, such as their size, depth, and water quality, were found to be conducive to aquaculture practices. The tanks' substantial water storage capacity and controlled environment provide an ideal setting for rearing various species of freshwater fish. Secondly, the socio-economic factors in the western Vidarbha region create a favourable environment for aquaculture development. The local communities possess a significant level of traditional knowledge related to fish farming, making them receptive to adopting modern aquaculture techniques. Moreover, the presence of well-established market channels and demand for fish in nearby urban centres offers a lucrative opportunity for the sale of aquaculture produce, thereby contributing to the socio-economic upliftment of the region. The integration of fish farming with existing agriculture practices, such as the use of tank water for irrigation, promotes sustainable resource utilization and mitigates potential environmental impacts. However, certain challenges need to be addressed to harness the full potential of Malguzari tanks for aquaculture. These include issues related to water management, infrastructure development, access to finance, technical capacity building, and policy support. Collaborative efforts among government agencies, local communities, and private investors are essential to overcome these challenges and facilitate the sustainable development of aquaculture in the region.

Theme II: Fisheries Resources & Environment Management

TRPSF-FREM-O-1

Analysis of Commercial Shrimp Trawl By-catch Using Pgis along the Coast of West Bengal, India

Rupam Samanta^{1,2*}, Nagesh T. Srinivasan¹, Nagaraj A. Talwar¹, Susmita Jana¹

¹Faculty of Fishery Sciences, WBUAFS, Kolkata-700094

²College of Fisheries, BASU, Kishanganj 855107

*Corresponding author: rupamsamanta328@gmail.com

Abstract

Bycatch and discards have become severe threats for sustainable fisheries at all levels, until and unless they are proficiently managed. The present study is carried out to envisage comparative analysis of faunal composition, bycatch quantification and seasonal variation from a commercial multi-day shrimp trawl along the coast of West Bengal, India. The study was conducted from July, 2019 to March, 2020 covering three seasons namely post monsoon (July, 2019 to September, 2019), winter (October, 2019 to December, 2019) and pre-monsoon (January, 2020 to March, 2020). A total of 62 hauls at a depth ranging between 9.5 m and 54.5 m were observed. A total of 148 species comprising finfishes and shellfishes was recorded during the study period with the maximum in the winter followed by pre-monsoon and post-monsoon periods. Maximum catch in shrimp trawl was contributed by sciaenid followed by prawns, clupeids, Bombay duck and ribbonfish. The percentage bycatch in was maximum in November. The overall target catches, retained bycatch and discards formed were 13.1 %, 67.1 % and 19.8, to the total, respectively. There existed a positive correlation between target catch and bycatch during the study period. The GIS mapping showed that maximum fishing operations were carried out in the south-east direction. Maximum and minimum bycatch per hour were found in July and January, respectively, Predictive total catch per haul of shrimp trawl along the West Bengal coast showed maximum catch in the south-east direction at a depth range of 25-30 m. Both overall discards per haul and discards per hour were maximum within 20 m depth. Spatio-temporal catch and discard data with species distribution maps would help in understanding the area and seasonal abundance of catch and bycatch. The geo-database generated by the present study would help the stakeholders to gather exact geospatial information on fishing activities of trawlers along the West Bengal coast.

Key words: Bycatch, GIS Mapping, Shrimp Trawl, West Bengal

TRPSF-FREM-O-2

Biological parameters of the barred spiny eel, *Macrognathus pancalus* from the middle stretch of the river Ganga, India

Surendra Kumar Ahirwal*, Jaspreet Singh, Kamal Sarma, Vivekanand Bharti, Tarkeshwar Kumar, Shailendra Raut

Division of Livestock and Fisheries Management, ICAR-Research Complex for Eastern Region, Patna-800014, Bihar, India

*Corresponding author: surendraahirwal@gmail.com

Abstract

Macrognathus pancalus (Hamilton 1822) is a medium-sized freshwater spiny eel with a very high market value. Besides its immense food value, the species also has ornamental value due to its bright coloration. In recent times, the population of the species has declined due to overfishing and habitat destruction. In light of this, the present study was designed with the objective of generating baseline data on biological parameters, which are crucial for the management of these important resources. Fish specimens were collected monthly from the middle stretch of the river Ganga at Patna during December 2022–January 2023. The specimens ranged in length from 75.83 to 165.20 mm and in weight from 1.05 to 17.39 g. Based on size frequency distribution, species are under juvenile overfishing, and the estimated morphometric characters vary within the size range (83 to 160 mm) of fish and depend on the growth of fish. Females were significantly heavier ($p < 0.0001$) and grew in a positive allometric pattern ($b > 3$), while males grew in an isometric pattern ($b = 3$). The condition factor reveals that males are significantly more robust than females ($p < 0.0001$). The estimated length at first maturity were 135 mm for females and 115 mm for males. The species have prolonged spawning seasons from February to October, with a peak at onset of the monsoon. The species' gonadosomatic index (GSI) values have an inverse correlation with the temperature ($r = -0.63$) and day length ($r = -0.61$). Females had significantly higher mean values for the hepatosomatic index (HSI) and stomach repletion index (SRI) than males. The GSI values of the species have a positive correlation with the HSI ($r = 0.69$) and SRI ($r = 0.53$) values. The species has a low fecundity (Mean \pm SD; 1057 ± 518.07), with larger egg size (1.17 ± 0.14). Overall sex ratio was 0.88:1 (M:F), which is statistically not deviated from the hypothetical value of 1:1. These findings will be valuable for conservation and sustainable utilization of the species in the long run.

Key words: *Macrognathus pancalus*, Biological Parameters, River Ganga

TRPSF-FREM-O-3

Climate change impacts on Inland Fisheries Sector of India: resilient practices

Brajendu Kumar

Krishi Vigyan Kendra, Banka – 813102, Bihar, India

*Corresponding author: brajbau@gmail.com

Abstract

Fisheries is an important sector of agriculture in India, providing employment, food and nutritional security particularly to the rural poor and better access to protein rich food for all. It is also contributing handsomely to the agricultural exports and engaging more than fifteen million people at primary and secondary level. Increase in atmospheric and aquatic temperature of rich potential fisheries resources of India due to climate change is going to have wider implications on their production and productivity. Biotic effects on the culture fisheries resources consisting of ponds and tanks are reduced dissolved oxygen (DO) level, reduced growth and reproductive success of fishes, increased susceptibility of fishes to diseases, alteration of their physiological functions such as thermal tolerance, growth, metabolism, food consumption, reproductive success and the ability to maintain internal homeostasis, increased biological oxygen demand (BOD), increased toxicity of pollutants, etc. The Inland fisheries resources of India constituted by culture, culture based and capture fisheries resources consisting of ponds and tanks, rivers and canals, floodplain lakes, reservoirs and brackish water-bodies. The biotic effects of climate change in these water bodies are manifested by habitat loss, shift in the species composition, alteration of biodiversity, enhancement of primary productivity and eutrophication, etc. The abiotic stresses are increased stratification of lakes and reservoirs, inundation of aquatic systems, alteration in flow regime of rivers, salinity changes etc. Operational cost of aquaculture and other associated activities will also be influenced. Hence, the impact of the climate change on communities directly or indirectly associated with the resources is difficult to ignore. Climate resilient practices should involve introduction of low oxygen tolerant species, selection of fish species that require short culture periods, provision of continuous supply of fish seed, integration of aquaculture with other farming practices, promoting culture based fisheries, enhancing provisions for breeding and recruitment, better weather surveillance and forecasting systems, capacity building to increase the resilience of fishing communities, promotion of fuel efficiency, conservation and sustainable use of resources in an equitable way etc.

Key words: Fisheries, Climate Change, Biotic Stress, Abiotic Stress, Adaptation Strategies

TRPSF-FREM-O-4

Developing spatial conservation planning measures for reducing fishing impact in Indian waters: A GIS modelling approach

Abdul Azeez P.^{*1}, Prathibha Rohit¹, Mohammed Koya K.¹, Mini Raman², Latha Shenoy³, Ashok Kumar Jaiswar³, Shikha Rahangdale¹, Divu D.¹

¹ICAR-Central Marine Fisheries Research Institute, Kochi- 682 018, India.

²ISRO-Space Applications Centre, Ahmedabad- 380 015, India.

³ICAR-Central Institute of Fisheries Education, Andheri West, Mumbai- 400 061, India.

*Corresponding author: abudul.p@icar.gov.in / azeez.cr7@gmail.com

Abstract

Conservation planning to mitigate the negative impact of fishing on ecosystems necessitates a thorough understanding of the spatio-temporal distribution of bycatch in fishing grounds. Unfortunately, the lack of such information makes it difficult for managers and policymakers in Indian waters to implement spatially explicit management measures. To address this issue, a preliminary study on the spatio-temporal distribution of key species caught as bycatch by a mid-water trawler targeting ribbonfish on the northwest coast of India to identify the areas where these key bycatch species were most persistent. Semi-variogram modeling was used for analyzing the spatio-temporal distribution patterns of the fishes. Kriging interpolation helped to create maps that showed significant variation in the abundance of bycatch species, depending on their associated habitats and depth preferences. Furthermore, a significant positive correlation between the abundance of different species caught as bycatch indicated that only a few species shared the same habitat in the region. Findings revealed that the key species bycatch was most concentrated in inshore areas during the post-monsoon and summer seasons. However, the abundance of these species was lowest in the inshore areas during the winter. This new understanding of the spatial and temporal distribution patterns of the fishery's key species will help with the future application of spatial management measures such as designating no-fishing zones and incorporating them into a conservation network.

Key words: Spatio-Temporal Management, Trawl Fisheries, Marine Spatial Planning, Arabian Sea

TRPSF-FREM-O-5

Environmental factors responsible for the sudden mortality of tilapia, *Oreochromis mossambicus*: the example of a lotic system, Sevalkulam Lake (Kanmai), Tuticorin, Southeast India

Manickavasagam S*, Sudhan C, Rishikesh Venkatrao Kadam, Padmavathy P, Manimekalai D, Ponmani M, Subhashree Devasena S

TNJFU-Fisheries College and Research Institute, Tuticorin-628008

*Corresponding author: manickavasagam@tnfu.ac.in

Abstract

The present study indicated that environmental factors were responsible for the sudden mortality of tilapia, *Oreochromis mossambicus*, along Sevalkulam Lake (Kanmai), Tuticorin, Southeast India. The mortality was observed on the 28th of March 2022 along the lotic bodies of the lake's surface waters, which spread from 9° 15' 50" N (latitude) and 77° 88' 40" E (longitude) to 9° 15' 25" N (latitude) 77° 84' 40" E (longitude). The surface waters of the lake region appeared dark green with floating murky oil slicks, an off-odour, and the gut content examination of the dead Tilapia fish samples indicated and revealed the presence of mud and debris particles in the mouth and gills. Turbidity is a measure of the amounts of suspended particles in the water. Algae, suspended sediment, and organic matter particles all contribute to turbidity. Suspended particles diffuse sunlight and absorb heat. The effects of this include an increased temperature of the water body, reduced light available for algal photosynthesis, and the clogging of fish gills. The result analysed were compared with permissible limits prescribed by WHO, FAO, BIS, and other references. In this study, the pH (6.76–8.03), total dissolved solids (2000–2400 mg/L), total suspended solids (1600–2100 mg/L), and total alkalinity (250–1350 mg/L) of the lake followed the prescribed limits set by WHO (1993) and BIS (1991). In this study, the reasons for the sudden death of tilapia fish in the lake include highly fluctuating values of the pH, total dissolved solids (TDS), total suspended solids (TSS), and total alkalinity of the lake water, especially in mortality periods. The study concluded that tilapia fish could not tolerate the extreme fluctuations of pH, TDS, TSS, and total alkalinity values of more than 500 mg/L. The increased level and high fluctuation of TSS and TDS values were the expected reasons for the sudden fish deaths in the lake during the mortality period. This observation study revealed that the sudden fish mortality occurred due to the placement of chemical industries producing phenolic compounds, matchbox-producing industries, and the discharge of sewage from domestic inhabitants. As a result, there is a critical need for frequent observations and assessments of inland water bodies in order to understand their environmental changes, pond productivity, and conservation of inland aquatic ecosystems.

Key words: Physico-Chemical Parameters; Tilapia; Suspended Solids; Mortality; Lotic System and Sevalkulam Lake

TRPSF-FREM-O-6

Evaluation on sub-lethal exposure of triclosan on intestinal gut microbiota of rohu, *Labeo rohita*

Angom Baleshwar Singh, Kundan Kumar*, Saurav Kumar, S.P. Shukla
ICAR- Central Institute of Fisheries Education, Mumbai, 400 061, India

*Corresponding author: Kundankumar@cife.edu.in

Abstract

Triclosan, a lipophilic broad-spectrum, is widely used as an antibacterial agent in various Pharmaceutical and Personal care Products and is often detected in wastewater effluent. The potential toxicity at lethal concentrations, usually towards the untargeted aquatic inhabitants, makes it a compound of utmost concern worldwide. In this study, the bioconcentration of triclosan (TCS) in the gut tissues of *Labeo rohita* was determined, and the subsequent effect on Total heterotrophic count bacteria of the gut was investigated after 30 days of exposure in two sub-lethal concentrations viz. T₁ (0.129 mg L⁻¹) and T₂ (0.065 mg L⁻¹), which are 1/5th and 1/10th of an estimated LC₅₀ of TCS in water. The results showed that TCS bioconcentration in the gut tissues was higher in T₁ fishes. At the same time, there was a significant (p<0.05) decrease in TPC of the triclosan exposed fish on the 30th day compared to the control group, which indicates the interference of TCS on sensitive gut bacteria, instigating the reduction in bacterial count from the normal. A significant reduction in relative percentage survival was observed with increasing TCS concentration. The present study revealed that low-level exposure to triclosan could disturb the balance of the ecosystem and reduce vital gut intestinal microbiota, which may further affect the overall health status of the host. However, further studies need to investigate the effect of TCS on antimicrobial sensitivity of gut microbes and its subsequent influence on the fish immune system.

Key words: Triclosan, Pharmaceuticals and Personal Care Products, *Labeo Rohita*, Bioconcentration

TRPSF-FREM-O-7

Impact of Sea turtle conservation in South Tamil Nadu

Sudhan Chandran*, Durairaja Ramulu, Jayakumar Natarajan, Mariappan Sangaralingam, Manickavasagam Samiyappan
TNJFU-Fisheries College and Research Institute, Thoothukudi, Tamil Nadu – 628 008 India

*Corresponding author: sudhan@tnfu.ac.in

Abstract

The present study reports 21 carapace shell remaining, 11 whole carapace shells and 2 turtle carcass of Olive ridley turtle, *Lepidochelys olivacea* (Eschscholtz, 1829). The species identified by beach surveying along the coast of southern Tamil Nadu using standard keys. Pls mention the GPS location if any. The field survey was carried out during April - December, 2022 along four districts of Tamil Nadu namely, Ramanathapuram, Thoothukudi, Tirunelveli and Kanyakumari, covering the coastal length of 520.70 sq. km. The locations were identified by the handheld GPS device (Garmin *vers.* 72) through coastal beach walking along the coast. The socio-economic survey reveals that the awareness of Sea turtle species identification and conservation were increased among the fishers due to various outreach like, on and off campus Sea turtle conservation awareness programme and hands-on training on species identification and field level awareness programme on Sea turtle conservation like protection of nesting ground in beach. The survey indicates that the studied areas are opt for turtle nesting, However, the nesting incidences were observed declining due to predation, less awareness among fisher, sound (acoustic) pollution, entangling in fishing gears, ghost fishing, trawling with diamond mesh size cod end and numerous habitat alterations which includes development of harbour, groynes and jetty constructions, parks and sea wall. Now a days, the Olive ridley species population shows declining trend as reported by International Union for Conservation of Nature and Natural resources (IUCN) and being categorized under Vulnerable (VU) category (A2bd). Besides, there are various activities and programmes are conducted by non-governmental organizations, forest and fisheries department towards Sea turtle conservation, like fixing of turtle excluder device (TED) in the trawl nets which is need to be strengthened by the regular monitoring and surveillance programmes. Further, the offshore challenges are to be accomplished for effective management and conservation of Sea turtle.

Key words: Sea Turtle, Species Identification, Turtle Excluder Device, Trawl Net, Sustainable Fishing

TRPSF-FREM-O-8

Laccase treated triclosan is safe for aquatic organisms: Process optimization and bioassay test

Shilpa Pradeep¹, Saurav Kumar^{1*}, Tapas Paul², S. P. Shukla¹, Prasenjit Pal³, Kundan Kumar¹

¹ICAR-Central Institute of Fisheries Education, Mumbai-400061, Maharashtra, India

²College of Fisheries, Bihar Animal Sciences University, Kishanganj-855107, Bihar, India

³College of Fisheries, Central Agricultural University, Lembucherra-799210, Tripura, India

*Corresponding author: saurav@cife.edu.in

Abstract

Triclosan (TCS), an antimicrobial biocide has raised serious concern among scientific community owing to its ubiquitous presence around the globe and toxicity to aquatic organisms. The present study aims on optimization of laccase enzyme mediated TCS degradation in water and evaluate the effects of treated water on aquatic organisms. Response surface methodology (RSM) along with Box-Behnken modeling showed that pH, temperature and laccase concentration combinations of 5, 30°C, 1 U/mL and 5, 40°C, 0.625 U/mL exhibits a significantly higher percentage (90.64 and 98.72 %) TCS degradation efficiency respectively. After analyzing the concentration of residual TCS in the 17 experiments using RSM, the best combination chosen for the final experiment was pH 4.93, temperature 39.77 and laccase concentration of 0.912 U/mL giving a percentage degradation efficiency of 96.56%. Bioassay test on *Chlorella vulgaris* and *Pangasianodon hypophthalmus* showed that the percentage inhibition in algal cell counts and cumulative mortality in fish was significantly less in enzyme treated TCS group as compared to the group exposed to water containing TCS. The results of the present study reveal that the most significant factor affecting the laccase-mediated TCS degradation is pH, followed by temperature, and the concentration of the laccase enzyme and the laccase-mediated TCS degradation could reduce the endpoint toxicity of TCS on aquatic organisms.

Key words: Triclosan, Laccase, Degradation, Bioassay, Response Surface Methodology, Toxicity

TRPSF-FREM-O-9

Management implication of changing environment on marine fisheries resources with discontinuous distribution

Rajan Kumar*, Shikha Rahangdale, Vinaya Kumar Vase, Rateesh Kumar
Indian Council of Agricultural Research-Central Marine Fisheries Research Institute, Kochi, Kerala-682018, India
*Corresponding author: rajanfrmcife@gmail.com

Abstract

Several resources have unique distributional pattern with strongly restricted latitudinal distributional pattern. These resources are known to be more sensitive to environmental variables like sea surface temperature (SST), bottom temperature, and salinity. The abundances of these resources are expected to vary significantly in response to the changing environmental variables. Bombayduck (*Harpadon neberus*) and Golden anchovies (*Coilia dussumieri*) along North West of India are a typical example of resources with discontinuous distribution with higher vulnerability to changing climate. Further, these resources are of high socio-economic importance to the coastal villages of Gujarat, as they form the key commodity to dried fish domestic trade and consumption. The sustainability of these resources is important for the prosperity of the coastal community involved in its value chain. The precise estimate of MSY forms the potential yield (or maximum sustainable yield) is key to sustainable management of marine resources in general and these unique resources in particular. Several estimates of MSY of these resources are available, but none of them have accounted for changing abundance attributable to a climatic variable in the estimation framework. The present work uses the most influential environmental variables as a covariate in the assessment model to arrive at more robust and scientifically justifiable estimates of MSY for these two unique resources of the region. The estimates form the baseline for formulating management strategies for these unique resources of high regional significance.

Key words: Bombayduck, Anchovies, Environmental Variable, North-West Coast, MSY

TRPSF-FREM-O-10

Morpho-Meristic Characterization of *Puntius sophore* (Hamilton, 1822) from Eastern India

Mukesh Kumar Singh^{1,2*}, H.N. Anjanayappa¹, S.R. Somashekara¹, Kumar Naik A. S.¹, T.S. Annappaswamy¹
¹College of Fisheries, Karnataka Veterinary Animal and Fisheries Sciences University, Mangaluru, Karnataka, India
²College of Fisheries, Dr. Rajendra Prasad Central Agricultural University, Dholi, Muzaffarpur, Bihar, India
*Corresponding author: mksingh@rpcau.ac.in

Abstract

The biometric studies are essential for proper species-level identification of fishes. In total 251 numbers of *Puntius sophore* specimens were collected from nine Indian states and subject to biometric analysis to provide updated identification keys. The *P. sophore* can be distinguished from its congeners species by presence of a black spot in the caudal peduncle region, another at the root of dorsal fin between 3rd to 6th branched ray, diffused golden spot on gill cover, lateral line complete with 22 to 26 scales including 1-2 scales on caudal fin base, $\frac{1}{2}4 - 5/1/3\frac{1}{2} - 4$ transverse scales from dorsal and ventral fin origin, 8-9 pre-dorsal scales, 10-11 pre-pelvic scales and 12 circumpeduncular scales, III- IV+8 rays in dorsal fin (consisting of two supernumerary and one unbranched ray) and last unbranched ray osseous and smooth; i+13 -14 rays in pectoral fin, i+8 rays in ventral fin, iii+ 5 rays in anal fin, and caudal fin bilobed with 10+9 principal rays. The overall standard length of the collected samples varied between 22.71 to 80.37 mm SL with the mean value of 48.16 ± 9.64 . The body depth of individuals varied in the range of 30.43-44.53% of SL with a mean 37.64 ± 2.36 , which lies under the range 28.90- 51.02% of SL and widest range 34.81-44.53% was observed in Bihar population with a mean value 38.51 ± 2.70 . Similarly, head length, length of caudal peduncle and depth of caudal peduncle ranged between 25.24-33.55%, 16.61-23.73% and 12.19-18.30% of SL respectively. Head depth behind the eye orbit, snout length and eye orbit diameter ranged between 60.04-75.98%, 19.34-28.64% and 26.03-38.91% of the head length.

Key words: *Puntius sophore*, Taxonomy, Morpho-Meristic Parameters

TRPSF-FREM-O-11

Relation between ichthyoplankton abundance and associated zooplankton biomass in the waters of Gulf of Mannar, Tamil Nadu

Jyoti Saroj¹, P. Jawahar², N. Jayakumar³, N. Neethiselvan³

¹College of Fisheries, Acharya Narendra Deva University of Agriculture & Technology, Ayodhya-224229, Uttar Pradesh

²Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Nagapattinam, Tamil Nadu

³Fisheries College and Research Institute, Thoothukudi, Tamil Nadu

*Corresponding author: [jyotisaroj31@gmail.com](mailto: jyotisaroj31@gmail.com)

Abstract

The correlation between ichthyoplankton abundance and zooplankton biomass were studied at 3 stations Mandapam, Thoothukudi and Punnakayal in the waters of Gulf of Mannar. A total 163 samplings were done at all the three stations with the help of 'Bongo' net with 158 µm mesh size. It was found that abundance of zooplankton plays significant role in the distribution of fish eggs and larvae in Gulf of Mannar. The correlation between fish eggs family and zooplankton group were found to be significant ($p < 0.01$) at Thoothukudi and Punnakayal and correlation between fish larval family and zooplankton group were found to be significant (both $p < 0.01$ and $p > 0.05$) at all three stations. The present study exhibited that the positive correlations between zooplankton and ichthyoplankton diversity in the waters of the Gulf of Mannar.

Key words: Eggs, Larvae, Zooplankton, Correlation, Gulf of Mannar.

TRPSF-FREM-O-12

Utilization of biosynthesized copper nanoparticles for enhancing bioremediation of ammonia in aquaculture systems: A mitigation approaches of climatic changes

Pabitra Barik^{1&2}, Neelam Saharan¹, Mohd Ashraf Malik¹, Kishore Kumar Krishnani¹, Debiprasad Kantal¹, Hemendra Kumar Vardia²

¹ICAR-Central Institute of Fisheries Education, Mumbai, India

²Dau S Bri Vasudev Chandrakar Kamdbenu Vishwavidyalaya, India

*Corresponding author: [pabitra.barik.cof.kwd@gmail.com](mailto: pabitra.barik.cof.kwd@gmail.com)

Abstract

Aquaculture is facing tremendous challenges due to climate change. Different phenomena include eutrophication, nutrient cycling, and health hazards that lead to the increased metabolic rate of fish. As a result of higher metabolic activities and decomposition of organic matter, BOD and COD load and generation of toxic ammonia cause havoc in aquaculture systems. This study aims to synthesize copper nanoparticles (CuNPs) using bacteria isolated from a mangrove environment and evaluate their efficiency in removing ammonia from Common carp tanks in ex-situ and in-situ conditions. *Bacillus megaterium* from the soil sample was isolated and identified by 16S rRNA gene PCR-amplified sequences. Copper NPs were synthesized using *Bacillus megaterium* and characterized by DLS-zeta potential, UV-vis, XRD, FTIR and TEM analysis. The mean zeta potential of the biosynthesized NPs was -31.46mV and had an average size of 8.2 nm. The concentration of ammonia in aerated tanks treated with CuNPs reduced to less than 0.03 mg/L from 0.3 mg/L. Also, fish mortality in these tanks was significantly controlled with the application of NPs. These findings suggest that synthesized NPs can remove ammonia from culture tanks.

Key words: Climate Changes, Ammonia, Eutrophication, Nanoparticles.

TRPSF-FREM-O-13

A novel composite material for enhanced removal of fluoride: a process optimization study for the treatment of fluoride contaminated groundwater

Ashutosh Kumar Singh^{1,2*}, Satya Prakash Shukla², Saurav Kumar², Vidya Shree Bharti², Rajendra. R. Deshmukh³, Priyanka Sahu²

¹College of Fisheries, Bihar Animal Sciences University, Kishanganj

²ICAR- Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai, Maharashtra-400061, India

³Institute of Chemical Technology, Mumbai

*Corresponding author: [ashutosh.singh1091@gmail.com](mailto: ashutosh.singh1091@gmail.com)

Abstract

A process for synthesis of a novel composite material using zeolite and industrial waste chitosan was developed and tested for adsorptive removal of fluoride. Removal efficiency (%) and adsorption capacity was used to evaluate the efficacy of newly developed adsorbent. The data of thirty experiments based on four variables was applied to Response

Surface Model (RSM) to find out optimum conditions for enhanced adsorptive removal of fluoride from the groundwater. The optimum conditions for removal of fluoride were: initial concentration of fluoride 5 ppm, dose of adsorbent 6 gL⁻¹, pH 6 and contact time 150 min. Under these specified conditions, 80 % removal efficiency was achieved. Two isotherm models were used to understand the sorption phenomenon and the Freundlich model showed a higher r² value (0.99) compared to Langmuir model. The study provides a complete protocol for fluoride removal from groundwater by developing a new low cost composite adsorbent material.

Key words: Removal, Fluoride, Model, Groundwater

TRPSF-FREM-O-14

Fish diversity and assemblage structures in the Jaldapara National Park complex in relation to environmental parameters and associated conservation measures

Dibakar Bhakta*, Ranjan K. Manna, Sangeetha M. Nair, Raban. C. Mandi, Srikanta Samanta and Basanta K. Das
ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata-700 120, West Bengal

*Corresponding author: dibakar.bhakta@icar.gov.in

Abstract

Jaldapara National Park is located on the banks of the Torsa River in the Alipurduar District of northern West Bengal, near the foothills of the Eastern Himalayas (between 25°58' N and 27°45' N). The National Park is located at an elevation of 61 meters and spans 216.51 km² of broad grassland and riverine woodlands. Other minor seasonal rivers, including Hollong, Chirakhawa, Buri Torsha, Sisamara, Sanjoy, and Bhaluka, which originate in the north from Bhutan and dry up during the winter, also crisscross the National Park in addition to the Torsa. Monsoon sampling was carried out in 2021 at five selected sample sites in the Jaldapara NP complex to study the fish assemblage structure in relation to environmental variables. Fish were mostly captured using gill nets (20–40 mm mesh size), cast nets, traps, electrofishing, and other methods. The Jaldapara National Park complex was home to 58 finfish species from nine orders and twenty families. Cypriniformes emerged as the most dominant group (34 species), followed by Anabantiformes (8 species), Siluriformes (7 species), Synbranchiformes, and so on. According to the IUCN Red List Status, 47 species are classified as Least Concern (LC), 4 as Not Evaluated (NE), 2 as Endangered (EN) and Vulnerable (VU), 1 as Near Threatened (NE), and 2 as Data Deficient (DD). Water temperature ranged between 22.2 and 25.9°C; water depth was shallow (76–150 cm); water flow varied between 0.15–0.42 m/sec; turbidity varied between 2.66–151.0 NTU; higher water pH (>8.3); alkalinity varied between 47–192 mg/l; and sufficient dissolved oxygen (6.8–8.0 mg/l). Dolomite mining and electrofishing have been identified as the two major threats to the aquatic ecology of the rivers surrounding the Jaldapara NP complex. A few conservation actions for long-term sustainability of the complex's fishery resources include reducing dolomite mining in the upper Torsa River and practising responsible fishing in and around the Jaldapara NP complex.

Keywords: Fish Assemblage Structure, Environmental Parameters, Jaldapara National Park Complex, Conservation

TRPSF-FREM-O-15

The occurrence of Microplastics in the Gastrointestinal tracts of selected fishes landed along Mumbai coast

Shahana S. Shashi Bhushan*, Binay Bhushan Nayak, & Martin Xavier
ICAR- Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai, Maharashtra-400061, India

*Corresponding Author: shashi@cife.edu.in

Abstract

The marine environment is not only contaminated with macroscopic plastics but also the microscopic particles of plastics called microplastics. The present study was carried out to assess the occurrence of microplastics in the gastrointestinal tracts of selected fishes landed along the coast of Mumbai, Maharashtra. The study area consisted of the major landing centres (Versova and Ferry wharf landing centre) of Mumbai and the species selected for the study were Goldspotted grenadier anchovy, *Coilia dussumieri* Valenciennes, 1848 and *Indian mackerel*, *Rastrelliger kanagurta* (Cuvier, 1816). The GI tracts of fishes were digested using alkali digestion protocol. The processed samples were subjected to Stereozoom microscopy and Attenuated Total Reflectance Fourier Transformed Infrared (ATR-FTIR) Spectroscopy. Plastic particles were classified into three broad shapes as fragment, filament and film, five size classes as < 5 µm, 5–50 µm, 50–500 µm, 500–5000 µm and >5000 µm and three colour categories as blue, red and others. Microplastics were found in fishes from both the landing centres. 76.67% of the occurrence of MPs was found in case of the *C. dussumieri* with the dominance of fragments in both the landing centres. Size of plastic particles observed in the GI tracts of *C. dussumieri* from Versova landing centre was smaller than that of Ferry Wharf samples. There was no significant difference between two landing centres in the abundance of various size classes and shapes except numbers

of fragments and plastic particles of size classes such as $<5\mu\text{m}$ and 5 to $50\mu\text{m}$. The Versova landing centre showed a higher number of plastic particles. *R. kanagurta* showed 83.33% of the occurrence of MPs with the dominance of fibres in samples of Ferry Wharf and fragments in Versova landing centre. Only the abundance of fibres showed a significant difference between the landing centres. The overall abundance of plastics observed in the guts of Indian Mackerel in both the landing centres was similar. The occurrence of Polyethylene was found in the GI tracts of *C. dussumieri* and Polyethylene and Ethylene Propylene Diene copolymer in the GI tracts of *R. kanagurta*. The study shows that the pelagic fishes landed along the coast of Mumbai are contaminated with plastics and intensity of plastic pollution in the fishing habitats is at a level or higher that lead the fishes to ingest the plastics involuntarily.

Keywords: Microplastics (MPs), *Rastrelliger Kanagurta*, *Coilia dussumieri*

TRPSF-FREM-P-1

A report on the stranded marine mammal *Dugong dugon* (Muller, 1776) along the Southeast coast of India

Ramulu Durairaj^{1*}, S. Manoharan², S. Muthukrishnan³, Jayakumar Natarajan¹, V. K. Venkataramani¹, Mahesh Chand Sonwal¹, Sudhan Chandran¹

^aDepartment of Fisheries Biology and Resource Management, Fisheries College and Research Institute, TNJFU, Thoothukudi – 628 008

^bTamil Nadu Forest Department, Forest veterinary unit, Tirunelveli – 627 007

^cDepartment of veterinary anatomy, Veterinary College and Research Institute, Ramayanpatti, Tirunelveli – 627 358

*Corresponding author: durairaja@tnfu.ac.in

Abstract

The *Dugong dugon* population has been Red listed as vulnerable to extinction by IUCN. Sea cow population was thriving well in the Gulf of Mannar, Palk Bay, Gulf of Kachchh, Andaman and Nicobar Islands in India (Annadale, 1905 and Anand et al. 2015). The Zoological Survey of India reported that 250 dugongs occurred in the Gulf of Mannar and Palk Bay in Tamil Nadu, Andaman and Nicobar Islands and the Gulf of Kuchchh in Gujarat, whereas in 2009 it was between 131 and 254 individuals (Sivakumar and Nair, 2013). Nowadays, these populations were dwindling drastically due to various anthropogenic disturbances that include fishing related mortality viz boat and propeller hit, fishing gear entangling and its habitat destruction (Perrin et al. 1996 and Marsh and Sobtzick, 2015). It is need of the hour to document a lesser studied group of dugong species in the World Heritage site like Gulf of Mannar, Tamil Nadu. In the present study a detailed investigation was carried out on the stranded marine mammal, female sea cow measuring about 3.24 meter length near the Kootapuli fishing village hamlet in Tirunelveli district of Tamil Nadu coast on 5th September 21. The specimen was washed ashore as per the intimation given by the local fishers. The detailed necropsy (or post-mortem) performed on stranded female sea cow is presented here.

Key words: *Dugong dugon*, Stranding, Gulf of Mannar, Conservation, South East coast of India, Seagrass

TRPSF-FREM-P-2

A Study on Occurrence and Environmental Risk of Triclosan In Selected Water Bodies of Mumbai

Ganesh Kumar T^{1*}, Saurav Kumar¹, Tapas Paul², S. P. Shukla¹, Kundan Kumar¹, Ashish Kumar Jha³

¹Aquatic Environment Management Department, ICAR- Central Institute of Fisheries Education, Versova, Mumbai-400061

²College of Fisheries, Bihar Animal Sciences University, Kishanganj

³ICAR-Central Institute of Fisheries Technology, Veraval Research Centre, Gujarat-362265

*Corresponding author: ganeshkumar.aempb202@cife.edu.in

Abstract

Triclosan (TCS) [5-chloro-2-(2, 4-dichloro phenoxy) phenol] is a broad-spectrum antibacterial biocide used widely in pharmaceutical and personal care products. It is detected in water and sediment matrices of the different aquatic systems and harming the aquatic organism. In the present study, the occurrence of triclosan was estimated from the water, sediment and organism in Versova creek and Mithi river of Mumbai using an isocratic reversed-phase HPLC. A sensitive and specific detection method for quantification of TCS in the water, sediment and organism was developed and validated according to ICH guidelines. The method was linearized (0.1-16 mg/L) and the regression equation obtained $y = 12.175x + 0.654$ ($R^2 = 0.9994$) with LOD and LOQ of 0.0001 and 0.001mg/L respectively. The estimated mean concentrations of triclosan for five-month samplings in Mithi river (water: 1.68 $\mu\text{g/L}$, sediment: 3.19 $\mu\text{g/kg}$ and organism: 0.33 mg/kg) were found to be higher than Versova creek (water: 0.49 $\mu\text{g/L}$, sediment: 0.69 $\mu\text{g/kg}$ and organism: 0.21 mg/kg). Pearson correlation and principal component analysis were used to predict the correlation of TCS concentrations to various physiochemical parameters showing a strong correlation between COD ($r=0.87$) and TOC ($r=0.46$). The environmental risk of TCS in Versova creek and Mithi river in terms of risk quotients (RQs) for different aquatic model organisms was estimated and results denoted the high risk of TCS ($RQ > 1$) in both the aquatic

environment. The bioaccumulation factor (BAF) was calculated based on the TCS level detected in water and sediment to organisms of respective aquatic bodies. In both the sampling site, the values $BAF_w > 1$ indicate TCS is bio accumulative in organisms (*Conus* sp. and *Eichhornia* sp.). The present study generates the baseline information of occurrence of TCS in two distinct aquatic system and it greatly helps in suggesting the management strategies to limit and regulate the triclosan in different products in daily use

Key words: Triclosan, Versova Creek, Mithi river, HPLC

TRPSF-FREM-P-3

Acute toxicity of 4-tert-butylphenol on *Labeo rohita* fingerlings

Sulav Mandal*, Sangram Keshari Rout, Sutanu Karmakar, Sayantan Bhattacharjee

¹Faculty of Fishery Sciences, West Bengal University of Animal and Fishery Sciences

*Corresponding author: sulavmandal03@gmail.com

Abstract

The study was carried out to investigate the impact of acute exposure of 4-tert-Butylphenol(4tBP) on behavioural and histopathological alteration of *Labeo rohita* (Hamilton, 1822). The 96 h LC₅₀ of 4-tert-Butylphenol for *Labeo rohita* was estimated to be 4.45 mg/l. The exposed fish in different treatment groups displayed distinct symptoms of toxicity during the acute toxicity test, to various degrees depending on the 4-tert-butylphenol concentration. The fish displayed excitement and unpredictable movements in the experimental tanks during the first few hours after adding the 4tBP. The rate of opercular movement of fish in the control tank was 120 + 5 beats per minute, but it was more than 160 + 8 beats per minute in the treatment tank. The fish's colour was changed to a pale yellowish hue. Huge mucus secretion, fusion of secondary gill lamella (SGL), totally damaged SGL and primary gill lamella (PGL), swelling of SGL, swelled cartilaginous core, inflammation of lamellar tip, Inflammation of cartilaginous core, abnormal direction of SGL etc. were documented during histopathological observation in gill and cell haemorrhage, minute tissue necrosis, degeneration of cell, pyknosis, vacuolation, cluster of fibroblasts etc. were observed in liver with respect to increasing concentration of 4tBP in treatment tank. With increasing anthropogenic activity, the study provides convincing evidence for the necessity of regulated use and safer disposal of 4-tert-Butylphenol to the environment.

Key words: 4-tert-Butylphenol, Toxicity, Behaviour, Exposure, Environment

TRPSF-FREM-P-4

Assessment of bavioural changes in indigenous walking catfish *Clarias magur* during acute exposure of triclosan

Debiprasad Kantal¹, Kundan Kumar¹, S.P. Shukla¹, Saurav Kumar¹, Tapas Paul²

¹Aquatic Environment and Health Management Division, ICAR-CIFE, Mumbai, 400061.

²College of Fisheries, Kishanganj, Bihar Animal Science University, Patna

*Corresponding author: debiprasad.aempb001@cife.edu.in

Abstract

Triclosan is a common antimicrobial compound found in a wide range of personal care and household products. Because of its widespread use, concerns have been expressed regarding its potential environmental effects, particularly on aquatic organisms. In this study, triclosan was evaluated for its toxicity in an indigenous commercially important freshwater catfish, *Clarias magur* and its behavioral response. Juvenile *C. magur* was exposed to 0.4, 0.8, 1.2, 1.6, and 2.0 mg L⁻¹ of triclosan solution under controlled laboratory condition. The end point toxicity of triclosan in terms of mortality of experimental fish and change in baviour of *C. magur* were evaluated. A probit analysis was performed to determine the 24, 48, and 96-hour LC₅₀ values, which were found to be 2.31, 1.44 and 1.14 mg L⁻¹, respectively. Safe levels were estimated by applying different factors to the 96-hour LC₅₀ values, resulting in a range of 0.01 to 0.11 mg L⁻¹. Observations of fish exposed to triclosan indicated significant increases in buccal movements, escaping or jumping tendency, excess mucus generation, and burst swimming movements across all concentrations tested. These behavioral changes further confirmed the toxic effects of triclosan on fish. The study concludes that triclosan is toxic to fish and recommends restrictions on its use. Overall, this research highlights the need to regulate the usage of triclosan due to its harmful impact on fish and emphasizes the importance of considering its ecological implications.

Key words: Triclosan, *Clarias magur*, LC₅₀, Safe level, Behavioral changes.

TRPSF-FREM-P-5

Assessment of coastal water colour changes in Gomezpuram water channel along Tuticorin coast, Gulf of Mannar, Southeast coast of India using in-situ and remote sensing data

Manickavasagam S*, Manimekalai D, Padmavathy P, Ponmani M, Subhashree Devasena S
TNIJFU- Fisheries College and Research Institute, Tuticorin-628008

*Corresponding author: manickavasagam@tnfu.ac.in

Abstract

This present investigation results of a preliminary study to understand and assess the water colour changes in the Gomezpuram water channel along the Tuticorin coast, Gulf of Mannar, Southeast coast of India, using in-situ and remote sensing data. In addition, the study has utilized in-situ observation and IMD gridded weather data and spectral profiles of algal pigments from the published literature. In order to verify whether the color change is a cyclic event, long-term satellite data of Landsat 8-OLI and Sentinel 2-MSI sensors from 2019 onwards were analyzed using spectral response in red and green bands. It was observed that even though a cyclic pattern exists, the colour change events occurred only during the year 2022. The present analysis showed a change in the color of the water channel from light green to pink twice during November–December 2022. Rainfall and temperature were used to identify possible causes of abiotic stress on the algae population of the water channel. The study observed light rainfall and a reduction in temperature just prior to the colour change event during November–December 2022. Though the cause of stress on the algae population is not known and is to be precisely identified by field surveys, the change in colour of the water channel appears to be caused by pigment(s), like phycoerythrin and carotenoids. As a result, there is a critical need for relevant observations and assessments of color changes in coastal waters in order to understand their taxonomic character and conserve marine ecosystems.

Key words: Water Colour Changes, Water Channel, Pigments, Water Quality Analysis, In-Situ and Remote Sensing

TRPSF-FREM-P-6

Assessment of the senility factor in an inland water body for the sudden mortality of Rohu (*Labeo rohita*): the example of a reservoir, Tuticorin, Southeast India

Manickavasagam S^{1*}, Manimekalai D¹, Sudhan C¹, Padmavathy P¹, Ponmani M¹, Subhashree Devasena S¹
¹TNIJFU- Fisheries College and Research Institute, Tuticorin-628008

*Corresponding author: manickavasagam@tnfu.ac.in

Abstract

The present study indicated that senility was a plausible reason for the sudden mortality of Rohu (*Labeo Rohita*), an inland water body in Tuticorin, Southeast India. The mortality was observed on June 9, 2022, in the inland water bodies of the reservoir surface waters. The water in the reservoir has appeared dark green and has spread across the reservoir. The water quality analysis revealed that the water is in good and permissible condition. The dead fish (Rohu) weighing between 2 and 3 kg were observed and noted for their state of condition. The reservoir is used for solar panels for electricity production. In particular, fish mortality has occurred due to old age (senility). The senility was a plausible reason for the sudden fish deaths in the reservoir during the mortality period. This observational study revealed that the sudden fish mortality occurred due to the underexploitation (2 years) of fish stocks in the reservoir. As a result, there is a critical need for partial harvesting of large-sized rohu fish from the reservoir to curtail further losses incurred, and further assessments of inland water bodies will be required in order to understand their reservoir productivity and carrying capacity.

Key words: Assessment, *Labeo rohita* (Rohu), Senility, Mortality, Reservoir

TRPSF-FREM-P-7

Biochar for sustainable aquatic environment management

Jateen Sinha¹, Tapas Paul², Saurav Kumar¹, Satya Prakash¹
¹ICAR-Central Institute of Fisheries Education, Versova, Mumbai, Maharashtra, India
²College of Fisheries, Bihar Animal Sciences University, Patna, Bihar-855107

*Corresponding author: Jateen Sinha

Abstract

Burning crops such as paddy straw has detrimental effects on environment and results in poor air quality index specially in agri-based country. Currently, waste disposal is also a huge issue globally. However, various kinds of waste materials could be used for biochar production such as paddy straw, sugarcane bagasse, banana peduncle, household waste, water hyacinth to overcome waste load. Biochar synthesized from carbon rich raw material is extremely suitable and biochar has potential of enhancing environment condition in agriculture as well as in aquaculture system.

Activation of biochar advances the latent potential of biochar in all properties such as its CEC, water holding capacity, alkalinity, electrical conductivity. Sediment quality could be dramatically improved by using biochar which eventually results in enhanced water quality such as reduction in ammonia-N value, controlling pH level in aquaculture system. Growth parameter is also Aquatic environment enhancement by using organic materials is considered to be more environmental friendly and sustainable practice.

Key words: Waste disposal, Biochar, Cation Exchange Capacity, Aquatic environment, Sustainability

TRPSF-FREM-P-8

Biology of *Mastacembelus armatus* (Lacepedae 1800) of the order Synbranchiformes from river Burhi Gandak, Bihar

Dheeraj Kumar Kashyap, Mogalekar H.S., Sahil, Adita Sharma, Pravesh Kumar, R.K. Ram, S.K. Nayak
College of Fisheries (RPCAU), Dholi, Muzaffarpur, Bihar - 843 121, India

*Corresponding author: mogalekar.hs10@gmail.com

Abstract

The research was conducted for twelve months duration from July 2019 to June 2020 to study the biology of *Mastacembelus armatus* (Lacepedae 1800) from Burhi Gandak river in Muzaffarpur and Samastipur districts of North Bihar. About 380 individual samples of *Mastacembelus armatus* were collected during the research period for biological examination. The 380 individuals comprises of 205 juveniles, 97 male and 78 female with mean size of 13.86 ± 0.65 to 27.45 ± 0.58 cm and 11.08 ± 1.49 to 52.25 ± 3.16 gm for Juvenile; 36.71 ± 0.82 to 48.73 ± 1.67 cm and 90.14 ± 4.04 to 157.88 ± 29.66 gm for male; and 40.42 ± 3.35 to 51.98 ± 1.36 cm and 96.28 ± 5.74 to 162.04 ± 10.29 gm for female were subject to biological study. The gut composition of *Mastacembelus armatus* comprises of prawn (*Macrobrachium species*), telson and uropod of prawn, chelate leg of crab, aquatic insects, chironomidae larvae, bivalve, backbone and fins of fishes, small fishes like *Pachypterus athernoides*, *Chandanama*, *Puntius terio* and *Canthophrys gongota*. The observed composition of *Mastacembelus armatus* gut showed that the fish is carnivorous feeding habit. Gastro-somatic index (GaSI) was calculated and monthly mean values of GaSI were ranged from 0.57 ± 0.12 to 6.84 ± 1.15 % for juvenile, 1.96 ± 0.29 to 12.34 ± 1.09 % for male; and 2.73 ± 0.50 to 9.89 ± 2.16 % for female. The monthly mean weight of gonad was in the range of 0.77 ± 0.14 gm (January 2020) to 2.57 ± 0.22 gm (April 2020) for male and 1.32 ± 0.18 gm (January 2020) to 7.26 ± 0.66 gm (October 2020) for female. The overall male: female ratios were 1.25:1, demonstrating slightly higher ratio than the ideal ratio. The monthly mean values of Gonado-somatic index were ranged from 0.53 ± 0.14 % (December 2019) to 2.40 ± 0.20 % (April 2020) for male and 1.37 ± 0.16 % (February 2020) to 6.32 ± 1.33 % (June 2020) for female. The maturing and spent individuals of *Mastacembelus armatus* were abundant during December 2019 to February 2020 and mature individuals found rest of the study period. The peak spawning observed during the months of October 2019, April 2020 and June 2020. The monthly mean fecundity of 78 mature females was in the range of 513.40 ± 513.40 eggs (November 2019) to 5895.63 ± 626.11 eggs (October 2019). The findings of present study could be helpful to develop breeding protocol, culture method, conservation and management of the *Mastacembelus armatus*.

Key words: Food & Feeding Habits, Sex Ratio, Gonadal Maturity, Spawning Season

TRPSF-FREM-P-9

Bioremediation of phenanthrene by *Bacillus* sp a new strain isolated from oil contaminated coastal waters of Thoothukudi, Tamil Nadu

Ponmani. M¹, Manimekalai. D², Padmavathy. P³, Parthiban. F⁴, Manickavasagam. S⁵
TNJFU- Fisheries College and Research Institute, Tuticorin-628008

*Corresponding author: ponmanimuthu1998@gmail.com

Abstract

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous in the environment and cause great environmental concern because of their persistence, toxicity and mutagenicity. PAHs are hydrophobic and readily adsorbed onto particulate matter and thus, coastal and marine waters become the ultimate sinks for such compounds. Seawater samples were collected from the fishing harbour and dry docking yard were streaked onto mineral salt medium plates enriched with phenanthrene as a hydrocarbon source. Bacterial strains were isolated from oil-contaminated coastal areas in the proximity of Thoothukudi and selected for poly-aromatic hydrocarbon (PAH) degradation. The phenanthrene utilizers in the water sample of different sites range from 4.51 to 6.7×10^4 cfu ml⁻¹ and 4.7 to 5.8×10^4 cfu ml⁻¹ respectively. The water samples were enriched with phenanthrene as a sole carbon and energy source. From the enriched cultures, several colonies of phenanthrene utilisers with distinct morphology were selected and their relevant

pure cultures were obtained. All the bacterial isolates were amplified using 16S rRNA gene universal primers 27f and 1492r. For genotyping, these isolates were subjected to ARDRA-PCR using 16S rRNA universal primers (27f and 1492r). Based on the ARDRA-PCR pattern the neighbour-joining dendrogram was constructed and grouped the isolates into two distinct clusters. They were sequenced and confirmed as 100 % similar to *Bacillus subtilis* and *B. licheniformis*. The biodegradation of phenanthrene at different concentrations (25, 50, 75, 100 mg l⁻¹) was performed over three and six days. *Bacillus subtilis* showed the highest phenanthrene degradation 81.70% in three days and 82.86% in six days at 25 mg l⁻¹. The present study shows that the indigenous microbial communities from the contaminated sites have a high potential to degrade polyaromatic hydrocarbons and gives an eco-friendly solution to the bioremediation of oil-contaminated sites.

Key words: Bioremediation, Phenanthrene, Oil, Degradation, Microbes, Polyaromatic hydrocarbon

TRPSF-FREM-P-10

Blue Growth Initiative: A Comprehensive Review of Initiatives and Work

Dipankar Das*, Mandira Paul

Department of Fisheries Resource Management, Faculty of Fishery Sciences, West Bengal University of Animal and Fisheries Science

*Corresponding author: dipzbfsc@gmail.com

Abstract

The FAO's Blue Growth Initiative (BGI) strives to develop fisheries and aquaculture sustainably while maximizing economic and social benefits and minimizing environmental degradation. Unlike conventional approaches, the BGI takes a balanced approach, addressing sustainable development's environmental, economic, and social pillars. Aligned with the 2030 agenda Sustainable Development Goals (SDGs), the BGI framework comprises three phases: creating enabling conditions, implementing targeted interventions, and mainstreaming sustainable practices. The BGI acknowledges the need to tailor its strategies to diverse realities, encompassing tropical inland fisheries to Arctic coastal countries. It underscores the importance of a comprehensive transition towards blue growth. By establishing enabling conditions within member states, the BGI lays the foundation for sustainable development in the fisheries and aquaculture sectors. Through targeted interventions, the BGI supports practical actions that tackle specific challenges and capitalize on opportunities. Collaborating closely with countries and communities, the FAO assists in implementing the BGI framework, yielding tangible benefits. The initiative revolves around three platforms of sustainable development: Blue Communities, Blue Production, and Blue Trade. Blue Communities focus on fostering community-level engagement and promoting sustainable practices. By empowering communities, the BGI encourages active involvement in decision-making processes and the adoption of sustainable fishing and aquaculture techniques. Blue Production advocates responsible practices throughout the value chain. It encompasses initiatives to enhance resource management, improve aquaculture techniques, and mitigate waste and pollution. The BGI strives to optimize production while safeguarding marine ecosystems through innovation and knowledge sharing. Blue Trade ensures the sustainable and equitable trade of fisheries and aquaculture products. This entails promoting fair market access, combating illegal fishing, and strengthening traceability and certification systems. The BGI aims to establish a transparent and responsible trade environment by addressing trade-related challenges. In conclusion, the FAO's Blue Growth Initiative (BGI) presents a comprehensive model for the sustainable development of fisheries and aquaculture. Aligned with the 2030 agenda SDGs, it emphasizes a balanced approach encompassing environmental, economic, and social dimensions. The BGI framework, composed of three phases, offers flexibility and adaptability to different realities. Through targeted interventions and the platforms of Blue Communities, Blue Production, and Blue Trade, the BGI seeks to maximize benefits while minimizing environmental impact.

Key words: FAO, Blue Growth Initiative, Sustainable Development, Fisheries.

TRPSF-FREM-P-11

Breeding of indigenous ornamental fish *Dawkinsia apsara* (Apsara barb) under captive condition

Gokul S¹, S Nanda^{2*}, Venkatesh¹, Velmurugan A¹

¹ICAR-Central Institute of Fisheries Education, Mumbai, 400061

²College of fisheries OUAT, Rangeilunda, Odisha – 07

*Corresponding author: saumyendrananda63@gmail.com

Abstract

The 80 days study was conducted to examine the effectiveness of breeding performance of indigenous ornamental fish *D.apsara* while using Wova FH inducing hormone where most widely used in the finfish hatcheries. *Dawkinsia apsara* is most beautiful indigenous ornamental fish in group of dawkinsia and ornamental trade, it only found in the Sita river and the Sowparnika river of the Western Ghats, Karnataka, India. The breeding of apsara barb fish in captive condition done in college of fisheries OUAT, Rangeilunda, Odisha. Here, the breeding experimental done in 50L capacity 10 glass tanks (9 tanks hormone + 1 as natural breeding) fitted with KMnO₄ treated hydrilla plant as egg collector because they are semi adhesive egg scatters in nature. In experimental design T₀ as a control, others 0.3ml/kg

(T₁), 0.5ml/kg (T₂) and 0.7ml/kg (T₃) Wova FH hormones. Male brooders and female weighted and injected with different doses of hormone at intramuscularly. After release into the breeding tank as per the dose with sex ratio 2:1 (M:F). At 8- 12hrs of latency period eggs are release into tank about 0.96 - 1.08 mm (0.93±0.02 mm), after that parents are removed from the tank and eggs are incubated tank itself with heavy aeration. The less latency period, good spawning rate, fertilization rate, hatching rate, and incubation period for (T₃) were observed to be 8.1±0.15hrs, 1323.6±9.9, 90.6±1.9 (%), 90.0±2.5 (%) and 31.7±0.20 hrs respectively, while injection of WOVA FH hormone at 0.7ml/kg female and 0.3ml/kg of male dose. About 32.5-33.3hrs at 27- 28°C of incubation period eggs are hatch out around 1.3mm length with heavy yolk sac in under the abdomen region. The hatchlings are turn into spawn after 72hrs, at this stage yolk sac are fully absorbed.

Key words: *D. apsara*, Wova FH, Induced Breeding, Sex Ratio.

TRPSF-FREM-P-12

Can Tamil Nadu Sustain Fisheries Growth? Insights from Long Term Trend Analysis

Shwetha Tony A*, Ananthan P.S.

ICAR-Central Institute of fisheries Education, Mumbai-400061, Maharashtra, India

*Corresponding author: shwetha.fexmb108@cife.edu.in

Abstract

The fisheries sector plays a vital part in the country's socioeconomic development. It has gained recognition as a potent source of income and employment since it fosters the expansion of several subsidiary sectors and provides access to affordable, wholesome food in addition to earning foreign exchange. The present analysis was undertaken to examine the structure of growth and export performance in Tamil Nadu fisheries over the period of 40 years using compound Annual Growth rate (CAGR) and Cuddy Della Valle Instability Index (CDVII). The findings revealed that the growth rate of marine, inland and total fish production (2.04%, 1.48%, 1.83%) was positive during the last 40 years. The decadal analysis indicated positive growth in marine sector during all the four decades while negative growth in inland fish production was seen during 1981-91 (-9.82%) and 2011-2021 (-1.62%). This has also meant relatively stable marine sector (CDVII of 6.56) as compared to the inconstant and unstable inland sector (CDVII of 25.49). Interestingly, Tamil Nadu bucked the national trend in marine fish catch during 2011-21 as its growth rate (3.47% CAGR) was almost thrice that of the country average of 1.2% CAGR. This indicates increasing capitalisation in marine fisheries of Tamil Nadu post-Tsunami (since 2005). On the other hand, her inland fish production growth was negative (-1.62%) in contrast to India's phenomenal growth (9.02%) during 2011-2021, for reasons yet to be ascertained. Fish exports from Tamil Nadu increased from 4,833 tonnes in 1981-82 to 1,10,022 tonnes in 2020-21, registering an impressive CAGR of 6.86% and a moderate instability index score of 15.14. The study further focuses on the relationship between production and export over the time period and the trend in export value realisation. It also compares and contrasts the growth trends in fisheries with those in livestock and crops in order to draw conclusions and similarities. With the dual goals of maintaining the progress gained in marine fisheries and concentrating on new growth areas, the study highlights the necessity to justify the allocation of limited budgetary and human resources by identifying viable areas for future growth.

Key words: Fisheries, Tamil Nadu, Fish Production, Export, Growth, Instability

TRPSF-FREM-P-13

Climate Change and It's Biological and Economic Effect on Marine Fisheries

Supratim Malla, Rupanjan Paul

College of Fisheries (Central Agricultural University, Imphal), Lembucherra, Agartala, Tripura – 799210

*Corresponding author: supratimsukla1998@gmail.com

Abstract

Ocean warming over the long term is a crucial indicator of past and present state of the climate. Due to various anthropogenic activities, there has been an increase in the concentration of greenhouse gases in the atmosphere, which traps the reflecting solar radiation resulting in Earth's Energy Imbalance. An increase of 1.5°C due to global warming in the near future, will cause unavoidable increases in multiple climate hazards and present multiple risks to ecosystems and humans. One of the major pieces of evidence on climate change in marine fisheries is the range shift of various species in response to various oceanographic parameters, especially "Climate velocity". Differences in the climate velocity help to predict the magnitude of the species shifts than variation in life histories. Often, tropical fishes tend to move towards new habitats in higher latitudes, i.e., pole-ward shift demonstrating the likelihood of cooler temperature. Pelagic fishes with larger body sizes and greater swimming capabilities have a high success rate of colonizing higher latitudes. Further, recent phenological changes in fish in relation to global warming are increasing at an alarming rate. Fisheries stock size might increase in future due to the latitudinal shifts due to an increase in growth rates with the

corresponding redistribution. Marine fisheries support the livelihood of more than 10% of the world's population, with a total average revenue of USD 100 billion every year. Climate-induced resource flows can substantially affect the livelihood of the fishermen. Species distribution shifts towards the cooler temperature and consistent changes in ocean productivity will reduce the maximum catch potential in the tropics. This will have large implications for the fishermen who depend on it for food and income; it will, in turn, affect the global economy. Due to climate change, there will be a loss of USD 10 billion by 2050. Climate change will affect the fishermen in different ways viz increasing bad weather, reduced fishing days, loss of fishing equipment and boats, loss of revenue etc. Due to the possible expansion and shifts in the distribution of the species, the fishermen need to replace the gear and to be refitted to catch the new target species. Further, variable costs in the fishing sector will be affected by climate change. The fishermen must travel a long distance to reach the desirable fishing ground, increasing the time and fuel spent on fishing.

Key words: Ocean, Climate, Fish

TRPSF-FREM-P-14

Cold Plasma Technology: A New Way of Bioremediation

Kurapati Nagendrasai

ICAR-Central Institute of Fisheries Education, Mumbai, 400061

*Corresponding author: kurapati.aemmb104@cife.edu.in

Abstract

Wastewater and contaminated soil treatment has become a stressful and difficult issue for societies as a result of the high levels of hazardous substances found in landfills and drinking water that are brought on by increasing industrialization and the widespread use of chemicals. In current treatment facilities, the removal of pollutants from soil and wastewater is frequently insufficient, especially with regard to complex organic molecules. Cold plasma is viewed as a promising remediation technique due to its compatibility with the environment, high contamination removal, and great energy efficiency of the process. To that purpose, several attempts have been documented describing the development of various plasma remediation systems by painstakingly and from diverse angles looking at different reactor layouts, plasma discharge types created inside or outside contaminated medium, in the presence or absence of catalysts, etc. A perfect setup can be established by simply designing and taking into account all relevant factors. The study outlines a thorough description of the application of this technology in the field of wastewater treatment to address concerns about the degradation of several aqueous contaminants and water-borne pathogenic microorganisms, including viruses, to a significant level. This seeks to give academics a clearer comprehension of the various features of cold plasma as remediation technology by looking forward to the key-role steps required for its industrial implementation.

Key Words: Cold Plasma, Wastewater treatment, Remediation.

TRPSF-FREM-P-15

Comparative study of the impact of temperature and salinity on growth of centric and pennate diatoms

Swati Choudhary, Geetanjali Deshmukhe*, Tejaswini P. Karale, Shashi Bhushan, Karan Kumar Ramteke, B B Nayak, S P Shukla

Department of Fisheries Resource Management, ICAR-Central Institute of Fisheries Education, Mumbai, Maharashtra-400061

*Corresponding author: dgeetanjali@gmail.com

Abstract

Microalgae are considered very important in aquaculture industry as they act as feed for many fishes. The growth of microalgae is dependent on various environmental variables such as temperature, salinity, pH, light and nutrients. For optimization of growth of microalgae, optimum temperature and salinity conditions should be maintained. Moreover, the microalgal species withstanding salinity stress and showing good growth rates are considered to have an advantage over other species. Two diatom species, one centric (*Cyclotella* sp.) and one pennate (*Navicula* sp.), were selected for the experiment on growth. These diatoms were exposed to three temperatures (24° C, 27° C and 30° C) and three salinities (15 ppt, 25 ppt and 35 ppt) combinations for a period of 10 days. The initial and final number of cells were counted in the Sedgewick rafter cell. The average daily growth rates were calculated and statistical analysis was done by two-way ANOVA to assess the impact of temperature and salinity on growth of these diatoms. The results indicated that the effect of salinity on these diatoms was more pronounced than the effect of temperature. *Navicula* sp. showed better growth in varying temperature and salinity conditions. *Cyclotella* sp. showed good growth in lesser salinities indicating that freshwater is more favourable for its growth. This concludes that pennate diatoms are more adapted to change in environmental conditions and can show a good growth even outside their favourable range of temperature and salinities. Therefore, it is economically feasible to prefer pennate diatoms for feedstock in aquaculture practices.

Key words: Diatoms, Growth, Temperature, Salinity, Centric, Pennate

TRPSF-FREM-P-16

Decolourization potential of freshwater green alga *Chlorella vulgaris* (Beijerinck, 1890) on azo dye (RB-5)

Bhautik D. Savaliya, Rathi Bhuvaneswari. G*, S.P. Shukla, Vidya Shree Bharti, K.A.Martin Xavier
ICAR-Central Institute of Fisheries Education, Mumbai, India-400061
*Corresponding author: rathi@icar.gov.in

Abstract

The present study investigated the efficiency of the green alga *C. vulgaris* to decolourize the synthetic azo dye, Reactive Black 5 (RB-5), which is widely used in cosmetics, printing, pharmaceuticals, textiles, pulp mills, paper, and food industries. After 96 hours of acute toxicity experiment, the median inhibitory concentration (96h IC₅₀) was found to be 25.23 mg L⁻¹. An optimization experiment on decolourization of RB-5 was carried out initially to optimize variables like number of algal cells/mL, pH and temperature in a batch culture system with a standard dye concentration. The optimum decolourization was found at 95 lakh cells/mL algal cell density, pH 8, and temperature 35°C, which was chosen for further study. Later, experiment was conducted with six different concentrations of RB-5 below IC₅₀ value (0.1, 1, 5, 10, 20, and 25 mg L⁻¹) for 21 days to study decolourization. Simultaneously, one biotic control (culture inoculated medium devoid of dye) and another abiotic control (medium with RB-5 below IC₅₀ value 0.1, 1, 5, 10, 20, and 25 mg L⁻¹ without algal inoculation) were also incubated. RB-5 decolourization was assessed using UV-Vis spectrophotometer with a gradual decrease in absorbance at 597 nm (λ_{max}). The maximum percentage of decolourization (98.70%) of RB-5 was achieved at 0.1 mg L⁻¹ concentration at 21 days. *C. vulgaris* effectively decolourized 0.5, 1, 5, 10, 20, and 25 mg L⁻¹ concentrations by 98.70%, 92.91%, 90.76%, 79.50%, 73.91%, and 69.09%, respectively, at the end of 21 days experiment. The contact time and initial dye concentrations were found to be the important factors impacting decolourization. The results revealed that the biological decolourization efficiency decreased with increased RB-5 concentration. The data and observations of the study provide baseline data about the potential of the green alga *C. vulgaris* for the remediation of the RB-5 dye in dye-contaminated wastewater.

Key words: Decolourization, Azo dye, Reactive Black 5, UV-Vis spectrophotometer.

TRPSF-FREM-P-17

Diet characteristics and ingestion of microplastics in creek-associated fishes of the Eastern Arabian Sea

Abhijit Mallik*, Shashi Bhushan
ICAR-Central Institute of Fisheries Education, Mumbai, India-400061
*Corresponding author: abhijit.frmpa902@cife.edu.in

Abstract

In the present study, we aimed to evaluate the diet composition and microplastic ingestion by fishes collected from the selected creek area of the eastern Arabian sea. This study examined the feeding biology of some commonly available fish species, characterized by the Vacuity index (VI); Diet breadth (Bi); Trophic level (TrL); Average number of food types (AF), and Index of preponderance (%IOP) of prey. A total of 1192 fish samples were collected monthly from December 2021 to February 2023 and were used for gut content analysis. It was found that the most preferable prey item is shrimps (26.23%) followed by algae (12%), fish (11.39%), and zooplankton (10.23%). Whereas microplastics contribute 4.83% of the total diet composition of the selected fishes. The color, size range, and polymer types of MPs in the gut of fishes were dominated by black fragments, 100-200µm, and polypropylene respectively. We also observed the presence of MPs in the liver ($1.75 \pm 0.47\mu\text{m}$) and gonads ($0.90 \pm 0.47\mu\text{m}$) of the selected fish samples.

Key words: Feeding habits, Microplastics, Hazard, Fish health and Polymer.

TRPSF-FREM-P-18

Diversity of freshwater catfishes (Teleosti: Siluriformes) in selected river systems of Maharashtra

Vineeth P, Karankumar K Ramteke, Dayal Devdas, A K Jaiswar*
ICAR-Central Institute of Fisheries Education, Mumbai, India-400061
*Corresponding author: akjaiswar@cife.edu.in

Abstract

Catfishes of the order Siluriformes are the important fishes in the inland areas contributing to the commercial catches all over India and in Maharashtra. Less attempts were made to study the diversity of catfishes from river systems of Maharashtra. A study was attempted to study the diversity of catfishes inhabiting selected river systems such as the Ulhas river, Kalundre river, Savitri river, Ghod river, and Godavari river of Maharashtra. During the study, a total of

nine species, belonging to five genera and three families, were recorded from different places such as Panvel, Bhiwandi, Poladpur, Roha, Mahad, Ambegaon, and Nashik. A comparative taxonomic study based on morphology, morphometric and meristic traits, was conducted on the nine species. A total of 20 morphometric and 7 meristic traits were recorded from the observed specimen. In catfishes, the largest otolith is known to be lapillus which is less studied and was observed to vary among species with the morphological features like rostrum, posterior, anterior, excisura, and margins showing variation among 9 species under five genera. The genera *Mystus* has been found to have kidney shaped otoliths, whereas in others, it is elliptical to oblong. During the study, Mitochondrial COI gene were amplified and the sequences were generated for 11 specimens of 8 species belonging to 5 genera. The highest and lowest divergent percentage was shown in genus *Heteropneustes* and lowest in *Ompok* respectively. A neighbor-joining tree was constructed with distinct clusters by using the K₂P model. The study suggests for a more detailed study on assessing the diversity of catfishes, needed for the conservation and sustainable management of catfishes in Maharashtra.

Key words: Siluriformes, Maharashtra, Mitochondrial COI

TRPSF-FREM-P-19

Effect of Chlorpyrifos Organophosphate Insecticide on Fingerlings of Common Carp (*Cyprinus Carpio*)

Kamalesh Panda*, Suchita Suresh Paunikar, Kalpana Chandravanshi, Manoj Kumar, Milap Singh, Manorama Soni, J.K. Jakhar, Sarita Kumari Das

Late Shri Punaram Nishad College of Fisheries, Kawardha, Dau Shri Vasudev Chandrakar Kamdbenu Vishwavidyalaya, Durg (C.G.)

*Corresponding author: kamalesh.panda@gmail.com

Abstract

The risks that agricultural pesticides provide to animals that are not their targets, particularly fish, are crucial. These insecticides interfere with physiological balances to affect metabolism at very low concentrations. The objective of the current experiment was to ascertain the acute toxicity of chlorpyrifos on haematological and behavioural traits of *Cyprinus carpio*, a freshwater fish. Using varying dosages of chlorpyrifos to the fish fingerlings, short-term acute toxicity studies were carried out using the renewal bioassay approach over a period of 96 hours. Fish fingerlings were exposed to sublethal concentrations of chlorpyrifos sublethal I (SL-I, 1/5th of LC₅₀ 1.5 mg/L) and sublethal II (SL-II, 1/10th of LC₅₀ 0.75mg/L) for 48 hours and 96 hours. The 96 hr LC₅₀ value was found to be 0.5 ppm. For haematological responses of common carp were recorded in the fish exposed to sub lethal concentrations, 1/5th LC₅₀ and 1/10th LC₅₀ of Chlorpyrifos for a period of 96 hours for accumulation phase. Parameters like Red blood cell (RBC) count, haemoglobin (Hb) content, Packed Cell Volume (PCV), and haematocrit (Hct) showed a substantial decline, although a rise in WBC count was observed with a steady increase in pesticide dose. When compared to the control, Mean Corpuscular Volume (MCV) was showing an increasing tendency. Other red blood cell indices, such as Mean Corpuscular Haemoglobin (MCH) and Mean Corpuscular Haemoglobin Concentration (MCHC), also exhibited considerable decline. These morphological and behavioural changes brought on by chlorpyrifos may cause serious physiological issues and, eventually, fish mortality. Therefore, suitable guidelines may be issued to regulate these agricultural insecticides for a sustainable environment.

Key words: Chlorpyrifos, Common Carp, Growth Rate, Hematological parameters

TRPSF-FREM-P-20

Emerging threats of climate change and adaptation of aquaculture

Qurratul An Qureshi, Tejpal Dahiya

College of fisheries Science, Chaudhary Charan Singh Haryana Agricultural University, Haryana, - 125004

*Corresponding author: Qurratulain2207@gmail.com

Abstract

Fisheries and aquaculture make a crucial contribution to global food security, nutrition and livelihoods. In agriculture, there is evidence of crops already being impacted due to warming temperatures and shifts in precipitation, with yields predicted to decline, particularly for nations in lower latitudes. In wild fisheries, reduction in productivity and distributional shifts of some stocks have been reported and are expected to continue in the absence of fisheries management and climate change mitigation. In general, average warming conditions could increase growth for some species, which, if food is not limited, could result in greater productivity. However, temperature extremes, not average conditions, can challenge such positive growth due to thermal stress. In addition, many stressors co-occur, likely making conditions more challenging. Species cultivated in different aquatic environments have to contend with an array of other anthropogenic climate-change related stressors, including ocean acidification, harmful algal blooms, hypoxia, sea level rise, as well as changes to average rates of precipitation. In addition, threats of disease and invasive species, induced by direct climate change effects, also impact aquaculture. Disease outbreaks are presently one of the largest threats to aquaculture and are likely to be exacerbated by climate change, but by how much and when remains challenging to predict. While all of these aspects can impact aquaculture, the relative importance and occurrence of stressors to specific regions is still being uncovered. Food production is one of the main contributors to climate change, but is also vulnerable to the resulting stressors, which is well documented for agriculture and fisheries.

Key words: Aquaculture, Climate change, Aquatic environment, Warming Temperatures.

TRPSF-FREM-P-21

Estimation of Maximum Sustainable Yield of Hilsa Shad along West Bengal Coast Using Relative Response Model

Samiran Mukherjee^{1*}, Nagesh Talagunda Srinivasan²

¹ICAR-Central Institute of Fisheries Education, Mumbai, Maharashtra, India

²West Bengal University of Animal and Fishery Sciences, Kolkata, West Bengal, India

*Corresponding author: samiranmukherjee1999@gmail.com

Abstract

The hilsa shad, *Tenualosa ilisha* is an important source of nutrition and income for local people of West Bengal having significant cultural and religious significance in the region. West Bengal is the leading state in India that supports large-scale hilsa fishery, which is largely confined to downstream of the Farakka Barrage. The study investigated the trend in average catch using four-year moving averages and estimated the Maximum Sustainable Yield (MSY) using relative response model of hilsa shad in West Bengal coast. Hilsa catch data were collected from the reports of Department of Fisheries, Government of West Bengal and ICAR-CIFRI during 1994-2018, which were used as inputs for the relative response model. The model implies that removing more fish in a single year results in higher growth in the remaining pool. The statistics showed a dramatic spike in landings soon after 1989, which could be attributed to the state's large-scale modernization of fishing gear. However, there was a continuous fall in landings after 2001, which could be attributed to resource overfishing throughout the post-modernization period. Moving average production was highest (67912.325 tonnes) during 1998 to 2002 and lowest (16810.5 tonnes) during 2014-2018. The variations in hilsa catch were related mostly to hydrological variables influencing breeding migration and recruitment of the species. The estimated MSY was found to be 36,535.86 tonnes (1994-2018) and 20291.34 tonnes (2004-2018) indicating that hilsa shad is overfished and fishery is unsustainable in nature. The study emphasized the necessity of sustainable fishing practices as well as the need for appropriate management techniques to preserve the long-term viability of the State's hilsa fishery.

Key words: Hilsa, Maximum Sustainable Yield, Relative Response Model, Moving Average, Bay of Bengal, West Bengal Coast

TRPSF-FREM-P-22

Evaluation of Different Agro-Waste-based Biochar For Remediation of Oxybenzone, A Toxicant to Corals

Shamika Shantaram Sawant¹, Vidya Shree Bharti^{*1}, Satya Prakash Shukla¹, Kundan Kumar¹, Rathi Bhuvaneswari G²

¹ICAR- Central Institute of Fisheries Education, Mumbai, India- 400061

²ICAR- Central Marine Fisheries Research Institute, Thiruvananthapuram, Kerala- 695521

*Corresponding author: vsbharti@cife.edu.in

Abstract

Oxybenzone (OBZ) is an organic UV filter mostly used in Personal Care Products and is regarded as an Emerging Contaminant. It has a widespread occurrence in all environmental matrices and is toxic to humans and aquatic organisms, including corals. Hence, it needs to be remediated. Biochar is a porous, solid material made by thermochemically converting waste biomass in an oxygen-depleted or anaerobic atmosphere; which has proven applications in wastewater treatment. The present study evaluated the remediation potential of biochar prepared from different agro-wastes and temperatures against OBZ. 12 different types of biochar were studied and sugarcane bagasse biochar prepared at 400°C showed maximum removal of $52.24 \pm 0.19\%$. Further, removal at varying biochar dosages was studied and 0.1% biochar dosage yielded the best result. The reaction followed 2nd order kinetics and best fitted to the Freundlich isotherm model, which suggests multilayer adsorption of OBZ to the biochar. The major mechanism of adsorption by biochar is estimated to be cation exchange and pore-filling. Thus, sugarcane bagasse biochar is a cost-effective solution for the remediation of oxybenzone in wastewater treatment plants.

Key words: Oxybenzone, Emerging contaminant, Agro-waste, Biochar, Remediation

TRPSF-FREM-P-23

Exploring the Ichthyofaunal Diversity in Navegaon Bandh Reservoir

Komal Nandagawali, Karankumar Ramteke*, Asha Landge, Binaya Nayak, Prashant Telvekar, Tejaswini Karale
ICAR-Central Institute of Fisheries Education, Mumbai-400061, Maharashtra, India.

*Corresponding author: karankumar@cife.edu.in

Abstract

The Navegaon Bandh Reservoir is a prominent water body located in Maharashtra, India. As an important aquatic ecosystem, it plays a crucial role in supporting the local biodiversity, particularly the ichthyofaunal community. The assessment of ichthyofaunal diversity in the Navegaon Bandh Reservoir has garnered significant attention among researchers and conservationists due to its ecological significance and potential impacts of anthropogenic activities. The study employed a combination of sampling methods to comprehensively document the fish species present in the reservoir. Preliminary results revealed a rich and diverse fish community in the Navegaon Bandh Reservoir, with a total of 41 species belonging to 16 families identified. Additionally, several economically important and endemic fish species were also observed, highlighting the reservoir's ecological and conservation value. The study further analyzed various ecological parameters such as species richness, abundance, and diversity indices to assess the overall health and stability of the fish community. The findings of this assessment will provide valuable insights for the conservation and management of the Navegaon Bandh Reservoir. The information gathered will aid in developing effective strategies to protect the existing fish populations, enhance biodiversity conservation efforts, and ensure the sustainable use of this vital aquatic ecosystem. In conclusion, the assessment of ichthyofaunal diversity in the Navegaon Bandh Reservoir highlights its ecological significance and provides crucial baseline data for future monitoring and conservation initiatives.

Key words: Aquatic ecosystem, Ichthyofaunal Diversity, Navegaon Bandh, Reservoir

TRPSF-FREM-P-24

Feeding habits and trophic structure of fishes of Manori Creek, Mumbai, Maharashtra

Rajarshi Bandyopadhyay*, Shashi Bhushan, Karankumar K. Ramteke, Shobha Rawat, Vidhya V.
ICAR- Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai-400061, India

*Corresponding author: rajarshi.frmmb108@cife.edu.in

Abstract

Manori creek is an important tidal creek of the Mumbai coast with Dahisar river meeting it up from the north. It creates a profitable fishing area, and numerous fishermen operate dol nets across the stretch. It serves as a crucial breeding and feeding habitat for a variety of species. Fishes of all the groups were collected from the landing centre the creek on weekly basis. Following the appropriate methodology, the digestive tracts of about 35 different fish species were examined wherein, most of the fishes were classified as omnivores, followed by carnivores, and then planktivores. The estuary was discovered to be dominated primarily by juveniles. It was discovered that the type of food items and their relative fullness varied amongst fish species. A slight monthly variation in the diet of a selected group of fishes was observed, but no significant differences were found. The majority of the fishes were found to be specialised feeders, and they were classified into four trophic guilds: piscivores, crustacivores, benthivores, and planktivores. *Acetes* forms the primary food component of around 40% of the fish species sampled. While around 30% of the sampled fishes were found to have digested matter. *Acetes* and juvenile penaeids, showed highest frequency of occurrence in stomachs, supporting crustacivore guilds with a higher proportion of diet generalists. For planktivores, the diatoms constituted the majority around 89 % of all planktivores followed by detritus matter and macrophytes. The findings will be critical in comprehending the system's complicated ecology.

Key words: Trophic Guild, Manori, Juveniles

TRPSF-FREM-P-25

Morphometric relationship between Fish and Otolith of *Puntius sophore* as index for environmental conditions in the Ganga and Punpun rivers of Bihar, India

Jaspreet Singh, S K Ahirwal, Tarkeshwar Kumar, Vivekanand Bharti, S M Raut, Kamal Sarma
Division of Livestock and Fisheries Management, ICAR Research Complex for Eastern Region, ICAR Parisar road, P.O. Bihar
Veterinary College, Patna- 800014, Bihar, India

*Corresponding author: Jaspreet Singh

Abstract

The current study was meant to ascertain the relationship between the fish and otolith morphometry of the economically and nutritionally significant 'Pool barb' *Puntius sophore* (Hamilton, 1822). During the period from September 2021 to March 2022, a total of 266 fish specimens were collected monthly from the rivers Ganga and

Punpun in the Indian state of Bihar. Several morphometric traits of fish were analysed in the present study. These included length-weight relationships (LWRs), frequency distributions of length, condition variables, and otolith aspect ratios. This species' length ranged between 5.57 cm to 11.17 cm, and its weight was ranged from 1.18 g to 18.98 g. According to the LWRs and condition factors, the conditions in both rivers were optimal for the development of this species. The *b* value for the Ganga samples was 3.20, while Punpun was 3.17. The coefficient of determination (R^2), for total fish length and otolith weight was calculated to be 0.942, and the coefficient of determination for fish length and otolith length was calculated to be 0.90. All of these connections are quite significant, and they can be used to manage fisheries. In addition, they will be useful for future research on food-feeding, stock structure, environmental change, and resource conservation including time series studies.

Key words: Otolith, Ganga River

TRPSF-FREM-P-26

Fish Assemblage Structure of Diversity in A Saroda Reservoir in Chhattisgarh

Sarita Kumari Das^{1*}, Kamalesh Panda², Niranjana Sarang²

¹Department of Fisheries Resource Management, Faculty of Fishery Sciences, WBUAFS, Kolkata-700094

²College of Fisheries (DSVCKV), Kawardha, Chhattisgarh - 491995

*Corresponding author: mita.saritadas@gmail.com

Abstract

It is essential to understand ichthyofaunal diversity in order to maintain a healthy aquatic ecosystem and create efficient conservation plans. The current study was conducted from March 2017 to February 2018 to examine the ichthyofaunal diversity of the Saroda reservoir, the small reservoir, which is situated in the Kawardha district of the state of Chhattisgarh. Fish samples were taken every month, and the fish community's structure was examined in terms of species composition, abundance, trophic guild, and conservation status. Pre-monsoon, monsoon, and post-monsoon seasons of the reservoir were studied for seasonal fish diversity using Shannon's diversity index, evenness index, and species richness index. All of these indices did demonstrate a meaningful distinction between and within the groups. The results of the study showed that the post-monsoon season was the most varied. 15 fish species in total were identified during the study period, with the Cyprinidae family making the largest contribution. The majority of the trophic guild's fish species were carnivorous, then planktivores. On the IUCN Red List, four fish species were discovered to be listed as Near Threatened. The reservoir's diverse fish population supports multispecies fishing and gives many local fishermen a source of income. According to the study, fish habitats should be protected in order to preserve their diversity and long-term ecological aspects.

Key words: Saroda Reservoir, Ichthyofaunal diversity, Trophic guild, Conservation.

TRPSF-FREM-P-27

FTIR and SEM Study of the Effect of Polystyrene Nanoplastics on Green Microalgae

Pritam Sarkar¹, Rathi Bhuvaneswari G^{2*}, SP Shukla¹, Martin Xavier³

¹Aquatic Environmental Management, ICAR-Central Institute of Fisheries Education, Mumbai

²Mariculture Division, ICAR-Central Marine Fisheries Research Institute, Kochi

³Post-Harvest Technology, ICAR-Central Institute of Fisheries Education, Mumbai

*Corresponding author: rathi@icar.gov.in

Abstract

There has been an explosion of global demand for plastics because of their versatility, stability, light weight, and low production costs. But unfortunately, after the intended use, these plastics finally end up into the environment. In all the environmental compartments, due to various environmental forces, the larger plastics get fragmented into smaller sized microplastics (MPs) (<5mm) and nanoplastics (NPs) (<1 μ m or <0.1 μ m). Eventually the adverse effect of these tiny particles on the various aquatic organisms have been reported. The aim of the present study is to evaluate the effect of polystyrene nanoplastics (PS NPs) on two types of microalgae viz. *Chlorella vulgaris* and *Spirulina platensis*. In this study sophisticated analytical tools such as Stereo microscopes, Fourier transform infrared (FTIR) spectroscopy and Scanning electron microscope (SEM) were used to determine the morphological and bio functional changes in the microalgae. Following the OECD guideline, a 96-hour toxicity study was conducted and 40.12% and 42.57% growth inhibition was recorded in *C. vulgaris* and *S. Platensis* respectively at 100 mg L⁻¹ PS NPs treatment. Under SEM it was observed that the control algae cells were normal, spherical (*Chlorella*), filamentous (*Spirulina*) in shape & remained compact, typical characteristics of healthy microalgae. In contrast, 100 mg L⁻¹ PS NPs treated algae were slightly deformed with uneven and grainy surfaces. In addition, nanoplastics were found adhered to the algal surfaces. This adhesion not only disrupts the functioning of the algal cells but can also harm the natural predator of algae, i.e., zooplankton. Further it may transfer via the food chain, which will ultimately affect fish. The FTIR analysis was done for PS NPs, control cells, 10 mg L⁻¹ treated cells and 100 mg L⁻¹ treated cells. The results of the FTIR study indicated that there were noticeable differences in the FTIR spectra between the control and both treatments of microalgae. The

microalgal spectra revealed that one new peak has arrived at 698 cm^{-1} for both the algae, which was the PS NPs characteristic peak. The peak was prominent in the 100 mg L^{-1} treated group whereas the peak was absent in the control group. This indicated that at 100 mg L^{-1} treatment, there is an interaction of PS NPs with the microalgae. This result is also supported by our previous SEM result, where NPs were visualized at the surface of the microalgae. In addition, several vibrations and stretching were observed in the spectra of PS NPs treatments. This indicated the alteration in the major functional groups of algae under nanoplastics treatment.

Key words: Microplastics, Nanoplastics, Microalgae, SEM, FTIR

TRPSF-FREM-P-28

Genetic Diversity Analysis of Giant River Catfish, *Sperata seenghala* using mitochondrial COI marker in River Sutlej, Punjab

Supreet Kaur, Grishma Tewari, Anuj Tyagi, Prabjeet Singh, S N Datta

Department of Fisheries Resource Management, College of Fisheries, GADVASU, Ludhiana – 141 004, India

*Corresponding author: grishmatewari@gadvasu.in

Abstract

The present study was conducted to characterize the basic genetic stock structure of *Sperata seenghala* from river Sutlej in Punjab (India). *S. seenghala* is one of the major commercial fishes captured from river Sutlej with high consumer demand. Furthermore, its aquaculture technology has not yet been commercially developed and the demand for this catfish is entirely reliant on natural resources. In view of that, assessment of genetic diversity status of the said species is of utmost importance for its sustainable production. Caudal fin clips from the specimen of *S. seenghala* were collected from landing centres / fish markets representing catch from upstream, midstream and downstream stretches of river Sutlej. Further the DNA extraction, amplification and sequencing was performed and data was analysed using different Bioinformatics software. The mt-DNA marker i.e. Cytochrome C Oxidase subunit I (COI) revealed the genetic stock structure of *S. seenghala* from river Sutlej. A total of 26 numbers of raw COI sequences obtained by Sanger sequencing showed nine haplotypes with haplotype diversity (Hd) as 0.625 indicated that stock of *S. seenghala* is moderately genetically diversified. Higher nucleotide diversity values (0.021) revealed more differences between haplotypes in *S. seenghala* population. The phylogenetic analysis revealed that all COI sequences from Sutlej stock were clustered in one clade showing the monophyletic origin of species. The Kimura 2 parameter model (K2P) depicted less intra-population genetic distance (0.00 to 0.107) in *S. seenghala* from Sutlej while slightly higher distance (0.002-1.185) from other geographically isolated populations (sequences obtained from NCBI). The COI marker used in present study confirmed its robustness in species identification. The genetic diversity parameters employed in present study indicated that seenghala population is genetically diverse at moderate level in Sutlej. To maintain the larger effective population size of species, the measures of reduced fishing efforts, mesh size regulation, closed season along with awareness program for fishers is needed for sustainable production of *S. seenghala* stock from Sutlej.

Key words: Genetic Diversity, Mitochondrial COI, *Sperata seenghala*, River Sutlej

TRPSF-FREM-P-29

High Proliferation of Gelatinous Zooplankton in the Shrimp Culture Coastal Ponds along the Northern Maharashtra, India

Naga Kalpitha Shree N N¹, Nayak B B¹, Asha T Landge^{1*}, Karankumar Ramteke¹, Ramkumar S², Tarachand Kumawat³, Abuthagir Ibrahim S¹

¹ICAR- Central Institute of Fisheries Education, Mumbai

²ICAR- Central Marine Fisheries Research Institute, Mumbai

³ICAR- National Bureau of Fish Genetic Resources, Lucknow

*Corresponding author: Asha T Landge

Abstract

Aquaculture is the fastest-growing food-producing sector globally. Jellyfish are causing detrimental interactions with aquaculture systems as coastal aquaculture expands. The present study investigated the gelatinous zooplankton in the shrimp culture coastal ponds along the northern region of Maharashtra from October 2022 to December 2023. The study revealed that a high proliferation of *Tripedalia cystophora* (mangrove box jellyfish), *Blackfordia* sp., *Turritopsis* sp. (immortal jellyfish), and *Pleruobranchia pileus* (sea gooseberry) in coastal shrimp culture ponds of *Penaesuvannamei*, affecting the growth of shrimps and overall culture system. The inlet of the semi-intensive aquaculture ponds serves as the medium for the transfer of gelatinous organisms from nearby coastal waters. The study recommends to investigate the factors associated with the blooming of gelatinous zooplankton and preventative measures to avoid future ecological and economic consequences.

Key words: Jellyfish, Gelatinous zooplankton, Coastal aquaculture, Proliferation, Ecological and economic consequences

TRPSF-FREM-P-30

Ichthyofaunal Diversity of the Upper Stretch of Ulhas River, Maharashtra

Vishal M*, Ashok Kumar Jaiswar, Sukham Monalisha Devi, Karankumar K Ramteke, Dayal Devadas, Shobha Rawat
ICAR-Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai-400061, India

*Corresponding author: vishal.frmbb104@cife.edu.in

Abstract

India is endowed with good number of riverine systems that include more than 20 major rivers and numerous tributaries. A number of systematic studies are from Indian rivers understanding their fish diversity and potential for fisheries. The Indian Western Ghats Mountain ranges are recognised for its tremendous biological diversity and endemism. They are known for their rich fish taxonomic diversity. The Ulhas River, a west flowing river from the northern Western Ghats, was studied to assess the diversity and distribution of the ichthyofauna. The fish specimens were collected and identifications were made on the basis of morphometric characters using standard taxonomic keys. The results of present investigation reveal the occurrence of 26 fish species belonging to 7 orders, 14 families and 21 genera. The order Cypriniformes was found dominant with 12 species, followed by Siluriformes with 5 species, Anabantiformes, Gobiiformes, Cichliformes, Synbranchiformes with 2 species each and Beloniformes with 1 species.

Key words: Ichthyofauna, Diversity, Ulhas River

TRPSF-FREM-P-31

Identification of Commercially important fish larvae from Karanja and Manori creek, Mumbai, Maharashtra

Rajesh Kumar, Shashi bhushan*, Suman Nama, Binay Bhushan Nayak, Karankumar Kishorekumar Ramteke, Annam Pavankumar

ICAR-Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai-400061, India

*Corresponding author: shashi@cife.edu.in

Abstract

The present work was undertaken for the identification of larvae of commercially important fish species from Karanja and Manori creeks of Mumbai, Maharashtra. The selected creeks are very much important as they provide a number of ecosystem services to the community as well as aquatic ecosystem associated with it. A total of 102 larvae and eggs were collected for the identification. After morphological examination the identification of the larvae confirmed using molecular tools. The molecular identification success rate was low about 23.33 % due to the difficulty in DNA extraction and the lack of standard PCR protocols for different species. From the selected samples, only seven proper sequences could be obtained. Out of the seven proper sequences blasted against the NCBI as well as BOLD databases, five were assigned species-level identification and two were assigned genus-level identification; the species and genus level identification being 71% and 29% respectively. The species identified include, *Stolephorus insularis*, *Thryssa dussumieri*, *T.hamiltonii*, *Terapon jarbua*, and *Planiliza sp.*, which belongs to three different families- Engraulidae, Terapontidae and Mugilidae. The study reflects the need for standardization of protocols for extraction of DNA from larvae and PCR conditions for different species.

Key words- Larvae, Identification, Molecular, Mitochondrial COI gene, Ichthyoplankton

TRPSF-FREM-P-32

Identification of selected fishes of Gomti River, Uttar Pradesh by using Integrative Taxonomy

Ashish Sahu^{1,2}, Priyanka^{1,3}, Mahender Singh*¹, Basdeo Kushwaha¹, Uttam Kumar Sarkar¹

¹ICAR- National Bureau of Fish Genetic Resources, Lucknow- 226 002, Uttar Pradesh

²Faculty of fisheries, Kerala University of Fisheries and Ocean Studies, Cochin- 682506, Kerala

³Department of Biochemistry, Dr .R.M.L. Avadh University Ayodhya-224001, Uttar Pradesh

*Corresponding author: Mahender.singh2@icar.gov.in

Abstract

An Integrative Taxonomy (IT) approach is a panacea for fish identification through the synergistic use of traditional taxonomy and molecular techniques. There is urgent need for creation of molecular signatures of freshwater fishes of Gomti River, Uttar Pradesh. We used traditional taxonomy (morphology, radiography-X-ray) and molecular biology (DNA barcoding) for the fish identification of collected individuals from selected sites. Here, we report the DNA barcoding of fishes, using the cytochrome oxidase subunit I gene (COI) for species identification, authentication and phylogenetic analysis, in addition to traditional taxonomy. A total of 23 different COI sequences of fishes were generated and representing 16 species, 14 genera, 9 families and 5 orders. All generated COI sequences were blasted in NCBI and the species identified based on morphomeric data were confirmed by DNA Barcode. The COI sequence

of *Balanoglossusaurantiaca*(OQ322732) is taken as an outgroup to root the phylogenetic tree. Model with the lowest (10666.923) Bayesian Information Criterion (BIC) score is considered to describe the best nucleotide substitution pattern. Non-uniformity of evolutionary rates among sites may be modeled by using a discrete Gamma distribution (+G) with 5 rate categories and by assuming that a certain fraction of sites is evolutionarily invariable (+I). The best fit nucleotide model for present COI dataset is GTR+G+I, based on 55 parameters. The uncorrected (p) genetic distance over all sequence pairs between genera was calculated with a total of 602 nucleotide positions in the final dataset. All genetic analyses were conducted in MEGA11. The average between the species p distance ranges from 11.79% between *Labeobata* and *Cyprinus carpio* 24.25% between *L. bata* and *Glossogobius giuris*. In addition to barcode-based species identification system, phylogenetic relationship among the species has also been attempted using maximum likelihood method, which revealed distinct clusters in concurrence with the taxonomic status of the species. The integrative approach is one of the best strategy to link the traditional taxonomy and DNA barcoding for helping the future research in fisheries.

Key words: DNA Barcoding, COI gene, Gomti River, Integrative taxonomy, MEGA, radiography.

TRPSF-FREM-P-33

Impact of Inland Saline Water on Growth of *Trapa* plant

Tejaswini Karale¹, Geetanjali Deshmukhe^{1*}, Saiprasad Bhusare¹, Swati Choudhary¹, Komal Nandagawali¹, Gajanan Kate¹, Rishikesh Kadam², Satkar Sagar³

¹ICAR-Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai-400061, India

²Fisheries College and Research Institute, Thootukudi

³Faculty of Fisheries, Kerala University of Fisheries and Ocean Studies, Cochin, Kerala

*Corresponding author: dgeetanjali@gmail.com

Abstract

Water chestnut (*Trapa bispinosa* Roxb) is an annual aquatic plant with floating leaves. It is an aquatic herb of great economic importance and grown for its starch-rich fruits. It contains a significant quantity of antioxidants, such as flavonoids, flavones, and total phenol, and is used as food for humans. The common name of the crop is 'Singhara' in Hindi; 'Pani Singhara' in Oriya; and in English. The present study has been designed to investigate the growth of the *Trapa* plant cultured in different salinities by using inland saline water for 60 days. *Trapa* plant cultured in Control -C 0ppt, Treatment1 (T1) ISW1ppt, Treatment 2 (T2) ISW 2ppt, Treatment 3 (T3) ISW 3ppt, Treatment 4 (T4) ISW 4ppt. In the *Trapa* plant culture trial, there was an increase in the number of rosettes in 0 ppt water from 30 to 56, the number of leaves from 728 to 1954, length of leaves from 18.46 cm to 23.72 cm, and width of leaves from 18.65 cm to 19.04 cm. There was an increase in the number of rosettes from 31 to 39 for *Trapa* plant in 1ppt water up to 30 days, and finally, there is a decrease up to 30. In 1 ppt, there was an increase in the number of leaves from 665 to 880 up to 30 days and then reduced to 755 after 30 days. The Initial values of number of rosettes in 2ppt water are 33 and decreased to 25 after 30 days. There was no survival of *Trapa* plant in more than 1 ppt after 30 days.

Key words: *Trapa*, Inland Saline Water, Water chestnut, rosettes, Salinity, Aquatic plant

TRPSF-FREM-P-34

Impact of Solar Ultraviolet Radiation on Marine Ecosystem

Rupanjan Paul, Supratim Malla

College of Fisheries, Central Agricultural University, Imphal, Lembucherra, Agartala, Tripura – 799210

*Corresponding author: rupanjanudp@gmail.com

Abstract

UV radiation (UVR) is a significant ecological factor in the marine environment that can have important effects on planktonic organisms and dissolved organic matter (DOM). The penetration of UVR into the water column is likely to change in the near future due to interactions between global warming and ozone depletion. UV radiation (UVR) usually divided into three spectral regions: i) UV-C (200 to 280 nm) ,ii) UV-B (280-315 nm) and iii)UV-A (315-400nm). There is a Methodology used to study the effects of UVR called double monochromator spectroradiometer. UV-B and UV-A radiations adversely affect the fish at different lifecycle stages, including embryo, larvae, juveniles and adults. UV-radiation affects the growth, mortality, behaviour, metabolism by affecting enzyme activities .UVR and environmental stressors, which potentially affects fish growth and survival. Skin damage is the most commonly reported effect of solar UV-B on fish. Montreal protocol- since depletion of stratospheric ozone layer has created the threat of enhanced UV-B which causes the reduction of productivity of water bodies by reducing the rate of photosynthesis, plankton growth, and overall yield in most of the fish species. A major goal of UV biologists is to be able to predict the effects of changes in UV exposure on all aquatic organisms and processes.

Key words: UVR, Dissolved Organic Matter, Ozone depletion, UV-A, UV-B, Montreal protocol.

TRPSF-FREM-P-35

Influence of Hook Size and Baits on the Catch Efficiency in the Lethrinids of Longlines of Thoothukudi Coast, India

T.Ravikumar, S.Mariappan, R.Velmurugan, N.Neethiselvan, A.Karthy
TNJFU- Fisheries College and Research Institute, Tuticorin-628008

*Corresponding author: ravikumar@tnfu.ac.in

Abstract

A survey was carried out to analyze the effect of traditional 'J' hook sizes viz., Hook No 13 and Hook No 14 with two different bait viz., Sardines and Squids on the catch efficiency of demersal longline fishery targeting Lethrinids in Thoothukudi coast, Southeast coast of India. *Lethrinus microdon*, *Lethrinus nebulosus*, *Lethrinus olivaceus*, *Lethrinus barak*, *Lethrinus ornatius*, *Lethrinus lentjan* and *Lethrinus mahsena* were the seven species recorded during the study. Among them *Lethrinus lentjan* was the single dominant species with the length ranges between 120 mm to 365 mm were caught in the long lines. As per the landing of *L. lentjan* in both the hook sizes such as hook No. 14 and 13 had capture of separate peaks size at 215 mm and 245 mm respectively. This result clearly revealed that Hook No.13 caught more of larger fishes than Hook No.14. However, *L. lentjan* attain sexual maturity at the end of third year when fish measured 300 mm standard length. This shows *L. lentjan* was caught more of juveniles in size and less than its length at first maturity. Hence, hook No.13 and 14 may be discouraged to use for fishing of *L. lentjan*. Further, Statistical analysis showed that there is no significant difference between the hook sizes and baits in the hooking rate ($p > 0.05$).

Key words: Longline, Hook Selectivity, Hooking Rate, Sardine Bait, Squid Bait

TRPSF-FREM-P-36

Is the Tide Turning? Untangling Kerala Fisheries Growth Story

Aiswarya Sali, Ananthan P.S.

ICAR-Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai-400061, India

*Corresponding author: Ananthan P.S.

Abstract

Fishing and fisheries are an important part of Kerala's social and economic heritage. This is a sector that augments nutrition and helps generate employment and revenue. India is the third largest fish-producing country in the world and accounts for 7.96 percent of global production. Kerala with a coastline of over 590km, and an Exclusive Economic Zone (EEZ) of 2.18 lakh sq km has a significant marine fisheries sector that has long been an important source of occupation and livelihood for the coastal population in the State. The fishery-related livelihoods are complex, dynamic, and adaptive. The study examines the forty-year trend in Kerala's fish production and export. Fish production ranged from 3,00,882 tonnes to 6,16,178 tonnes from 1981 to 2021. The compounded annual growth rate (CAGR) over the forty years (1981-2021) for total, marine and inland fish production in Kerala was found to be 1.62, 0.82, and 6.21, respectively. The highest CAGR for inland fish production was 8.27 during the decade 1991-2001, while for marine fish production, it was 7.88 during the decade 1981-1991. The instability indices revealed a high degree of fluctuation in total production during the decades 1981-91 and 2011-21. The data indicates that inland fish production in Kerala grew at a faster rate than marine fish production. However, the instability index for inland fish production is higher than that of marine fish production, indicating a higher degree of volatility in inland fish production. The negative growth rate in marine catch since 2001 is an indication of the limited scope for further growth and the need to sustain the gains. Relatively higher growth of inland fish production, during the decade 1991-2001 indicates the potential for further growth in the inland fisheries including the aquaculture sector is a positive sign, though the growth momentum appears to have slowed during 2011-2021. Marine product exports have grown consistently positively over the past four decades, with an overall CAGR of 4.83%. However, the growth momentum has lost its sheen during 2011-2021 (0.39% CAGR) as compared to the peak growth attained during 1981-1991 (5.56% CAGR). As could only be expected, it was observed that the growth was more unstable during periods of higher growth. The study further explores the trend in export value realization and the relationship between production and export over the period, as well as compares and contrasts the growth trends in fisheries with crop and livestock trends, drawing parallels and insights. Identifying the potential areas for future growth, the study underlines the need to rationalize the allocation of limited budgetary and human resources with the twin objectives of sustaining the gains made in marine fisheries and focusing on new growth areas.

Key words: Kerala, Fish production, Marine product export, CAGR, Instability

TRPSF-FREM-P-37

Isolation and Characterisation of Triclosan-Degrading Bacteria from Versova Creek

Sakshi Patil, Kundan Kumar*, S.P. Shukla, Saurav Kumar
ICAR-Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai-400061, India

*Corresponding author: kundankumar@cfje.edu.in

Abstract

Triclosan (TCS) is a broad-spectrum antimicrobial agent widely found in toothpaste, soaps, cosmetics, pharmaceuticals, and personal care products (PPCPs). It is an emerging micropollutant due to its omnipresence in water resources and even in biological samples that has attracted considerable attention due to its toxic effects on organisms and aquatic ecosystems, and its concentration in the water environment is expected to increase since the COVID-19 pandemic outbreak. The widespread use of triclosan provides several pathways that finally reach the WWTP and enter the aquatic environment like groundwater, sea, river, and sediment. Thus, the current study aims to screen and characterise the triclosan degrading bacteria from Versova creek of Mumbai, Maharashtra, India. A total of 15 (water and sediment each) samples for the screening of TCS tolerant bacteria were collected from three different sampling stations viz: Versova Jetty, Effluent from Sewage Treatment Plant, Lokhandwala, and Malad Creek Mumbai. The concentration of TCS used to screen the tolerant bacteria was 100 mg/L. Seven bacteria were found to be tolerant toward TCS. Further, all the isolated tolerant bacteria were investigated for the degrading potential of TCS. A total of seven bacteria were identified, namely *Vibrio vulnificus* (SW5), *Streptococcus thoraltensis* (SW7), *Pseudomonas stutzeri* (SW8), *Vibrio alginolyticus* (SW11), *Pseudomonas aeruginosa* (SW14) from water samples, whereas *Pseudomonas putida* (SS8) and *Pseudomonas stutzeri* (SS14) from soil sediment samples. Among the isolated bacteria, SW5, SW8, SW11, SW14, SS8, and SS14 were able to tolerate and degrade by utilizing the compound TCS as a carbon source. However, the isolated bacteria SW7 was only tolerant towards the TCS. The present study has generated information on potential bioremediating bacteria for triclosan from wastewater. Among all the bacteria, *Pseudomonas putida* is the only bacteria that is non-pathogenic and capable of degrading TCS. Moreover, *Pseudomonas putida* is commonly found in wastewater. Thus, the present study suggests that these bacteria could be a good candidate for bioremediation of triclosan in WWTPs.

Key words: Triclosan, Removal, Biodegradation, WWTP, PPCPs, Antimicrobial

TRPSF-FREM-P-38

Length weight relationship and Population parameters of *Pachypterus atherinoides* (Bloch, 1794) in the Burhi Gandak river of North Bihar

Sahil¹*, H. S. Mogalekar¹, Sudhan Chandran², Jham Lal¹

¹College of Fisheries (Dr. Rajendra Prasad Central Agricultural University, Pusa), Dholi, Muzaffarpur - 843121, India.

²Fisberies College & Research Institute (TNJFU), Thoobukudi - 628008, Tamil Nadu

*Corresponding author: frmcof14b@gmail.com

Abstract

Pachypterus atherinoides (Bloch, 1794) is an important catfish with high nutritional and ornamental features belonging to the family Schibiidae under the order Siluriformes. Length composition data of samples ranging from 3.1 cm to 7.8cm (TL) were collected during March 2019 to February 2020 from Burhi Gandak river and is used to estimate the length-weight relationship (LWRs) and population parameters of the species. The allometric coefficient *b* of the LWR was found out to be 3.30. Based on length frequency analysis, the growth parameters of Von Bertalanffy equation were calculated as $L_{\infty} = 7.98$ cm; $K = 0.52$ yr⁻¹. The estimated total mortality (*Z*), natural mortality (*M*), fishing mortality (*F*) and exploitation rate (*E*) were 1.71, 1.70, 0.01, and 0.01, respectively. The results of this study indicated that fish exhibited positive allometric growth and natural mortality was higher, as small fishes are more prone to natural mortality rather than fishing mortality. The estimated value of exploitation indicated that this species were under exploited in Burhi Gandak River, hence worth, the exploitation rate should be increased.

Key words: Burhi Gandak River, *Pachypterus atherinoides*, LWRs, Population Parameters.

TRPSF-FREM-P-39

Length-weight relationship and condition factor of freshwater mussel *Lamellidens marginalis* (Lamarck, 1819) from the River Burhi Gandak, North Bihar, India

Sanjay Chandranvanshi*, Mogalekar, H.S., Sudhan Chandran

Fisberies College & Research Institute (TNJFU), Thoobukudi - 628008, Tamil Nadu

*Corresponding author: Sanjay Chandranvanshi

Abstract

The length-weight relationship of freshwater pearl mussel, *Lamellidens marginalis* (Lamarck, 1819) were collected and analyzed during the sampling months July 2020 to June 2021 from the River Burhi Gandak. The collected mussel

specimens were found to be in the 30 to 80 mm shell length, and 3.1 to 36.7 g shell weight. The results length-weight relationship $W = 0.495L^{2.504}$ and the calculated R^2 value was 0.731. The condition factor (K) value was 0.905. The growth pattern of freshwater mussel was found to be ($b = 2.504$) negatively allometric. The findings of the present study will provide a baseline data for the effective and efficient management of the freshwater mussel resources along the River Burhi Gandak, North Bihar, India.

Key words: Growth pattern, Negative allometry, *Lamellidens marginalis*, River Burhi Gandak, Bihar

TRPSF-FREM-P-40

Length-Weight Relationship and Juvenile Estimation of *Lepturacanthus savala* (Cuvier, 1829) and *Coilia dussumieri* Valenciennes, 1848, from Dolnet catch of Mumbai coast

Akanksha, Asha T Landge, Abuthagir Ilbrahim S., Karankumar Ramteke, Shobha Rawat, S. Thanga Anusya, Rajesh Kumar

ICAR-Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai-400061, India

*Corresponding author: Asha T Landge

Abstract

The species *Lepturacanthus savala* and *Coilia dussumieri* form an important component of dolnet fishery in Mumbai coast and are an important food item locally, either in fresh or dried form. They are also ecologically important in maintaining a balance in the oceanic food web. However, Dolnet fishery operation does not promote responsible fishing and huge catch of juveniles have been recorded due to usage of small mesh size. The monthly juvenile proportion of these species from Dolnet catches in Mumbai coast was estimated. Also, the relationship between length and weight was determined by the method of least squares using the equation $\log W = \log a + b \log L$. The study was based on 200 specimens of *Lepturacanthus savala* and 221 specimens of *Coilia dussumieri* collected during January 2023 to May 2023 from the traditional dolnet fishing grounds of Mumbai. The total length and total weight were measured to the nearest 0.1 cm and 0.01 g respectively. The length of *Lepturacanthus savala* caught in the dolnet ranged between 154 mm and 654 mm and the weight ranged between 1.38 and 215.9 g. The length of *Coilia dussumieri* caught in the dolnet ranged between 66 mm and 183 mm and the weight ranged between 1 g and 17.9 g. For *Lepturacanthus savala*, the equation for length weight relationship is $\log W = -3.18622 + 2.880 \log L$. The value of the exponent b was observed to be 2.88, thus indicating that the species shows allometric growth. Correlation coefficient r for the species was calculated as 0.7371. For *Coilia dussumieri*, the equation for length-weight relationship is $\log W = -1.92951 + 2.482 \log L$. The value of the exponent b was observed to be 2.482. Correlation coefficient r for the species was calculated as 0.6684. These studies provide valuable insights for assessing fisheries and predicting weight based on length, essential for accurate yield estimation and comparative growth analyses. The month-wise juveniles estimated for *Lepturacanthus savala* in dolnet catch was: January (6.8%), February (60.6%), March (30%), April (38.77%) and May (57.69%). Length at first maturity for *Lepturacanthus savala* is 38 cm, so, the specimens below this length were observed to be juveniles. The highest number of juveniles were observed during February. The month-wise juveniles estimated for *Coilia dussumieri* in dolnet catch was: January (60%), February (80.5%), March (57.6%), April (51.1%) and May (53.44%). It shows that the highest number of juveniles were observed during February. Length at first maturity for *Coilia dussumieri* is 14.5 cm (males) and 14.7 cm (females). This data shows the abundance of juveniles in the catch thus giving an indication of growth overfishing.

Key words: Length-weight relationship, Month wise juvenile proportion, Dolnet

TRPSF-FREM-P-41

Length-Weight Relationship and Population Parameters of Selected Ambassisid Fishes from the Burhi Gandak River, North Bihar

Sahil, HS Mogalekar*, Jham Lal, Sudhan Chandran S. K. Nayak, Shivender Kumar

College of Fisheries, Dr. Rajendra Prasad Central Agricultural University, Pusa, Dholi, Muzaffarpur - 843121, Bihar, India

*Corresponding author: frmcof14@gmail.com

Abstract

The present study provides information on the life history traits of two Ambassisid fishes, namely *Chanda nama* and *Chanda ranga*, found in the Burhi Gandak River in North Bihar. A total of 362 samples for each species were collected randomly on a seasonal basis from March 2019 to February 2020. Traditional fishing gears such as Aupha Jaal, Ghana Jaal, and Pelni Jaal were employed to capture the specimens. The measurements of each fish included total length (TL), standard length (SL), and total body weight (BW), with a precision of 0.01 cm and 0.01 g, respectively. The recorded total length ranged from 14 to 83 mm for *C. nama* and 14 to 64 mm for *C. ranga*, while the total weight varied from 0.016 to 12.24 g for *C. nama* and 0.04 to 32 g for *C. ranga*. The exponential b values of the length-weight relationship (TL vs. BW) indicated positive allometric growth for both species. The value of b was 3.3 with a correlation coefficient (R^2) of 85% for *C. nama*, and 3.49 with a correlation coefficient (R^2) of 83% for *C. ranga*, which also demonstrated positive allometric growth. The asymptotic length, representing the mean length of very old fish, was estimated to be 80.85 mm for *C. nama* and 61.95 mm for *C. ranga*. The total mortality coefficient (per unit time) was calculated as 2.44

for *C. nama* and 2.31 for *C. ranga*. Furthermore, the natural mortality coefficient (per unit time) was determined to be 1.93 for *C. nama* and 1.34 for *C. ranga*. The fishing mortality coefficient (per unit time) was found to be 0.51 for *C. nama* and 0.79 for *C. ranga*. The exploitation rate (F/Z) was estimated as 0.21 for *C. nama* and 0.37 for *C. ranga*. Overall, this study provides baseline information that will contribute to further research on the conservation and management of these fish species.

Key words: Ambassids, Life history traits, Ganga River, Bihar

TRPSF-FREM-P-42

Morphometric and meristic characteristics of Reeve's croaker from the coast of West Bengal, India

Susmita Jana^{1*}, Nagesh T. Srinivasan¹, Dibakar Bhakta²

¹Department of Fisheries Resource Management, Faculty of Fishery Sciences, West Bengal University of Animal and Fishery Sciences, Kolkata-700094, West Bengal, India

²ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata-700120, West Bengal, India

*Corresponding author: zmouaayu999@gmail.com

Abstract

The morphometric and meristic characteristics of Reeve's croaker, *Chrysochir aurea* (Richardson, 1846) from the West Bengal coast of India were analysed by examining 618 specimens (286 males and 332 females) ranging from 124 to 417 mm in length collected monthly between September 2021 and September 2022. The current study, which is the first of its kind, revealed comprehensive morphological variation and sex-based morphological differentiation of *C. aurea*. A high degree of significant ($p < 0.01$) positive correlation was observed among different morphometric characters of *C. aurea* in relation to total length or head length. Standard length showed the fastest growth rate, while second anal spine length had the slowest when compared to the total length of the fish. When compared to head length, the post-orbital length and eye diameter had the fastest and slowest growth rates, respectively. Among 13 meristic counts, the coefficient of variation was found to be highest in arborescent appendages and lowest in the dorsal fin spine. The fin formula of *C. aurea* based on the meristic counts from the present study could be described as D. X-XI/1/25-28, P. i 16-18, V. I/5, A. 2/7, C. 16-18. The current research also revealed that there were 24 to 29 pairs of arborescent appendages along the edges of the gas bladder and 7 to 9 gill rakers in the left side of the first gill arch. The results indicated a high degree of homogeneity within the population of *C. aurea* occurring on the coast of West Bengal and will be useful in comparing the same species from different locations and to measure the discreteness between different fish stocks.

Key words: *Chrysochir aurea*, West Bengal

TRPSF-FREM-P-43

Occurrence of microplastics (MPs) in selected fishes landed along the Southwest Coast of India.

Sagar Ronad, Shashi Bhushan*, Abhijit Mallik, Binay Bhushan Nayak, Martin Xavier

ICAR-Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai-400061, India

*Corresponding author: shashi@cife.edu.in

Abstract

An investigation on the occurrence of the Microplastics (MPs) in the selected fishes were carried out along the South-West Coast of India. The fishes selected for this study were *Sardinella longiceps* (Indian Oil Sardine) and *Cynoglossus macrostomus* (Malabar sole) which are commercially important and heavily consumed fishes in the Southwest region. A total of 120 samples were analysed for occurrence of Microplastics. The samples from 30 specimens from each species were collected from the Dhakke landing centre (Mangalore, Karnataka) and Thoppampadi landing centre (Kochi, Kerala). In total, 720 MPs particles were found in 120 samples examined, wherein 384 MPs particles were found in Oil sardine (217 and 167 MPs particles in Mangalore and Kochi samples respectively) and 336 MPs particles (94 and 242 MPs particles in Mangalore and Kochi samples respectively) were found in Malabar sole samples. In Mangalore samples, an average of 7.17 ± 0.818 MPs particles per individual were found in Oil Sardine and 3.13 ± 0.688 per individual MPs particles were found in Malabar sole. When the data were pooled for both the fishes, the dominant type was fiber (44%), followed by fragment (34%), microbead (15%), and film (7%). Transparent color was the most dominant followed by black, red, blue. In Kochi samples, A total of 5.57 ± 0.855 MPs items per individual was observed in Oil Sardine and 8.07 ± 0.980 items per individual was observed in Malabar Sole. On the basis of shape, fragments occupied the dominant position and Transparent color was the most dominant, followed by black color (37%), red color (12%), blue color (3%), and brown (1%). The heavy occurrence of the microplastics from the selected fishes along the South-West coast of India indicates the heavy microplastic pollution along the Indian water.

Key words: Microplastics (MPs), *Sardinella longiceps*, *Cynoglossus macrostomus*, Southwest Coast

TRPSF-FREM-P-44

Paddy straw biochar: Sustainable Alternative and Green Adsorbent for the Remediation of Tetracycline

Swaraj Rajendra Adakney^a, Vidya Shree Bharti^a, Shamika Sawant^a, Tao Kara^a, Amal C. T^a.
^aICAR-Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai-400061, India
*Corresponding author: Vidya Shree Bharti

Abstract

Antibiotics are an important, rapidly emerging and non-biodegradable class of pollutants worldwide. Most antibiotics (50-90%) were excreted by humans and animals in their un-metabolised state. Hence causes water contamination with antibiotics and gives rise to antimicrobial resistance (AMR). Tetracycline (TC) is one of the most used antibiotics worldwide and has wide applications in human therapy, animal husbandry, agriculture and aquaculture. Under the scenario of one health approach, it is essential to remove the TC residues to overcome the AMR issue and to get good quality water for aquaculture. Biochar (BC), carbonaceous material, produced by the pyrolysis of agro-waste, plastics, tires, paper, wood and other forms of biomass. BC is a well-known adsorbent and can be efficient in the adsorption of a wide range of pollutants and is inexpensive. The objective of this study was to study the remediation potential of the engineered paddy straw biochar for tetracycline. Initially different types of biochar were screened for the removal of the tetracycline. Biochar was prepared from different agro-waste e.g.: paddy straw (PS), sugarcane bagasse (SB), coconut (CB) and banana peduncle (BP) in biochar kiln maintaining the temperature at 400. Two doses of biochar 2 gm/l and 4 gm/l were attempted for the removal of the biochar. Significantly higher removal of tetracycline was obtained by using paddy straw biochar. PS-BC at a dose of 4 gm/l resulted in higher removal of TC after 2 hours of contact time. Later, paddy straw biochar prepared at different temperatures was studied for the removal of TC. PS-BC was prepared at different temperatures: BC-400, BC-500, BC-600, BC-700 and BC-800. Among these, PS-BC-600 at a dose of 4 gm/l shows the highest removal, after two hours of contact time. The main mechanisms responsible for the adsorption of TC by BC were determined as hydrophobic interactions and π - π electron donor-acceptor interactions. This inexpensive and readily available adsorbent may provide an effective solution for removing TC and can provide one of the strategies for the one health approach.

Key words: Tetracycline, Biochar, Paddy Straw, Antimicrobial Resistance, Engineered Biochar

TRPSF-FREM-P-45

Phenotypic Plasticity in the Post Embryonic Stages of Silver pompano, *Trachinotus blochii* (Lacépède, 1801) in Captivity

Silpa R¹, Surya S², Karankumar Ramteke¹, Abhuthagir Iburahim S¹, Dayal Devdas, Asha T Landge^{1*}
¹ICAR-Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai-400061, India
²ICAR-Central Marine Fisheries Research Institute, Vizhinjam
*Corresponding author: ashalandge@cife.edu.in

Abstract

The silver pompano, *Trachinotus blochii* of the family Carangidae, is one of the most widely cultured coastal fish along the Indian coast. The larval stage represents the stage with the highest vulnerability in fish life cycle. The rapid morphological changes and organ development during this period will affect further fish development and survival. All carangids exhibit a large scale of morphometric variations throughout the larval phase compared to other marine species. Though culture techniques and scientific studies concerning silver pompano have been popularised in India for over a decade, limited knowledge is available on its larval phenology and morphometry. A total of 230 larval samples were observed from hatching (0dph) to metamorphosis (23dph) to study the stage specific plasticity. The microscopic examinations of morphological characteristics identified five post-embryonic stages: yolk-sac (0-4 dph), preflexion (5-10), flexion (11), post flexion (12), and juvenile (13-23dph). The relation between total length and days post hatch in silver pompano from hatching (0 dph) to metamorphosis (23 dph) followed a linear function. The descriptive morphology and stage-specific morphological changes will serve as a base line data for identification of larval stages, to conduct species level comparative studies and an input for critical period theory of larval culture.

Key words: *Trachinotus blochii*, Post Embryonic Stages, Plasticity, Critical period.

TRPSF-FREM-P-46

Seasonal Dynamics of Plankton of Sorada Reservoir in Relation to Hydrobiological Parameters

Maharana R.K.*, Mishra S.K., Das N.,
ICAR-Central Institute of Fisheries Education, Mumbai, 400061
*Corresponding author: rajeshkumar.aqcpb205@cife.edu.in

Abstract

The water quality parameters deploy a huge influence on the maintenance of a healthy aquatic environment and ensuring growing condition for aquatic animals. Emphasizing the prevailing need for analysing the water quality of Sorada reservoir, Ganjam, Odisha, an attempt was made to study the seasonal variations of plankton population and

selected physico-chemical parameters of Sorada reservoir for a period of nine month i.e. during pre-and post-monsoon periods. In the study, we have recorded 20 species of phytoplankton which, 7 species belongs to Bacillariophyceae, 6 species belongs to Cyanophyceae, 5 species belongs to Chlorophyceae and 2 species of Euglenophyceae. Among phytoplankton, particularly *Clorella vulgaris* was the dominant species during post-monsoon periods while, *Spirogyra* contributed highest abundance during pre-monsoon periods. Moreover, *Anacystis* sp of Cyanophyceae was recorded to be the least abundant among the phytoplankton population during pre-monsoon and post-monsoon, respectively. Zooplankton community is also correlated with physicochemical parameters. 21 species of zooplankton were recorded from the reservoir out of which Rotifera was plentifully noticed with 7 no. of species followed by ostracoda with 4 no. of species. Among the species *Cyclops* was the most dominant species, 32.9Nos/l in post-monsoon and 28.9Nos/l in pre-monsoon. The physico-chemical parameters include Temperature, pH, Transparency, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Alkalinity, Total Hardness, Phosphates and nitrates were varied seasonally. Based on the correlation matrix, the physico-parameters such as DO, Nitrate and phosphate show a positive correlation with the productivity and plankton abundance of the reservoir whereas temperature shows a negative relation with the DO.

Key words: Physico-Chemical Parameters, Phytoplankton, Productivity, Reservoir, Seasonal Fluctuations, Zooplankton.

TRPSF-FREM-P-47

Stock characterization of *Boleophthalmus dussumieri* (valenciennes, 1873) from Indian water using truss network and Parasite as biological tag

Pritam Das¹, Shashi Bhushan¹, Rajendran K.V¹, B.B Nayak¹, Layana P¹
ICAR-Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai 400061, India

*Corresponding author: shashi@cife.edu.in

Abstract

Mudskipper, *Boleophthalmusdussumieri* is amphibious goby found in muddy bottom, mainly in mangrove areas subjected to tidal rise and fall. 292 specimens collected from Gujarat, Maharashtra, and West Bengal are subjected to stock differentiation using truss morphometry and parasite as biological tag. Twenty-six variables extracted with 12 anatomical landmarks subjected to PCA shows > 80% variation for first two factor. In linear discriminate analysis (LDA), classification indicate 100% discrimination indicating presence of 3 different stock, where stocks of Maharashtra to Gujarat show minimum and stocks of Maharashtra to West Bengal show maximum distance. The only parasite (*Ellipsomyxa* sp.) found on fish gall bladder is not specifying the requisite characteristics to be used as tag parasite for stock discrimination, so it should not be used for *B. dussumieri* differentiation.

Key words: Mudskipper, Truss Network, *Ellipsomyxa* sp., Linear Discriminate Analysis

TRPSF-FREM-P-48

Studies on indigenous fishing techniques of Indian spiny loach, *Lepidocephalichthys thermalis* (Valenciennes, 1846) in inland waters of Southern Tamil Nadu, India

Muthukumar Senthurapandi, Mariappan Sangaralingam*, Ravikumar Thangaraji, Neethiselvan Neethirajan
Fisheries College and Research Institute, Tamil Nadu Dr.J. Jayalalithaa Fisheries University, Thoothukudi-628008, Tamil Nadu

*Corresponding author: mariappan@tnfu.ac.in

Abstract

Two different indigenous fishing gears, *Ayirai Koodu* (fish trap) and *Ayirai Valai* (Drag net) were used to capture loaches, *Lepidocephalus thermalis* (Valenciennes, 1846) locally called as *Ayirai*, operated in inland waters of southern districts of Tamil Nadu. The box shaped loach trap has dimension of 750 mm length and 400 mm height, respectively. *Ayirai Koodu* constructed with two openings, one is on the upper side with 100 mm dia and it was bifurcated into two smaller circles through which the fishes enter into the trap besides lower side opening with 80 mm dia which is used to collect the fishes from the trap. The upper side opening is wider, when compared to the lower opening. The trap was operated for 10-12 hours per day with the average catch of 30 kg/ day. *Ayirai Valai* is a kind of drag net used for capturing loaches and small cat fishes. A split bamboo stick made into inverted 'U' shape; conical shaped bag made of mosquito net was fastened with bamboo stick and a stick was attached vertically in the center portion of net for vertical mouth opening of the net. The net is slowly dragged by the fishermen by holding the net by agitating the water with the lengthy stick on the other hand. The fishes are frightened and directed towards the mouth of the net. Fishing by drag net was carried out in the early morning or late evening hours. The average fishing duration was about 4-5 hrs/day and the average catch was about 10 kg/day. The peak fishing season of *Ayirai Koodu* and *Ayirai Valai* was found to be August to December.

Key words: Indigenous fishing, *Ayirai Koodu*, *Ayirai Valai*, Loach fishery

TRPSF-FREM-P-49

Study of Physiochemical Characteristics of Bengre, Thannirbhavi and Chitrapur off Mangalore coast

Madhu Kumari

Department of Aquatic Environment Management, College of Fisheries, Kishanganj

*Corresponding author: madhu.pinki.2016@gmail.com

Abstract

The study of various physiochemical parameters is of great importance in understanding the health status of an environment. The present investigation was carried out for the period of eight months along Bengre region having estuarine influences and receiving load of domestic sewage and Thannirbhavi receiving treated effluents from Fertilizer industry and Chitrapur receiving treated effluents Refinery Petroleum limited and Soda factory. The hydrographical parameters such as water temperature, pH, salinity and dissolved oxygen of surface and subsurface water were analyzed. Water temperature exhibited unimodal seasonal oscillation. Thermal stratification is more pronounced at Chitrapur followed by Thannirbhavi and Bengre. The pH value fluctuated from 7.4 to 8.51. The dissolved oxygen value ranged from 2 to 5 mg/l with lowest in December. Industrial activity could also be one of reason for low dissolved oxygen content. Bengre coast registered lower value of salinity compared to Thannirbhavi and Chitrapur coast.

Key words: Physiochemical parameters, Mangalore coast, industrial effluents.

TRPSF-FREM-P-50

Study on Seasonal fluctuation of Physio-chemical properties and faunal diversity of Moti Lake East Champaran

Ram Prawesh Kumar¹, Kundan Kishor Rajak*

Department of Zoology, School of Life Science Mahatma Gandhi Central University Bihar

*Corresponding author: kkrajak@mngcub.ac.in

Abstract

Present studies were carried out to determine fluctuation of physio-chemical characteristics of water and its impact on faunal diversity of Moti Lake East Champaran during different seasons of the year 2019-2022. This lentic ecosystem is average in aquatic diversity. Physico-chemical parameters such as temperature (Air and water), dissolved oxygen (DO), hydrogen ion concentration (pH), electrical conductivity, nitrogen, phosphate, turbidity, transparency and total dissolved solids (TDS) were analysed at regular intervals. Results indicate major fluctuation in selected physio-chemical parameters between limnetic and benthic zones during winter, summer and monsoon seasons. The water temperature (highest- 35.25 °C and Lowest- 19 °C), pH (highest- 9.02 and Lowest- 7.32), electrical conductivity (highest- 1370.5 µs/cm and Lowest- 841.5 µs/cm), TDS (highest- 675.25 ppm and Lowest- 432 ppm), DO (highest- 7.8 mg/L and Lowest- 4.9 mg/L) and concentration of Nitrate (highest- 1.5 mg/L and Lowest- 0.41mg/L) were recorded. Furthermore, only 42 native and 2 exotic fish species were found in the selected area. In Moti Lake, Janitor fish and Tilapia were identified as exotic species. Population of Tilapia was more prominent than Janitor Fish in Moti Lake. Only 20 out of 42 species of fish were found in Moti Lake in other seasons. While looking for other animals in the community, eight types of insects, seven species of molluscs and eleven zooplanktons had been collected and identified. The impact of seasonal fluctuations in physio-chemical parameters on faunal diversity is important and will be useful in the future to improve the stability of the significant historical wetland of East Champaran.

Key words: Physio-chemical, Lentic ecosystem, East Champaran

TRPSF-FREM-P-51

The Mangrove - Distribution, Type, Zonation, Adaptation, Importance and Conservation

Siddharth Kumar Jatav^{1*}, Ravikant², Pragma Mehta¹, Satyendra Katara³, Varsha Likhar³

¹*Department of fisheries resources Management, College of fisheries science, CCS HAU, Hisar*

²*Department of Zoology, COBS&H, CCS Haryana agricultural university, Hisar*

³*College of fisheries science, Kamdhenu University, Veraval, Gujarat*

*Corresponding author: siddharthsinghjatav@gmail.com

Abstract

Mangroves are a group of tropical trees that have evolved to live in salt water. At the boundary between land and water, mangroves are a special type of intertidal forest. Mangrove ecosystems are incredibly prolific and provide a habitat for both marine and land species. Only mangrove plants (also known as halophytes) can tolerate high levels of salt in water. They can be found primarily on the coasts of the tropics and subtropics, both above and below the equator. Mangroves are found in much of the world between latitudes 5°N and 5°S. Mangroves are divided into four groups: buttonwood mangrove, white mangrove, red mangrove, and black mangrove. Along the same beach,

buttonwood and red, black, and white mangrove trees can all flourish. The unique characteristics that all mangrove plants have enable them to endure in their saline environment. Mangroves are an essential component of nature's defense system against cyclones, ecological catastrophes, and the erosion of shorelines. Fish, amphibians, reptiles, birds, and mammals are just a few of the marine animals that use them as breeding and hatcheries grounds. An estimated 20% of mangrove forests around the world have disappeared. Around the world, mangroves are vanishing at a startling rate. The loss of habitat caused by human activity could have catastrophic impacts on biodiversity. Different activities should be done in order to protect mangroves such as afforestation, legislation, monitoring and surveys.

Key words: Mangrove, Intertidal, Tropics region, Halophytes, Afforestation, Conservation

TRPSF-FREM-P-52

Understanding Length-Weight Relationship and Estimation of Juvenile *Trypauchen vagina* (Bloch & Schneider, 1801) from Dolnet Catch in the Waters of Mumbai Coast, India

Rajesh Kumar, Karankumar Ramteke, Abuthagir Ibrahim S., Bharda Sheetal Kanubhai, S. Thanga Anusya, Akanksha
ICAR-Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai 400061, India
*Corresponding author: karankumar@cife.edu.in

Abstract

The Red Goby, scientifically known as *Trypauchen vagina*, is a pink-colored fish with an eel-like shape found in coastal areas, estuaries, and brackish waters of India. It is commonly caught using dol nets near the shore and is frequently seen in Mumbai's fish markets. People consume it fresh or dried, and it is also used as bait for crab fishing. Some believe it has medicinal properties for convulsing patients. To determine the relationship between length and weight, the method of least squares was employed using the equation $\log W = \log a + b \log L$. The study was conducted using 114 specimens collected from the Mumbai Coast of Maharashtra between December 2022 and May 2023. In the laboratory, the total length (L) and total weight (W) were measured with a precision of 1 mm and 1 mg, respectively. The length of the specimens ranged from 45 mm to 186 mm, while the weight ranged from 2 to 248 mg. The equation for the length-weight relationship is $\log W = -5.77 + 3.14 \log L$. The exponent b was observed to be 3.14, indicating positive allometric growth in the species. The correlation coefficient (r^2) was calculated as 0.94, signifying its significant relationship for the species. The juvenile percentage was highest in December and February (100%) and lowest in April (57%), while in January, March, and May, it was 85%, 69%, and 86%, respectively. Understanding the length-weight relationship and estimating the number of juvenile Red Goby fish are crucial for monitoring the population's status and conducting further research on reproductive and feeding biology, as well as conservation efforts. This study provides valuable information for fisheries management and conservation of the Red Goby species in Mumbai's coastal waters.

Key words: Length-weight relationship, Juvenile, Dolnet, *Trypauchen vagina*, Red Goby

TRPSF-FREM-P-53

Understanding the Dynamics of Fish Production Growth and Instability in Maharashtra

Akilandeshwari A., Shivaji Argade*
ICAR-Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai 400061, India
*Corresponding author: shivaji@cife.edu.in

Abstract

The Indian economy greatly benefits from the livelihoods, food security, and foreign exchange that fisheries and aquaculture provide. In 2021-22, India's marine fish production was 41.27 lakh tons, while Maharashtra's marine fish production was 4.33 lakh tons. Maharashtra ranks sixth in the country with a 10.5% share of total marine fish production. In the fiscal year 2021-22, India's inland fish production was 121.21 lakh tons, while Maharashtra's inland fish production was 1.57 lakh tons. Maharashtra ranks 17th in the country with a 1.3% proportion of total inland fish production. The inland and marine fish production figures for the years 1981-2020 were obtained from the Maharashtra Commissionerate of Fisheries' Fish Production Reports. The Compound Annual Growth Rate (CAGR) and Cuddy Della- Valle Instability Index was calculated for 40 years as a whole and decade wise [Period I (1981-1990), Period II (1991-2000), Period III (2001-2010), and Period IV (2011-2020)]. Sindhudurg is the only coastal district with a negative annual growth rate of -1.07% in marine fish output, while the remaining four coastal districts had positive CAGRs, and the annual growth rate of marine fish production in Maharashtra was 3.16%. In Maharashtra, inland fish production increased at a rate of 4.22% each year. During Period IV, regions such as Pune, Amravati, and Nagpur

recorded negative annual rates of -7.17%, -2.54%, and 5.65%, respectively. The CDVII was 5.29% during period IV, indicating less volatility in the state's marine fish production, followed by 5.6% during period III, and the CDVII of marine fish production in Maharashtra for 40 years was calculated to be 8.59%, indicating low instability and volatility in the state's marine fish production. Of the five coastal districts, Sindhudurg had the highest volatility in marine fish production during period II, with CDVII at 33.71%, while Greater Mumbai had the lowest volatility during period IV, with CDVII at 4.1%, showing progressive and stable increase. In the case of inland fish production in Maharashtra, the instability was found to be high during period IV with CDVII 18.76% and low during period III with CDVII 5.32%. Of the seven regions, Pune region had the highest volatility in inland fish production during period III, with CDVII 4.16%, while Aurangabad region had the lowest volatility during period I, with CDVII 4.16%. For the entire 40-year period, instability was found to be high in the Nagpur region, with CDVII 42.21% implying high volatility in inland fish production, and low in the Nashik region, with CDVII 22.2% indicating lower volatility in inland fish production. In Maharashtra, both inland and marine fish production are expanding, with Nagpur and Pune regions producing the most inland fish. The emphasis must be on expanding inland fish production in the state's remaining regions through increased stocking in water bodies and effective management. Maharashtra can expand its fisheries and aquaculture sector while guaranteeing the long-term conservation of its aquatic resources with competent management, sustainable practices, and technology improvements.

Key words: Compound Annual Growth Rate, Cuddy Della- Valle Instability Index, Inland fish production, Marine fish production, Maharashtra.

TRPSF-FREM-P-54

Effects of Triclosan and Microplastic on Haematological Parameters in *Pangasianodon hypophthalmus*: Implications for Fish Health and Synergistic Interactions

Vipul Singh Badguzar, Saurav Kumar*

ICAR-Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai 400061, India

*Corresponding author: saurav@cife.edu.in

Abstract

This study aimed to investigate the chronic effects of triclosan (TCS) and microplastics (Polystyrene (PS), mean size 900 μm , density 1.08 g/cc) (MPs) on the haematological parameters of *P. hypophthalmus* as indicators of fish health status. In addition, the potential interactions between TCS and MPs in exacerbating the toxic effects was evaluated. In this study, blood parameters were estimated after a 45 days chronic exposure to TCS and MPs in combination, a significant reduction in Total Erythrocyte Count (TEC), Hemoglobin (Hb), Hematocrit value, Mean corpuscular volume (MCV), Mean corpuscular hemoglobin (MCH), Mean corpuscular hemoglobin concentration (MCHC). An increase in Total leukocyte count (TLC) was observed in T1 (235.4 $\mu\text{g L}^{-1}$ TCS) and T2 (117.7 $\mu\text{g L}^{-1}$ T) of TCS and MPs (2.5 mg/L) exposed groups for *P. hypophthalmus* while no significant change was observed for T3 (58.85 $\mu\text{g L}^{-1}$ TCS + MPs) as compared to control 1 (having solvent, NaOH). Similarly, a significant interaction between of TCS and microplastic that potentiate the toxic effects of NOEC level of TCS. These findings highlight the importance of haematological parameters as indicators of fish health and the potential for water quality changes to impact these parameters. The study suggests that the combination of TCS and MPs can have synergistic effects, emphasizing the need for further research and monitoring to understand and mitigate the potential risks posed by these pollutants to aquatic ecosystems.

Key words: Triclosan, Microplastic, Fish Health, Haematology, *P. hypophthalmus*

TRPSF-FREM-P-55

Spatio-temporal effect of water pollution on the fish species diversity and relative abundance along the river Jhelum, Kashmir, India

Shahid Gul, Swadesh Prakash*, Neha W. Qureshi, Vinod Kumar Yadav, Arpita Sharma, Shakir Ahmad Mir

Fisheries Economics, Extension and Statistics Division, ICAR-Central Institute of Fisheries Education, Mumbai-400 061, India

*Corresponding author: swadeshprakash111@gmail.com

Abstract

This study attempts to link the change in the water chemistry of the river Jhelum with species diversity, richness, and relative abundance over the years. The literature regarding fish species diversity and physicochemical parameters available up to date was taken into consideration for empirical evidence. A spatio-temporal comparison was made between the upper and lower stretch of the river. The entire river is dominated by the family Cyprinidae with eight species, followed by the Nemachilidae with only two species. For the upper stretch, the values of different diversity indices like Shannon-Wiener diversity index (H'), Simpson's dominance index (D), heterogeneity index (1-D),

Margalef's index (d), and Pielou's evenness index (J') worked out to be 2.192, 0.104, 0.896, 1.436, and 0.350, while for the lower stretch, the values were 1.978, 0.145, 0.855, 1.144, and 0.323, respectively. It indicates that fish species diversity, richness, and relative abundance have decreased in the lower stretch. The results are also supported by the literature, which shows water pollution is higher in the lower stretch of the river than in the upper stretch. Besides planned urbanisation and afforestation of the barren lands, there should also be regular monitoring of water quality parameters and the controlled use of pesticides and fertilisers in the catchment area of the Jhelum to preserve its pristine aquatic ecosystem.

Keywords: Pollution, Fish diversity, River Jhelum, Diversity indices, Schizothorax, Anthropogenic activities

TRPSF-FREM-P-56

Assessment of physical and chemical variables of sewage discharging into coastal waters of Veraval, Gujarat, India

*Manisha F Panthi**

College of Fisheries Science, Veraval, Kamdbenu University, Gujarat.

Corresponding author: manishafpanthi17@gmail.com

Abstract

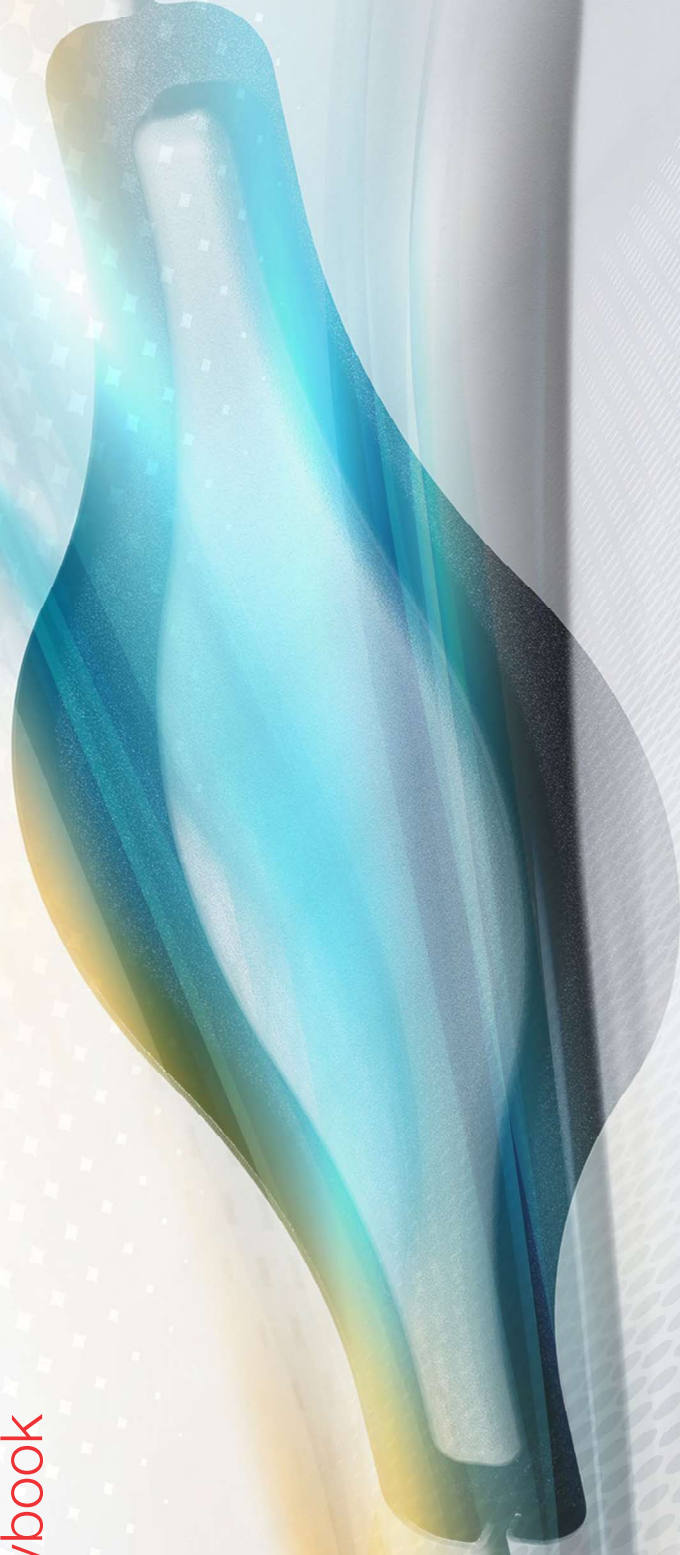
The present study was conducted to investigate the physical and chemical variables of sewage from ten discharge channels on the Veraval coast of Gujarat from November 2020 to April 2021. The study revealed that the physicochemical parameters across ten different municipal sewage channels varied depending upon geographical locations, the thickness of the population residing nearby, types of industry, and various other activities occurring close to sewage channels. The result showed that, temperature varied from 25.4 ± 3.9 °C to 26.7 ± 3.9 °C, pH 7.3 ± 0.4 to 7.9 ± 0.6 , electrical conductivity 755.7 ± 76.3 to 1880.8 ± 191.9 $\mu\text{S cm}^{-1}$, turbidity 82.8 ± 8.4 to 46.0 ± 6.9 NTU, salinity 4.2 ± 0.2 to 30.0 ± 1.3 ppt, biochemical oxygen demand 326.1 ± 17.5 to 344.7 ± 34.6 mg l^{-1} , dissolved oxygen 0.006 ± 0.002 to 0.015 ± 0.011 mg l^{-1} , total solids 17001 ± 1171 to 2089 ± 659 mg l^{-1} , total suspended solids 1293.7 ± 115.1 mg l^{-1} to 379.00 ± 36.34 mg l^{-1} and total dissolved solids 15772 ± 1142 mg l^{-1} to 1587 ± 639 mg l^{-1} . The variables such as pH, dissolved oxygen, total solids, total dissolved solids, total suspended solids, turbidity, conductivity, and salinity varied significantly between sewage channels, while temperature and BOD does not show significant differences across different discharge channels. The temperature and pH were within permissible limits according to the standards prescribed by CPCB, India, while odor, BOD, and total suspended solids were in alarming status. The present study suggests to have an effective approach towards the treatment and management of untreated sewage discharge into the coastal waters, for the sustainability of the marine biota.

Keywords: Sewage, Dissolved Oxygen, Sustainability, Natural Resources

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Theme III: Biotechnological Interventions For Improving Fisheries Production

TRPSF-BIOTECH-O-1

Dietary modification with molecular approach for enhancing Omega 3 Fatty Acid in Olive barb (*Systemus sarana*)

JanmejyParhi*, Kashti Prerna Deorao, Aditi A. Tripathy, Sumit Mallick, Sagar C. Mandal
College of Fisheries, Central Agricultural University, Imphal, Lembucherra, Pin: 799 210, Tripura, India

*Corresponding author: jjparhi@gmail.com

Abstract

Transcriptomics approach was taken to identify the genes involved in Omega-3 fatty acid biosynthesis in *Systemus sarana*. Freshwater fishes have lower levels of omega-3 content than marine fish species, but they can produce omega-3 from C18-PUFA. Although dietary supplementation of fatty food has been successfully demonstrated to enhance fatty acid, but increasing omega-3 fatty acid in freshwater fish species remains a challenge. The process of omega-3 fatty acid biosynthesis contains desaturation and elongation steps which are related to various key genes. Resveratrol was used as Omega-3 fatty acid enhancer in the treatment feed. The expression profiling of genes identified from RNA seq data was done by using the RT-PCR. The increase in the expression of omega-3 fatty acid biosynthesis genes in liver tissue of olive barb was observed from 0 days to 30 days which was further validated by fatty acid analysis in GCMS. This result suggests that resveratrol potentially induced endogenous n-3 fatty acid.

Keywords: Omega-3 fatty acid, Resveratrol, Biosynthesis, *Systemus sarana*

TRPSF-BIOTECH-O-2

Genetic diversity of striped murrel, *Channa striata* (Bloch, 1793) from Eastern India as revealed by mtDNA control region

G. Samal¹, L. Sahoo^{2*}, Rajesh Kumar³, P. C. Nandanpawar², Jackson Debbarma³, P. Das², Roshan Kumar¹, P. P. Srivastava¹, Adita Sharma¹ and Shivendra Kumar¹

¹Department of Fisheries Resource Management, College of Fisheries, Dholi. RPCAU, Bihar

²Fish Genetics and Biotechnology Division, ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar, Odisha

³Aquaculture Production and Environment Division, ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar, Odisha

*Corresponding author: lakshmansahoo@gmail.com

Abstract

The striped murrel, *Channa striata* is one of the indigenous freshwater food fish having high market demand and consumer preference due to its tender flesh, unique aroma and less intramuscular spines. It also has high nutritive value and medicinal importance. Therefore, this fish is in high demand in several states like Telangana, Andhra Pradesh, North-eastern states, West Bengal, Kerala, Tamil Nadu, Karnataka, Punjab, Haryana, Bihar and Maharashtra. The species is extensively dispersed throughout countries in Western to South-East Asia, including Bangladesh, Cambodia, China, India, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Nepal, Pakistan, Sri Lanka, Thailand, and Vietnam. Striped murrel can grow in weed infested aquatic environment and water with low dissolved oxygen. Therefore, it is suitable for culturing in high density. This is also one of the important species for species diversification as well as climate resilient aquaculture. Fishery management and genetics can interact in a variety of ways. The distribution of subpopulations in mixed fisheries can be calculated when the genetic population structure of a species is understood. Based on these distributions, harvest can be regulated to safeguard populations that are more vulnerable. The availability of polymorphic neutral markers facilitated the genetic analysis of wild populations. In the present study, mtDNA control region is used to investigate the population genetic structure of West Bengal (Ganga), Bihar (Burhi Gandak) and Odisha (Mahanadi) stocks of *C. striata*. The GC and AT percentages of mtDNA control region of *C. striata* was observed to be 63.8% and 36.2%, respectively. In total 18 haplotypes were observed and number of haplotypes ranged from 5 to 9 and with haplotypic diversity of 0.9328. Haplotypic diversity and nucleotide diversity ranged from 0.7143 to 0.8947 and 0.0052 to 0.08794, respectively. Highest haplotypic and nucleotide diversity was observed in West Bengal and Odisha population. AMOVA analysis revealed 84.45% variation was due to within population and 15.55% was due to between population variations. Significant genetic differentiation was observed among the *C. striata* populations. Highest genetic differentiation was observed between Bihar and West Bengal population. The results of the present study would be very much helpful in formulation of effective restoration programmes for the conservation of natural populations and sustainable exploitation of this commercially important species.

Keywords: *Channa striata*, mtDNA, Haplotypes, Genetic Differentiation

TRPSF-BIOTECH-O-3

Identification of a Novel Potential Vaccine Candidates against *Aeromonas hydrophila* using Immunoinformatic Approach

Amrita Mohanty^{1*}, Gowhar Iqbal¹, Gulshan Kumar², Prabhat Kumar Behera³

¹ICAR-Central Institute of Fisheries Education, Mumbai, India

²College of Fisheries Science, Gumla, Birsa Agricultural University Ranchi, Jharkhand, India

³Chitkara College of Pharmacy, Chitkara University, Rajpura, Punjab, India

*Corresponding author: mamaamrita95@gmail.com

Abstract

Aeromonas hydrophila is a common gram-negative bacterium causing regualinfection in freshwater fish. Among Gram-negative bacteria, efflux pumps of the RND (Resistance-Nodulation-Division) transporter permease family are prevalent and catalyse the active efflux of numerous antibiotics and chemotherapeutic drugs. Bacterial efflux pumps belonging to the RND superfamily mediate resistance to several biocides, such as; Cu(I) and Ag(I) ions. A RND efflux pump typically coordinates with an outer membrane channel and a periplasmic membrane fusion protein to form a functioning tripartite protein complex. This protein is a well-known antigenic protein and reported from mammalian pathogens. In this study, we have used several bioinformatics online servers for determining immunogenic property of efflux pump RND protein. The study includes several bioinformatics approaches to analyse various aspects of RND protein, such as; physico-chemical properties, transmembrane domains, secondary and tertiary structure, B and T-cell potential epitopes, and other important immunological characteristics of this protein. Also, 12 transmembrane domains were recognized for this protein. The secondary structure of RND protein comprised of 48.27% alpha-helix, 16.51% extended strand, and 27.64% random coil. Additionally, several potential B and T-cell epitopes were also identified for RND efflux pump protein. In addition, prediction of this protein's antigenicity and allergenicity revealed that it is immunogenic and non-allergenic. Based on the outcomes of the Ramachandran plot analysis of predicted tertiary structure; 95.7%, 3.2%, and 1.1% of the amino acid residues, respectively, were included in the favoured, allowed, and outlier regions. Hence, this work identified efflux RND transporter as a potential vaccine candidate to mitigate the infection of *Aeromonas hydrophila*, a common freshwater fish pathogen.

Keywords: *Aeromonas hydrophila*, RND, Immunogenic, Bioinformatics Analysis, Vaccine

TRPSF-BIOTECH-O-4

Microbial inoculums improve growth and health of *Heteropneustes fossilis* via biofloc-driven aquaculture

Vikash Kumar*, Himansu Sekhar Swain, Suvra Roy and Basanta Kumar Das
ICAR-Central Inland Fisheries Research Institute (CIFRI), Barrackpore, 700120, India

*Corresponding author - kumar.vika.vikash2@gmail.com

Abstract

Biofloc technology aims to maximize fish farming productivity by effectively breaking down ammonia and nitrite, promoting healthy flocculation, and enhancing the growth and immunity of cultured animals. However, a major limitation in this field is the suitable starter microbial culture and narrow number of fish species that have been tested with the biofloc system. Here, we investigated various microbial inoculum containing beneficial microbes with probiotics, immunostimulatory and flocs development and bioremediation properties would lead to the development of ideal biofloc development. Three treatment groups with different microbial combinations, viz., group 1 (*Bacillus subtilis* (AN1) + *Pseudomonas putida* (PB3) + *Saccharomyces cerevisiae*), group 2 (*B. subtilis* (AN2) + *P. fluorescens* (PC3) + *S. cerevisiae*) and group 3 (*B. subtilis* (AN3) + *P. aeruginosa* (PA2) + *S. cerevisiae*) were used and compared with the positive control (pond water without microbial inoculums) and negative control (clear water: without microbial inoculums and carbon sources) on biofloc development and its characteristic features to improve the water quality and growth of fish. We demonstrated that microbial inoculums, especially group 2, significantly improve the water quality and microbiota of flocs and gut of the test animal, *Heteropneustes fossilis*. The study further demonstrates that biofloc system supplemented with microbial inoculums positively regulates gut histomorphology and growth performance, as evidenced by improved villous morphology, amylase, protease and lipase activity, weight gain, FCR, T3, T4 and IGF1 levels. The inoculums induced an antioxidative response marked by significantly higher values of catalase (CAT) and superoxide dismutase (SOD) activity. Furthermore, the supplementation of microbial inoculums enhances both specific and non-specific immune responses and significantly elevated levels of immune genes (transferrin, interleukin-1 β and C3), and IgM was recorded. This study provides a proof-of-concept approach for assessing microbial inoculums on fish species that can be further utilized to develop biofloc technology for use in sustainable aquaculture.

Keywords: Aquaculture, Biofloc Technology, Microbial Inoculums, Water Quality, Growth Performance, Immunity, *Heteropneustes fossilis*

TRPSF-BIOTECH-O-5

Mining of labelled SSR libraries through Excel to find polymorphic SSR markers for Giant rivercatfish *Sperata seenghala*

Aditya Pratap Acharya¹, A Pavan Kumar², Gopal Krishna² and Sagarika Swain³

¹West Bengal University of Animal & Fisheries Sciences, Mohanpur, Nadia-741252, West Bengal, India.

²ICAR-Central Institute of Fisheries Education, Mumbai-400061, Maharashtra, India

³College of Fisheries, Bihar Animal Sciences University, Kishanganj-855115, Patna, Bihar, India.

*Corresponding author: adityapratapacharya@gmail.com

Abstract

Mining polymorphic SSR markers is an extremely challenging task in and of itself. Multiple numbers of software are required to find out polymorphic SSR, and the outcomes are also not very encouraging. Polymorphic SSR markers can be quickly and accurately found from the sequencing data set by using the probe enrichment approach and Excel spreadsheet. The Giant River Catfish, *Sperata seenghala*, a commercially significant freshwater catfish, was selected for SSR marker mining. The best markers for characterising genetic stocks are SSR markers. Out of numerous techniques, the probe enrichment method is particularly best suited for fish. The dorsal fins of 30 individuals from each river, i.e., Brahmaputra, Ganga, Godavari, Mahanadi, and Narmada rivers, were collected and aseptically maintained for total genomic DNA isolation. 10 individuals from each stock's genomic DNA were extracted and combined to create a genomic library. The SSR (probe repeat) enriched DNA libraries were sequenced using the Ion Torrent personal Genome machine (PGM™) (Thermo Fisher Scientific, USA). Each library was ligated with an individual adapter (the Ion Express P1 adapter sequence) to make it distinguished from others. Total contigs obtained from the Ganga, Godavari, Mahanadi, Narmada, and Brahmaputra rivers were 2184, 9226, 5116, 6541, and 1438, respectively. To create a single master contig, all of the separate stocks contigs were combined. The master contig was then mapped against the individual contig. The SSR repetitions differ from stock to stock, but they also coincide with identical repeats from same other stocks. The repeat area overlapped with each other when all the contigs were aligned together on the Excel Spreadsheet and the polymorphic SSR units were clearly visible and may be chosen accordingly with best flanking lengths. Through this approach a total of 28 polymorphic loci with an appropriate flanking sequence were chosen for validation out of which 15 loci were amplified. These loci were characterised using 30 samples of *S.seenghala* & all the 15 loci were found to be polymorphic. The repeat type of these selected SSRs is two dinucleotide, seven trinucleotide, four tetra nucleotide and two pentanucleotide.

Keywords: *Sperata seenghala*, Polymorphic, SSR, Marker, Probe Enrichment.

TRPSF-BIOTECH-O-6

Molecular Modeling of *Danio rerio* TRP Channel TRPV1 Reveals Similarity in Structure but Difference in Ligand Interaction to Mammalian Counterpart

Gulshan Kumar^{1*}, Rohitash Yadav¹, Deepak Agarwal² and A. K. Singh¹

¹College of Fisheries Science Gumla, Birsa Agricultural University, Ranchi, Jharkhand, India

²TNjFU, Institute of Fisheries Post Graduate Studies, OMR, Chennai, Tamil Nadu, India

*Corresponding author: gulshankumarabc@gmail.com

Abstract

Transient receptor potential channel vanilloid subtype TRPV1 is the most thoroughly studied member of TRP family is important for sensing of temperature as well as capsaicin, the pungent agent from chili peppers. Structural and functional information of TRPV1 from fishes are not reported so far. In this study structure and ligand interaction of TRPV1 from *Danio rerio* (DrTRPV1) was analyzed using computational modeling approach. Blastp analysis of DrTRPV1 showed sequence identity 47.20% and query cover 94% with human TRPV1. The physico-chemical property analysis using amino acid sequence showed molecular weight 93.6 kDa and isoelectric point 6.47. Conserve domain analysis predicted presence of N-terminal ankyrin repeat domain and C-terminal ion-transport domain. DrTRPV1 exhibits four-fold symmetry around a central ion pathway formed by transmembrane helices (S1-S6). The structural superimposition with rat structure (rTRPV1) shows overall RMSD 1.404 Å with perfect fitting in the transmembrane and ankyrin repeat region. The region between S5 and pore helix is very large in DrTRPV1 when compared to rTRPV1. The pore profiling confirms its dual gating mechanism. Length of the channel is 50.3 Å. The pore bottle neck is 1 Å and overall charge is -8 due to presence large number of Asp residues. Asn528A of DrTRPV1 involves with capsaizepine in place Glu570 of rTRPV1. This confers a weak interaction and hence weak response to vanilloids like non-mammalian groups. It can be concluded that DrTRPV1 shows structure similarity to mammalian but ligand interaction to non-mammalian counterparts.

Keywords: TRP channel, Zebrafish, Bitter Taste, Temperature, Ion Transport

TRPSF-BIOTECH-P-1

Characterization of Functional groups of Chitosan Nanoparticle using FTIR Spectroscopy

Akshaya Mayekar*, and Rupam Sharma

¹ICAR-Central Institute of Fisheries Education, Panch Marg, Versova, Mumbai-61, Maharashtra, India

*Corresponding author: akshayamayekar2397@gmail.com

Abstract

Among the recent scientific breakthroughs, nanotechnology is fast emerging as the new science and technology platform for many areas of science and various technological applications. Nanotechnology has provided the opportunity to deliver drugs to specific cells. Several types of nanoparticles have been used for drug delivery, but concerns regarding biocompatibility and toxicity led to the development of biodegradable nanoparticles. Chitosan and PLGA nanoparticles have been extensively investigated for drug delivery. Chitosan is a natural biodegradable cationic polymer derived by partial deacetylation of chitin, the second most abundant polysaccharide subsequent to cellulose. Chitosan nanoparticles have been examined for their potential in developing controlled-release drug delivery systems for peptides, protein antigens, oligonucleotides, and genes. Different methods for synthesizing chitosan nanoparticles include ionotropic gelation, microemulsion, emulsification solvent diffusion, and polyelectrolyte complex. Among these methods, ionic gelation is the most commonly used method for synthesizing chitosan nanoparticles. In the current study, chitosan nanoparticles were synthesized using the ionic gelation method. The mean particle size and zeta potential of chitosan nanoparticles were determined by using the Horiba Scientific Nanoparticle Analyzer SZ-100 series (Kyoto, Japan) at 25°C. Particle size analysis was performed by dynamic light scattering (DLS) method. The mean particle size and polydispersity index of chitosan nanoparticles were 63.76 nm and 0.64, respectively. The mean zeta potential of chitosan nanoparticles was determined based on the laser Doppler electrophoresis technique in the same instrument and was recorded as +15.23 mV. The FTIR spectra of the given sample exhibited peaks between 1547 and 1713 cm⁻¹ which indicated the presence of an acetylated amino group, and the peak at 1411 cm⁻¹ showed the presence of a carbonyl group. The synthesised nanoparticles will be used for various other applications.

Keywords: Chitosan, FTIR, Nanoparticle

TRPSF-BIOTECH-P-2

DNA Barcoding and Genetic Diversity Analyses of Fish Fauna of River Mahananda

Mamta Singh*, V. P. Saini, Lakan Lal Meena, Narendra Kr. Verma & Rupam Samanta

Department of Fish Biotechnology, College of Fisheries, Bihar Animal Sciences University, Kishanganj-855107

*Corresponding author: mamta0131@gmail.com

Abstract

The prerequisite for development of effective conservation strategy for an ecosystem is accurate assessment of species. The importance of this will reach to entirely different level when we deal with the river facing unrestricted and unsustainable fishing. Consequently, the need of the present study was conceptualized, which dealt with the comprehensive molecular appraisal of Mahananda's Fish fauna. A total of specimens representing 57 species were collected from 7 different sampling stations situated along the main stretch of river Mahananda flowing in the Indian state of Bihar and West Bengal. In present study, cytochrome oxidase I (COI) sequences of all the samples were generated and analysed. The analyses conducted in the present study, i.e. K2P genetic divergence, bPTP and Neighbour-Joining suggest that DNA Barcoding is an efficient and reliable tool for species identification and deciding the species boundary. Most of the species of Mahananda showed the clear existence of barcode gap. However, the presence of intra-specific and inter-specific genetic distance overlap in some species revealed the existence of hidden taxa. The COI barcode database of Mahananda's fish fauna, established in the present study, may serve as a reference library for accurate identification of fishes and will help ichthyologist, researcher, students, biodiversity managers and policy makers in proper planning with regard to conservation and management of the resources.

Keywords: DNA Barcode, COI, Mahananda, Genetic Diversity, bPTP

TRPSF-BIOTECH-P-3

Effect of oral administration of synthetic Salmon GnRH and Domperidone (Ovatide®) on reproductive performance of *Devario devario* (Hamilton, 1822)

Suparna Deb*, Jham Lal, Pradyut Biswas, Soibam Khogen Singh, Gusheinzed Waikhom, Shubham Kashyap and Arun Bhai patel

College of fisheries, Central Agricultural University, Tripura, India

Corresponding author: debsuparna66@gmail.com

Abstract

A 40-day trial was aimed to investigate the effect of oral administration of synthetic Salmon GnRH (gonadotropin-releasing hormone) and Domperidone (Ovatide®) on the reproductive performance of *Devario devario*, an indigenous ornamental fish species. Five experimental gel-based diets with different doses of the hormones were prepared to deliver specific amounts of GnRH and DOM per kilogram of fish body weight. The doses included 100µg of GnRH and 50 mg of DOM, 50µg of GnRH and 25 mg of DOM, 25µg of GnRH and 12.5 mg of DOM, 12.5µg of GnRH and

6.25 mg of DOM, and finally, 0µg of GnRH and 0 mg of DOM per kilogram of fish body weight. These diets were labeled as T1, T2, T3, T4, and Control, respectively. During the trial, the fish were fed with their respective diets, and monitored various reproductive parameters like spawning behavior, gonadal development, hormone levels, egg diameter, fertilization rates and gonad histology were monitored to assess the effects of the hormone administration. The trial concluded that the fish fed with a dose of 50µg of GnRH and 25 mg of DOM per kilogram of body weight showed significant improvements in reproductive parameters and growth compared to other treatments. Initially, on the 20th day, the inclusion of a higher dose of hormones (100µg GnRH and 50 mg DOM per kilogram of body weight) led to a significant increase in the gonadosomatic index (GSI). However, by the 40th day, the group receiving the immediate lower dose (50µg GnRH and 25 mg DOM per kilogram of feed) exhibited a significantly higher GSI. Histological observations also revealed advanced stages of oocyte development in the group supplemented with 50µg GnRH and 25 mg DOM, which correlated with GSI and fecundity. Conversely, higher doses of GnRH had a suppressive effect on oocyte maturation. Similar observations were made regarding testicular development. The testosterone hormone level in male fish and vitellogenin hormone level in female fish were highest in the groups supplemented with 25µg GnRH and 12.5 mg DOM per kilogram of body weight and 50µg GnRH and 25 mg DOM per kilogram of body weight, respectively. These hormone levels corresponded to an increased number of spermatozoa and early mature oocytes in the testes and ovaries, respectively. The results of the trial provided an insights into the impact of synthetic Salmon GnRH and Domperidone on the reproductive performance of *Devario devario* and help determine the most effective dosage for improving reproductive success in this species.

Key words: Ovotide®, Gonado-Somatic Index, Fecundity, Egg Diameter, *Devario devario*.

TRPSF-BIOTECH-P-4

Evaluation of Zinc oxide nanoparticles (ZnO-NPs) as a growth promoter in Freshwater fish (*Cirrhinus mrigala*)

Suchismita Dey*, Paresh Nath Chatterjee, Srinibas Das, Iman De, Amrita Tah, Soma Garani
Department of Fish Nutrition and Head of the Department, WBUAFS, Kolkata-37, West Bengal, India;
Corresponding author: dey.suchismita11@gmail.com*

Abstract

Zinc plays a crucial role in growth, production and reproduction of all classes of animals including fish. Considering its potential in conferring disease resistance the requirement of Zn has been revised in the latest version of NRC (2011). Precised dietary supplementation of extra Zn most often leads to improved body antioxidant status which in turn ensures improved production performances and least disease incidences. Zinc in its nano-dimensional form seems to be more efficient considering its higher bioavailability and favouring gut microbial niche. The present study emphasizes the effectiveness of zinc oxide nanoparticles (ZnO-NPs) alone or in combination with vitamin-E in freshwater carp Mrigal (*Cirrhinus mrigala*). The basal diet (CP 29.77%) was used as control (T1). The basal diet was devoid of vit-E (dl- α -tocopheryl acetate) and zinc (Zn) fortification. In treatment groups, basal diets were supplemented with vit-E (dl- α -tocopheryl acetate @ 100 IU) in T2, inorganic zinc oxide (ZnO @ 30 ppm) in T3 and nano-sized zinc oxide (nano-ZnO @ 30 ppm) in T4. The diet for Treatment 5 (T5) was fortified with inorganic zinc oxide (ZnO @ 30 ppm) along with vit-E (dl- α -tocopheryl acetate @ 100 IU), while diet 6 (T6) was fortified with nano-sized ZnO (nano-ZnO @ 30 ppm) along with vit -E (dl- α -tocopheryl acetate @ 100 IU). Fortification of basal diet with ZnO-NPs and vit-E, significantly improved growth performance, nutrient utilization, survivability, digestive enzyme activity and decreased pathogen count in the gut of the experimental fish *Cirrhinus mrigala* by virtue of its higher absorption, bioavailability and gut optimizing role. The overall potency of ZnO-NPs (@ 30 ppm) has been intensified in presence of vit-E (@ 100 IU). This synergism needs to be further explored at largescale commercial application to designate it as a 'new generation feed additive' for aquaculture use.

Keywords: Growth, Nutrient Utilization, Digestive Enzyme Activity, Zinc Oxide Nanoparticles, Vitamin-E

TRPSF-BIOTECH-P-5

Expression profiling of selected genes confirms neuro-endocrine inhibition of milt release from *Clarias magur* males during induced breeding

Diganta Dey, Kiran D. Rasal, Dhalongsaih Reang, Aparna Chaudhari*
Fish Genetics and Biotechnology Division, ICAR-Central Institute of Fisheries Education, Mumbai
*Corresponding author: aparnac@cife.edu.in

Abstract

The Indian catfish *Clarias magur* is an important aquaculture species due to its taste and nutritional benefits. In the wild, magur breeds naturally after a complex reproductive behaviour, but captive breeding is not very successful. The commercial-induced breeding agents do not induce spontaneous milt release from magur males, and it is a practice to sacrifice/ surgically operate males to collect mature testis. Recently, gonad and brain transcriptomes of magur were

sequenced by FGB Division, CIFE and the comparative analysis of genes expressed at mature, 6 h post Ovotide injection (h.p.i.) and 16 h.p.i. stages revealed that although LH surged post GnRH administration in male magur, a few factors like the inhibitory neurotransmitter GABA, altered ratio of T: 11-KT, increased testicular bile acids, and sevatoxin-neurophysin, were most likely involved in a neuro-endocrine inhibition of milt release. Since the hypothesis was based on RNASeq data, this present work was carried out to profile the expression of six relevant genes by real time PCR. These were glutamic acid decarboxylase genes *gad67* & *gad65* (GABA synthesis), sodium and chloride dependent GABA transporters *gat1* & *gat3*, sterol 12-alpha-hydroxylase gene *cyp8b1* (determines bile acid ratios in bile), tyrosine hydroxylase gene *th* (dopamine synthesis), and P450 aromatase genes *cyp19a* & *cyp19b* (estrogen synthesis). Two groups of three males and three females each were made. Brain and gonad tissues were collected from uninjected mature fish and 16 h post GONOPRO-FH™ injection that was administered @ 1.0 mL Kg⁻¹ B.W. to females and 0.5 mL Kg⁻¹ B.W. to males. Total cDNA was prepared and PCR conditions were optimized. The 7 PCR products were confirmed by Sanger sequencing and relative expression profiling was done by real time PCR with β actin gene as the internal control. While *gad67* transcript was comparable in the mature male and female brains, they had 3.5- and 3.0-fold higher expression, respectively, at 16 h.p.i. Since GABA Transporters Gat 1 and 3 were downregulated at this time point, this indicates the upregulation of free GABA. Gad65 had <2-fold variation. Cyp8b1 shows 10-fold upregulation in testis at 16 h.p.i., but not in the ovary. This indicates the altered ratio of bile acids that may adversely affect testicular function. CYP19b is the brain isoform of the enzyme that synthesizes estrogen and it showed 2.5-fold upregulation in male brain at 16 hpi, which could negatively impact male sexual behaviour. It is plausible that upregulation of Cyp19b is part of the neuro-endocrine inhibition of milt release observed in magur males. The *th* gene expression was 5- and 3-fold higher in the female and male brains, respectively. Although dopamine synthesis is an expected response to GnRH administration, it is possible that the quantity of the dopamine antagonist domperidone included in the commercial GnRH formulation is not enough to inhibit the dopamine being produced in the catfish brain at 16 hpi. Thus, expression profiling of targeted gene by real time PCR affirms the earlier hypothesis of neuro-endocrine inhibition of milt release from magur males and confirms the involvement of GABA, estrogen, and testicular bile acids in the control of magur male reproductive behaviour during captive breeding.

Keywords: *Clarias magur*, GnRH, GABA, Induced Breeding

TRPSF-BIOTECH-P-6

Molecular Characterization of Dopamine receptor of Striped Murrel *Channa striata* (Bloch, 1793)

Siba Shinde^{1*}, Prachi Asgolkar¹, Kiran D. Rasal¹, Arpit Acharya¹, P. Vinay Kumar¹, Rajesh Kumar², Arvind Sonwane¹, Manoj Brahme¹, Aparna Chaudhari¹, and Naresh Nagpure¹

¹ICAR- Central institute of Fisheries Education, Mumbai 400061, Maharashtra, India

²ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar 751002, Odisha, India.

*Corresponding author: shinde.ftmb107@cife.edu.in

Abstract

The reproduction in teleost is controlled by Brain pituitary gonadal axis (BPG). Dopamine is a neurotransmitter and plays an important role in control of reproduction in all over vertebrates. Dopamine inhibits the stimulatory regulation of the BGP axis by inhibiting secretion of gonadotropin releasing hormone (GnRH). Dopamine receptors are G-protein coupled receptor (GPCR) and are classified into two types D1 and D2 and D1 type receptor having role in inhibition of adenylyl cyclase and it subsequently inhibit secretion of GnRH results in failures in reproduction. Striped murrel (snakehead) *Channa striata* (Bloch, 1793), is an important food fish in India. Asynchronous maturation of striped murrel during breeding season creates a problem. In present work molecular characterization of DR was carried out. The full length sequencing cDNA by using RACE PCR was carried out and it showed a DR sequence of 825 bp which encodes 275 amino acids. BLASTp analysis revealed that the Dopamine receptor (DR) amino acid sequence had 98.9% similarity with *Channa argus* followed by 99% with *Scatophagus argus*. The deduced amino acid sequences of the DR showed the expected conserved domains, which includes seven membrane spanning domains. It was observed in phylogenetic analysis that it has close association with *Channa argus* along with other fish species. The sequence information revived through sequencing can be used to understand reproductive biology of murrel using expression studies and devise strategies for induced breeding.

Keywords: Brain Pituitary Gonadal Axis (BPG), Neurotransmitter, Phylogenetic Analysis, G-Protein Coupled Receptor (GPCR)

TRPSF-BIOTECH-P-7

Molecular characterization of genes associated with vitellogenesis and choriogenesis in the liver tissue of *Channa striata* (Bloch, 1793)

Ajmeera Usharani, Manoj Brahmene, Kiran Rasal
ICAR-Central Institute of Fisheries Education, Panch Marg, Versova, Mumbai-61, Maharashtra, India
*Corresponding author: usharani@meera@gmail.com

Abstract

Channa striata (striped snakehead) is commercially important species. It gains its importance due to its taste, texture and medicinal value of this fish. Vitellogenesis is a process of formation of yolk in oocyte which provide nutritionally suitable environment for embryonic development and choriogenesis is a process of formation of chorion (egg envelope) which is helpful in fertilization and protects the developing embryo against environmental and mechanical factors. Vitellogenesis and choriogenesis are the process mediated by vitellogenin and choriogenin precursor proteins. They synthesized in liver when it exposes to estrogen and moves through haemolymph and accumulate in the oocyte. Both the vitellogenin and choriogenin used as biomarkers for estrogenic xenobiotic studies in amphibians and reptiles. Here we cloned and characterized the partial coding sequence of vitellogenin A (*vtg A*), vitellogenin C (*vtg C*) and choriogenin H (*chg H*) genes from *Channa striata*. The primers for these genes are designed from the conserved regions of the *Channa argus* and *Channa punctata*. Cloning was done by Pjet 1.2 blunt vector. The quality of the sequences is checked by DNAbaser and homology search was done by NCBI BLASTn. The partial coding sequences of vtg A, vtg C and chg H are 446 bp, 386 bp and 456 bp respectively which encodes 148, 128 and 151 amino acids. This partial sequence information is useful to characterize the full-length sequence and for expression studies. It will be useful to understand their role in reproductive pathway and Xenobiotic studies.

Key words: Vitellogenesis, Choriogenesis, Chorion, Embryonic Development.

TRPSF-BIOTECH-P-8

Molecular Characterization of Gonadotropin Releasing Hormone Receptor of Striped murrel (snakehead) *Channa striata* (Bloch, 1793)

Prachi Asgolkar¹, Siba Shinde¹, Arpit Acharya¹, Pokanti Vinay Kumar², Kiran D. Rasal¹, Arvind Sonwane¹, Rajesh Kumar², Manoj Brahmene¹, and Aparna Chaudhari¹
¹ICAR - Central Institute of Fisheries Education, Mumbai 400061, Maharashtra, India.
²ICAR - Central Institute of Freshwater Aquaculture, Bhubaneswar 751 002, Odisha, India.
*Corresponding author: prachiasgolkar23@gmail.com

Abstract

The reproduction in teleost fish is primarily controlled by the brain-pituitary-gonadal axis. The gonadotropin releasing hormone receptors (GnRHR) play an important role in activation of gonadotropin releasing hormone (GnRH). GnRHR is the G-Protein coupled receptor (GPCR) which binds to GnRH and promotes activation of the BPG axis. The action of GnRH is necessary for release of gonadotropins that plays an important role in maturation and spawning. Striped murrel (snakehead) *Channa striata* (Bloch, 1793), an air-breathing fish, is one of the most important food fish in India, Thailand, Vietnam, Malaysia and Philippines. The asynchronous maturation of this species during breeding season creates a serious problem in seed production. In this work, molecular characterization of GnRH-R gene was carried out and computational tools were used for analysing sequence data. Studies implicated that GnRH receptors in fish show 1323 bp sequence, encodes 440 amino acids in ORF. The architecture of GnRHR gene exhibited key features of G protein-coupled receptors (GPCRs), including seven membrane spanning domains, putative N-linked glycosylation motifs, and phosphorylation sites of serine and threonine residues. Phylogenetic analysis depicted close association with *Channa argus* and other fish species. It shared 88%, 85%, and 83% sequence identities with *Channa argus*, *Lates calcarifer*, and *Anabas testudineus* GnRH II receptor sequences, respectively. The generated sequence information will help to understand reproductive biology of murrel using expression studies and devise strategies for induced breeding.

Keywords: *Channa striata*, Gonadotropins, N-Linked Glycosylation Motifs, ORF

TRPSF-BIOTECH-P-9

Molecular Characterization of Nematode Parasite Infecting Fish of Barvi Reservoir, Maharashtra

Gowhar Iqbal, A. Pavan-Kumar*, Balange A.K., Sanath Kumar H., Rajendran K.V
ICAR-Central Institute of Fisheries Education Mumbai, Maharashtra
*Corresponding author: pavankumar@cife.edu.in

Abstract

A parasite is an organism that survives in or on another species, usually at the expense of its host. Among the fish-infecting parasites, three types of helminth parasites, namely, roundworms (nematodes), flatworms or flukes (trematodes), and tapeworms (cestodes), have the potential to cause zoonotic diseases. Accurate identification of fish

parasites is essential to studying host-environment relations and formulating subsequent preventive strategies. The present study characterized the nematode parasites of the fishes caught from the Barvi reservoir, Maharashtra using the nuclear 18S rDNA (SSU) sequence. The nuclear 18S rDNA (SSU) was amplified into two overlapping amplicons and sequenced to identify the species based on the sequence similarity with the NCBI GenBank database. The 18S rDNA sequences showed 98% similarity with the species of *Eustrongylides*. The average genetic distance value between the present study sample and species of *Eustrongylides* was 0.003. In the phylogenetic tree, the sequence clustered with the species of *Eustrongylides* with significant bootstrap values.

Keywords: Parasite, Eustrongylides, 18S rdna, Molecular Characterization

TRPSF-BIOTECH-P-10

Molecular Docking-Assisted Bioremediation: A Promising Approach for Environmental Restoration

Satyam*, Supriya Rani

College of Fisheries, Central Agricultural University, Lembucherra, Agartala, Tripura

*Corresponding author: satyamsingh0711@gmail.com

Abstract

Bioremediation, the use of living organisms or their components to eliminate or mitigate environmental pollutants, has emerged as a sustainable and cost-effective strategy for environmental restoration. However, the success of bioremediation techniques often depends on the efficient identification and utilization of suitable bioremediation agents. In recent years, molecular docking, a computational technique, has gained significant attention as a powerful tool for predicting the interactions between small molecules and target proteins, thereby enabling the rational design and optimization of bioremediation processes. This abstract aims to highlight the potential of molecular docking in enhancing the efficacy of bioremediation processes. Through molecular docking, the binding affinity and interaction modes between pollutants and potential bioremediation agents can be predicted, facilitating the selection of optimized microbial strains or enzymes for specific remediation tasks. By understanding the molecular basis of these interactions, researchers can identify key residues or functional groups involved in pollutant degradation and further engineer or modify the bioremediation agents to enhance their catalytic activities. Moreover, molecular docking can aid in identifying synergistic interactions between multiple bioremediation agents, leading to the development of novel consortia or microbial communities capable of degrading complex mixtures of pollutants. Through the rational design of enzyme cascades and metabolic pathways, molecular docking can assist in optimizing the degradation efficiency and substrate specificity of the bioremediation agents, enabling the efficient removal of a wide range of contaminants from diverse environmental matrices. Furthermore, the integration of molecular docking with other omics technologies, such as genomics, transcriptomics, and proteomics, can provide a comprehensive understanding of the genetic and biochemical mechanisms underlying pollutant degradation. This knowledge can guide the development of genetic engineering strategies to enhance the bio-degradative capabilities of microbial strains and improve their survival and performance in the target environment.

Keywords: Environmental Pollutants, Bioremediation Processes, Metabolic Pathways, Synergistic Interactions

TRPSF-BIOTECH-P-11

Molecular identification through DNA barcoding of different ambiguous SIS (Small Indigenous Species) fishes from Sylhet water bodies

Shamima Nasren

Fisheries Faculty, Sylhet Agricultural University, Bangladesh

*Corresponding author: snasren-fbg@sau.ac.bd

Abstract:

The ichthyofaunal diversity of Sylhet in Bangladesh is diverse and is affected due to various anthropogenic factors. For authentic identification at species level, approximately 655 bp of the mitochondrial cytochrome c oxidase subunit I (COI) gene of 7 small indigenous fish species (SIS) were amplified and a barcode dataset was generated. The genetic diversity of freshwater fishes is still anonymous in several drainage systems in northwest Bangladesh. Moreover, the comparative genetic analysis is largely sporadic to judge their actual diversity and true status. We generated 7 DNA barcodes of 30 morphologically identified SIS fishes collected from three major waterbodies of Sylhet region; namely: the Surma river, Ratargul swamp and Singairbeel. The genetic similarity for species discrimination from NCBI was detected (91.69-100)% in 07 species (*Botiadario*, *Channapunctatus*, *Ompokpabo*, *Lepidocephalichthysannandalei*, *P. chola*, *P. stoliczkanus*, *P. ticto*), which signified the occurrence of concealed genetic diversity in this ecozone. The present study would help to develop conservation schemes for the native species and collegiate ecosystem, which associated with the

livelihoods of people in this region. This study, for the first time, focuses on COI based molecular characterization of the ambiguous small indigenous species of Sylhet, Bangladesh and therefore, might work as a referral study for their authentic identification and in-situ conservation.

Keywords: DNA Barcoding, Cytochrome C Oxidase Subunit I (COI), Collegiate Ecosystem

TRPSF-BIOTECH-P-12

Study of genotoxicity and gene expression modulation associated with selected antiparasitic drug used in aquaculture on *Danio rerio* (Hamilton, 1822)

Ad Viral Kumar G¹, Sujit Kumar^{1*}, Vivek Shrivastava¹, Smit Lende¹, S.I. Yusufzai².

¹Post Graduate Institute of Fisheries Education and Research, Rajpur (NAVVA) Himmatnagar, Kamdbenu University

²College of Fisheries Science, Veraval

*Corresponding author: sujit@ku-guj.com

Abstract

Parasites are one of the major threats to aquaculture and the application of various antiparasitic chemicals is a widely practised strategy by aquafarmers. Many such antiparasitic drugs are toxic to hosts at higher concentrations and may induce genotoxicity. Our research aimed to study one of the antiparasitic chemicals Dichlorvos, for its genotoxic effect on zebrafish along with its effect on the expression of *p53*, *Cyp450* and *Bcl2* gene expression. The LC₅₀ and LC₂₅ 96 hr was estimated in adult zebrafish based on sub-lethal toxicity experiment and it was found to be 10.6 and 6.78 ppm respectively. The *in vivo* experiment was conducted with four different test concentrations (2.5 mg/l, 5 mg/l, 7.5 mg/l, 10 mg/l) of dichlorvos and blood samples were analysed for micronucleus and comet assay. A significant increase in micronucleus frequency, by 5.5 fold, was observed between T1 (2.5 ppm) and T4 (10 ppm) after 24 hr. The frequency of micronucleus significantly ($P < 0.01$) increased from 24 to 96 hr in all corresponding treatments. The zebrafish exposed to different concentrations of DDVP, exhibited significantly higher DNA damage ($P < 0.01$) in T4 followed by T3, T2, T1 and control. The lowest DNA damage was observed at 24 h and there was a gradual non-linear increase in the DNA damage in erythrocytes with exposure duration and the highest DNA damage were observed after 96 h for all treatments. The *p53* gene expression in gill was found to be 9.25 and 6.5 fold upregulated in T4 and T3 respectively as compared to control. The *Cyp450* gene expression was found to be 8.66 and 2.96 fold upregulated T4 and T3 gill respectively as compared to control. The expression of *Bcl2* gene was found to be upregulated by 19.1 and 10.45 fold in gill of T4 and T3 respectively as compared to control and change is more than *p53* and *cyp450*.

Keywords: Genotoxicity, Zebra Fish, Antiparasitic Drugs, LC₅₀, LC₂₅

ROUTINE OR RESEARCH

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Theme IV: One Health for Fish Wealth

TRPSF-HEALTH-O-1

Assessment of bioconcentration of biogenic iron nanoparticles in rohu fish, *Labeo rohita*

Rajive Kumar Brahmchari^{1,2}, Saurav Kumar², Ram Prakash Raman², K Paniprasad², PremPrakash Srivastava¹

¹College of Fisheries, Dr. Rajendra Prasad Central Agricultural University, Dholi, Muzaffarpur – 843 121, Bihar

²ICAR-Aquatic Environment & Health Mgt. Division, ICAR-Central Institute of Fisheries Education, Mumbai – 400 061, Maharashtra

*Corresponding author: rajive.cof@rpcau.ac.in

Abstract

Iron oxide nanoparticles (IONPs) are evaluated as a potential material to control microbes in aquaculture however; chemically synthesised particles have showed toxicity towards host. The present study was aimed to evaluate the bioconcentration and depuration of biogenic iron nanoparticles (IONPs) in *Labeo rohita*. The experimental fish were exposed to sub-lethal concentration (1/4th of LC₅₀) of biogenic iron nanoparticles through water for a period of 28 days. The uptake of IONPs in the gills, intestine, liver, and kidney was evaluated at 7, 14, and 28th day. Further, depuration study of IONPs from *L. rohita* was assessed after an additional 7, 14, and 28 days in clean water. Bioconcentration data showed highest IONPs levels in the intestine, while the lowest levels in the kidney. Iron levels were found to be increased significantly ($p < 0.05$) with exposure duration. Additionally, the depuration kinetics of IONPs revealed that the shortest elimination time for iron noticed in the intestine. Consequently, our findings demonstrate that the accumulation and depuration of iron from IONPs in *L. rohita* depends on the specific tissue and exposure duration.

Keywords: *Labeo rohita*, Iron Nanoparticles, Bioconcentration, Depuration

TRPSF-HEALTH-O-2

First report on isolation of *Aeromonas salmonicida* subspecies *salmonicida* from aquaculture environment in India: Polyphasic identification, virulence characterization and antibiotic susceptibility

Subham Kumar Pradhan¹, Rajashree Devi¹, Md. Idrish Raja Khan^{1,2}, Dibyendu Kamilya^{1,3}, Tanmoy Gon Choudhury^{1*}, Janmejey Parhi⁴

¹Dept. of Aquatic Health & Environment, College of Fisheries, CAU, Lembucherra, Tripura – 799210, India

²Late Shri Punaram Nishad College of Fisheries, DSVCKU, Kawardha-491995, Chhattisgarh, India

³Agricultural and Food Engineering Department, Indian Institute of Technology Kharagpur, Kharagpur, West Bengal-721302, India

⁴Dept. of Fish Genetics & Reproduction, College of Fisheries, CAU, Lembucherra, Tripura – 799210, India

*Corresponding author: tanmoygc@gmail.com

Abstract

This study reports for the first time the polyphasic identification, characterization of virulence potential, and antibiotic susceptibility of *Aeromonas salmonicida* subspecies *salmonicida* COFCAU_AS, isolated from an aquaculture system in India. The physiological, biochemical, 16s rRNA gene sequencing, and PAAS PCR test identified the strain as *Aeromonas salmonicida*. The MIY PCR tests established the subspecies as '*salmonicida*'. The *in vitro* tests showed the test bacterium as haemolytic with casein, lipid, starch, and gelatine hydrolysis activity, indicating its pathogenic attributes. It also showed the ability to produce slime and biofilm, and additionally, it possessed A-layer surface protein. *In vivo* pathogenicity test was performed to determine the LD₅₀ dose of the bacterium in *Labeo rohita* fingerlings, which was found to be 10^{6.9} cells fish⁻¹. The bacteria-challenged fingerlings showed skin lesion, erythema at the base of the fins, dropsy, and ulcer. Almost identical clinical signs and mortalities were observed when the same LD₅₀ dose was injected into other Indian major carp species, *L. catla* and *Cirrhinus mrigala*. Out of the twelve virulent genes screened, the presence of nine genes viz., *aerA*, *act*, *ast*, *alt*, *blyA*, *vapA*, *exxA*, *fstA*, and *lip* were detected, whereas *ascV*, *ascC*, and *ela* genes were absent. The *A. salmonicida* subsp. *salmonicida* was resistant to antibiotics such as penicillin G, rifampicin, ampicillin, and vancomycin while highly sensitive to amoxycylav, nalidixic acid, chloramphenicol, ciprofloxacin, and tetracycline. Taken together, the findings revealed that the *A. salmonicida* subsp. *salmonicida* was a virulent pathogen and could cause significant mortality and morbidity in Indian major carps.

Keywords: COFCAU_AS, *In Vivo* Pathogenicity, Virulence Genes, Antibiotics Susceptibility, Indian Major Carps

TRPSF-HEALTH-O-3

Measuring well-being of banded gourami with or without infestation of *Clinostomid* metacercariae

Tarun kumar¹, Raju Baitha², Kundan Kishor Rajak^{3*}, Abhijeet Upali⁴ & Simanku Borah⁵

^{1, 3, 4}Department of Zoology, School of Life Science, Mahatma Gandhi Central University Bihar

²Fisberies Enhancement and Management Division, ICAR-Central Inland Fisberies Research Institute, Barrackpore, Kolkata

⁵ICAR-Central Inland Fisberies Research Institute, Regional Centre, Gunnabati, Assam

*Corresponding Author: kkrajak@mgcub.ac.in

Abstract

Fishes are hosts to taxonomically diverse parasites and infestations can be significantly affect their wellbeing. In the present study, Clinostomid metacercariae were collected from banded gourami, *Trichogaster fasciata* Bloch and Schneider 1801, from a floodplain wetland (*Kararia maun*) of Gandak River basin. The recovered metacercariae was characterized as *Clinostomum* sp. belonging to the family Clinostomatidae, from the peritoneal cavity, gills and viscera during winter of 2022-2023. The biological parameters of host fish viz. Length-Weight relationship (LWR), Condition factor (CF), Relative Condition Factor (RCF), Gastro-Somatic Index (GaSI) and Hepato-Somatic Index (HSI) was estimated for infested and non-infested fish separately. Regression parameter of Length-Weight Relationship (*b* value), mean±SE of CF, RCF, GaSI and HSI was 3.15, 1.77±0.04, 1.06±0.06, 5.92±0.26 and 0.80±0.08 for non-infested fish, respectively. In case of infested fish, LWR (*b* value), mean±SE of CF, RCF, GaSI and HSI was 2.88, 1.74±0.03, 1.01±0.01, 5.37±0.27 and 0.70±0.05, respectively. Further, prevalence (P), mean intensity (MI) and mean abundance (MA) of the parasitic infection was also calculated and correlated with biological parameters of the fish. The estimated value of P, MI and MA were 58.77%, 21.48±6.42 and 12.62±6.42, respectively. Higher values of CF and RCF revealed that, non-infested hosts were in better condition compared to infested hosts. Regression parameter of LWR (*b*) was found to be positively allometric in non-infested fishes (*b*>3) and negatively allometric in infested ones (*b*<3). This shows that being a slightly deep-bodied fish, increase in weight of the infested fishes was low compared to non-infested hosts. Further, values of GaSI and HSI in non-infested fishes were found to be on the higher side, indicating higher feeding intensity compared to infested hosts. Hence, the present study indicated that overall well-being of non-infested hosts were better compared to infested hosts.

Keywords: Kararia Maun, River Gandak, Banded Gourami, *Clinostomum* sp.

TRPSF-HEALTH-O-4

Isolation and identification of *Citrobacter freundii* from suspected *Carassius auratus* (goldfish) and *Cyprinus carpio* var. *Koi* (Koi carp)

Simran Kaur, Harpreet Kaur, Naveen Kumar B.T.* , Anuj Tyagi

College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, 141004, Punjab, India

*Corresponding author: naveenkumarbt2022@yahoo.com

Abstract

Aquarium/ornamental fishes were subject to infectious disease outbreaks due to poor management and lack of scientific rigor. Therefore, it is crucial that, the timely diagnosis and treatment of the disease is very important. Additionally, a disease surveillance programme and early diagnosis are essential for preventing the entry and spread of disease. In this connection, ornamental fish samples (*Carassius auratus*; *Cyprinus carpio* var. *Koi*) were received from a fish hobbyist from the Ludhiana district of Punjab. A running mortality of 2-3 fishes per day with gross signs such as lethargy, fish staying at the surface and sides, etc.were recorded under case history. In the laboratory, swollen belly and edema were observed and recorded under the Level-I diagnosis. In level-II diagnosis, kidney samples showed black-centered green-colored colonies on selective media (Rimmler-Shotts agar). It was further confirmed by level-III diagnosis; 16S rRNA gene sequencing which showed 97.59% similarity with *Citrobacter freundii* strain (Accession number – MF288078.1). The results of the current study exhibited that the *Citrobacter freundii* bacteria is the causative agent of the disease.

Keywords: Ornamental Fish, *Carassius auratus*, *Cyprinus carpio* var. *Koi*, Bacteria, *Citrobacter freundii*

TRPSF-HEALTH-O-5

Efficacy of green synthesized silver nanoparticles against *Argulus* sp. an ectoparasite of fish

Pushpa Kumari¹, R. K. Brahmchari², Saurav Kumar³, K. V. Rajendran³, S.P. Shukla³, Rupam Sharma³, R.P. Raman^{3*}

¹College of Fisheries, Kishanganj, Bihar Animal Sciences University

²College of Fisheries, Dr. Rajendra Prasad Central Agricultural University, Dholi, Muzaffarpur – 843 121, Bihar

³ICAR-Central Institute of Fisheries Education, Mumbai – 400 061, Maharashtra

*Corresponding author: rpraman@cife.edu.in

Abstract

Argulosis is a dreadful disease of *Argulus* sp., a crustacean macro ectoparasite causing significant economic loss to the global aquaculture industry. In the present study, silver nanoparticles (AgNPs) were synthesis from 1mM AgNO₃

solution using aqueous leaf extract of *Azadirachta indica* (neem) acting as a reducing and capping agent. Green synthesized AgNPs was then characterized under UV-Vis spectroscopy, dynamic light scattering (DLS) technique, zeta potential measurements, transmission electron microscopy (TEM) and Fourier Transform Infrared Spectroscopy (FT-IR). The UV-Vis spectrum showed a surface plasmon resonance peak at 425 nm. Zeta potential analysis proved the stability of AgNPs by having the value -28.5 mV. The FTIR analysis showed that AgNPs were capped by various phytochemicals and TEM confirmed the spherical shape of nanoparticles of size ranging from 20 to 50 nm. The in vitro antiparasitic efficacy (AE %) of synthesized AgNPs was tested against the copepodid and adult stages of *Argulus* sp. The experiment was conducted in triplicates with positive (1 mM AgNO₃) and negative control (without AgNPs). Significantly higher AE of 100% was found for biosynthesized AgNPs against copepodid at 25 ppm and adult *Argulus* at 50 ppm with an estimated 6 h EC₅₀ of 9.66 and 16.03 ppm, respectively. However, no mortality was observed in the negative and positive control groups within 6 h of exposure. Hence, the present study reveals that the biosynthesized AgNPs could be a promising nanoform for safe and effective control of different life stages of *Argulus* parasites.

Keywords: Green Synthesis, Silver Nanoparticles, *Argulus*, Antiparasitic Efficacy, Nanodrug

TRPSF-HEALTH-O-6

Prevalence and genotyping of Non-Typhoidal *Salmonella enterica* (NTS) in seafoods in Mumbai

Parmanand Prabhakar¹, Manjusha Lekshmi², Toms C. Joseph³, Binaya Bhusan Nayak², Sanath Kumar H^{2*}

¹Department of Fish Processing Technology, College of Fisheries, Bihar Animal Sciences University (BASU), Kishanganj, Bihar-855107

²Quality Control Laboratory, Department of Post-Harvest Technology, ICAR-Central Institute of Fisheries Education (CIFE), Mumbai-400061, India.

³Department of Microbiology, Fermentation & Biotechnology, ICAR-Central Institute of Fisheries Technology (CIFT), Wilington Island, Kochi-682029, India

*Corresponding author: sanathkumar@cife.edu.in

Abstract

Non-typhoidal salmonella (NTS) is an important cause of food-borne infections worldwide and is often found as a secondary contaminant in seafood. The diverse NTS serotypes associated with seafood might vary in terms of their virulence potential. In this study, 82 seafood samples collected from three fish landing centres and seven retail fish markets in Mumbai were studied with respect to the distribution of virulence genes and antimicrobial resistance. A total of 94 *Salmonella* isolates were recovered from seafood samples using multiple enrichment broths and selective isolation media with an overall incidence of 20.73 %. The isolates were further screened for the virulence genes associated with *Salmonella* pathogenicity islands (SPIs). Based on the presence virulence genes *Salmonella* isolates were categorised into 41 (G1-G41) genotypes. The isolates belonging to different genotypes carried 3-14 genes and the group G1 harboured the least number of genes (*invA*, *stn* and *misL*). The genotype G41 with 12 isolates (12.7 %) was positive for all 14 genes (*invA*, *hilA*, *marT*, *mgtC*, *orfL*, *spiC*, *pipD*, *stn*, *ttrC*, *sodC*, *gogB*, *sopB*, *misL* and *iroB*) tested in this study. The results of this study suggest a higher level of contamination of seafood with *Salmonella*. Further, the seafood-borne NTS can vary significantly in their virulence gene composition and therefore might differ in their pathogenicity.

Keywords: *Salmonella*, Genotype, Seafood, Pathogenicity

TRPSF-HEALTH-O-7

Study of the parasite burden in selected fish from the lentic ecosystems of East Champaran

Abhijeet Upali, Tarun Kumar and Kundan Kishor Rajak*

Department of Zoology, School of Life Science, Mahatma Gandhi Central University Bihar

*Corresponding Author: kkrajak@mngcub.ac.in

Abstract

Fish health in any aquatic ecosystem is an important indicator of water quality. In the present study, seven prevalent small fishes namely *Puntius conchoni*, *Heteropneustes fossilis*, *Mystus tengara*, *Channa punctata*, *Colisa lalia*, *Mastacembellus guntheri* and *Ompak pabda* were selected for screening of parasitic load in lentic ecosystems of East Champaran. For ecto-parasite, the external surface of the fish was examined with the help of the magnifying glass. Further, in collected fish species scales, fins, tail, and gills were rubbed thoroughly with the help of a brush in 10 ml of 0.9% NaCl. The collected NaCl solutions were screened for ecto-parasites under the microscope with different magnification. Furthermore, for endo-parasites, fish was anesthetized with the help of clove oil and left for some time in cold water to euthanize. After dissection, internal organs such as the gills, liver and digestive tract were kept in NaCl solution for further screening. Among the selected fish species there are no parasites found in the *Ompak pabda*. The maximum parasitic burden was found in *Colisa lalia*. Among the seven selected fish, six were infected with Monogenean,

Digenean, Acanthocephalans, Cestode and Aspidogastrea. Thus, the present study indicates the freshwater fishes were highly exposed to be infected by parasitic infections which cause a lot of economic loss.

Keywords: Endoparasites, Lentic ecosystem, East Champaran

TRPSF-HEALTH-O-8

Vaccination of Koi carp (*Cyprinus Rubrofasciatus*) against *Aeromonas Hydrophila* employing Biofilm Oral Vaccine

Abhiman, Naresh Raj Keer, Sagarika Swain, Showkat Ahmed Dar, Susmita Rani, Sangeeta Kumari
College of Fisheries, Kishanganj, Bihar Animal Sciences University, Patna

*Corresponding author: abhifishco@gmail.com

Abstract

Biofilm of *Aeromonas hydrophila* oral vaccine was developed in the laboratory to evaluate the effect of biofilm oral vaccine on the growth, survival, antibody titre, hematological, immunological responses and disease resistance in koi carp. Fish were fed with biofilm and free cell at the dosage of 10^{10} cells/fish/day for initial 20 days and basal feed for remaining experimental period. Specific growth rate, Mean weight gain, was significantly higher ($p < 0.05$) and Feed conversion ratios were best in the biofilm vaccinated group than free cell vaccine and control. Biofilm vaccine had a significant effect on the hematological, antibody response, immunological and serum biochemical indices. Higher Relative percent survival (87%) was observed in the group immunized with the biofilm than free cell immunized group (40%). At the end of the experiment, histopathology of mid gut of biofilm vaccinated samples showed multiple gut associated lymphoid tissue, organized enterocytes and hind gut of biofilm treated fishes showed elongated villi with reduced lumen area, intact architecture of villi, enterocytes and increased in number of goblet cells.

Keywords: Biofilm Vaccine, Free Cell Vaccine, *Aeromonas hydrophila*, Koi Carp

TRPSF-HEALTH-O-9

Enhancing fish growth and immunity in hill aquaculture: exploring the potential of mango kernel

Chandan Debnath¹ & Sanjay Kumar Das^{1*}

¹Division of Animal and Fisheries Sciences, ICAR Research Complex for NEH Region, Umiam, Meghalaya, PIN-793103

*Corresponding author: chandannath23@gmail.com

Abstract

Aquaculture practices have transitioned from extensive to semi-intensive and intensive modes in many states of Northeast India. However, this transition presents a major concern: the impaired growth, diminished immunity, and reduced disease resistance capacity of fish within hill ecosystems. Under the prolonged cold climate conditions prevalent in hilly areas, fish growth, immunity, and disease resistance capacity remain suppressed. Consequently, aquaculture in such regions has not attained the same level of success as in the plains. To surmount this challenge, a potential solution lies in exploring plant-based approaches, specifically by fortifying fish feeds with locally available herbal products as additives. Mango kernel, renowned for its antimicrobial, antiviral, antifungal, antioxidant, properties could serve as a valuable natural enhancer of fish immunity and growth. It has been employed as a non-conventional feed for Tilapia, broiler chicken, and rats. However, no studies have been conducted to evaluate its effects on fish species gaining importance in hills. In this regard, we conducted an assessment of mango kernel powder derived from the Amrapalli variety as a feed additive for *Labeo gonius*, a medium carp species gaining prominence in Meghalaya. Our study revealed that feeding mango kernel at 0.1% to 0.5% of feed can improve fish growth rate by 15% to 16.3%, while survival against *Aeromonas hydrophila* infection increased by 25.6% to 32.3%. Based on feed conversion ratio (FCR) and fish biomass yield, our findings suggest that a dosage of 0.5% mango kernel powder appears to be the most effective. Furthermore, harnessing the abundant quantities of mango kernel waste generated in the region as a feed additive could contribute to the concept of "waste to wealth" and further enhance fish growth and immunity. While mango kernel has displayed promising results, numerous other products possess the potential to serve as enhancers of fish immunity and growth. However, their utilization remains untapped due to limited information. Therefore, we recommend ongoing research efforts to explore these aspects, placing a particular emphasis on hill aquaculture. Such endeavors can greatly contribute to ensuring safer, more secure, and sustainable fishery-based livelihoods in the region.

Keywords: Mango kernel, *Labeo gonius*, *Aeromonas hydrophila*, Immunity

TRPSF-HEALTH-O-10

Intelligent Diagnosis of Fish Diseases: A futuristic approach in Aquatic Animal Health Management

Sudeshna Sarker

College of Fisheries, Bihar Animal Science University, Kishanganj, Bihar 855107, India

*Corresponding author: sudeshna.bfsc@gmail.com

Abstract

India was the second-largest fish producing nation of the world in 2017-18 (DAHDF, 2019). Though gradually the overall fish production in the country has shown an increasing trend (2019-20: 141.64 LT; 2021-22: 162.48 LT), at present India stands in the third position following Indonesia and China. Production loss and economic loss due to fish diseases is one of the major causes of concern for the fish farmer's community. Along with better health management practices, prompt disease diagnosis is equally important. Based on manual visualization, fish health monitoring is a time consuming laborious task. With the current emergence in the technology revolution, automatic, fast, reliable and user friendly smart disease detection technology could be one of the evolutionary approach in the field of aquaculture. Several studies are already underway around the world to build intelligent software applications based on Artificial neural networks (ANNs), SMS (Short Message Service), and Fuzzy neural networks that will work depending on observed gross and clinical symptoms. DAHDF, Govt. of India, introduced an android-based mobile app RFD (Report Fish Disease) by ICAR-NBFGR on June 28, 2023, to assist farmers in reporting incidences of fish disease. Another promising intelligent technology is image-processing technique. It offers opportunities to improve the traditional approach in achieving accurate results, which will assist human experts in providing the right treatment. The purpose of this article is to emphasize the possibility of intelligent detection of fish diseases as a health management tool.

Keywords: Fish Diseases, Artificial neural networks, Image-processing technique, Management

TRPSF-HEALTH-O-11

Current status of aquatic vaccines and their future development possibilities

Bhartendu Vimal*, Sudeshna Sarker & Pushpa Kumari

College of Fisheries, Arrabari, Kishanganj, Bihar Animal Sciences University, Patna

*Corresponding author: bhartenduvimal1@gmail.com

Abstract

Aquatic vaccines, including vaccines for fish and other aquatic organisms, are essential tools in the management of diseases in aquaculture. There are several aquatic vaccines currently commercially available for use in aquaculture. These vaccines have been developed to target specific pathogens prevalent in various fish and shellfish species, including bacterial, viral, and parasitic pathogens. Aquatic vaccines are available in different types, including inactivated vaccines, attenuated vaccines, subunit vaccines, and DNA vaccines. Each vaccine type has its own advantages and limitations in terms of efficacy, safety, and ease of administration. The vaccines are designed to target a range of pathogens, including bacterial pathogens (e.g., *Vibrio*, *Aeromonas*), viral pathogens (e.g., Infectious salmon anaemia virus, Infectious pancreatic necrosis virus), and parasitic pathogens (e.g., sea lice). The selection of target pathogens depends on the prevalent diseases according to the particular aquaculture setting. There are various vaccination delivery methods employed for aquatic organisms, such as immersion, injection, bathing, and oral methods. The choice of vaccination method depends on factors such as the characteristics of the target pathogen, the fish species, and the practicality and efficacy of the vaccination technique. The future development of advanced vaccine technologies holds great promise for aquatic vaccines. These include the utilisation of novel adjuvants that enhance immune responses, innovative delivery systems such as nanoparticles or microparticles, and the application of genetic engineering and recombinant DNA technology to produce more effective and targeted vaccines. Advances in genomics and proteomics are expected to contribute significantly to the development of aquatic vaccines. These technologies can aid in the identification of potential vaccine targets, the understanding of host-pathogen interactions, and the discovery of novel antigenic proteins, leading to the development of more effective vaccines. Researchers are exploring the use of immune-stimulating compounds, such as immunostimulants and probiotics, to enhance the immune response in vaccinated aquatic organisms. These compounds have the potential to improve vaccine efficacy and disease resistance. The development of multivalent vaccines that protect against multiple pathogens in a single vaccine formulation is a possibility. Multivalent vaccines can simplify vaccination programmes, reduce stress on fish, and improve cost-effectiveness. Advancements in vaccine delivery systems, including new adjuvants, controlled-release formulations, and mucosal delivery systems, are being explored. These systems aim to improve vaccine uptake, enhance immune

responses, and provide longer-lasting protection. Ongoing research focuses on improving vaccine safety and efficacy testing methods specific to aquatic organisms. This includes the development of standardised challenge models, the evaluation of immune responses, and the assessment of long-term protection. Continued advancements in disease surveillance and diagnostics, such as rapid diagnostic tests and molecular techniques, contribute to the identification of emerging pathogens, improved disease monitoring, and the development of targeted vaccines. Overall, the current status of aquatic vaccines is promising, and there are several exciting possibilities for their future development. As research progresses and technology advances, it is expected that aquatic vaccines will become more effective, safe, and widely available, contributing to improved disease management and the sustainable growth of the aquaculture industry.

Keywords: Aquatic Vaccines, Fish Vaccination.

TRPSF-HEALTH-O-12

Designing Fusion Construct Co-expressing Glycereraldehyde 3-phosphate dehydrogenase Gene of *Edwardsiella tarda* and Interferon-gamma Gene of *Labeo rohita*

Anisha Valsalam¹, Megha Kadam Bedekar^{1*}, P.Gireesh Babu², K.V. Rajendran³

¹Aquatic Animal Health Management Department, ICAR-CIFE, Mumbai, India

²ICAR- National Research Centre on Meat, Hyderabad-500092, India

³Department of Zoology, School of Biological Sciences, Central University of Kerala, India

*Corresponding author: megha.bedekar@cife.edu.in

Abstract

The intensified aquaculture industry needs some intervention for the prevention of disease occurrence in the culture systems such as the application of vaccines. *Labeo rohita* is the important cultivable species in Indian aquaculture, and this species is reported to be affected by bacterial pathogens, including *Edwardsiella tarda*. Hence this study aimed to develop a fusion gene DNA vaccine construct for preventing *Edwardsiella tarda* infection in *Labeo rohita*. The antigenic gene of *E. tarda* and Interferon-gamma gene of *L. rohita* were taken for the fusion process. Fusion sequence selection was made by analysing the selected vector sequence, and the codon optimisation was done on the GAPDH and Interferon-gamma gene sequences for proper functionality. Two-step cloning process was done in eukaryotic expression plasmid vector pcDNA3.1 (+). The fusion gene was synthesized by overlapping PCR primers which allowed the fusion of both genes as one unit. Spacer between two genes allowed individual expression of both genes. The construct was designated as pGAPD-IFN. The pGAPD-IFN was expressed in-vitro in the SSN-1 cell line. Successful expression of pGAPD-IFN construct *in vitro* ensured the genes' proper functionality and possible use as a vaccine candidate in future. The fusion construct contained the antigenic and immune adjuvant gene for providing high protection in a short time by utilising the fish's cellular and humoral immunity pathways. Hence the fusion constructs harbouring GAPDH gene of *E. tarda*, and Interferon-gamma gene of *L. rohita* can be used for vaccinating *L. rohita* for the prevention of *E. tarda* infection.

Keywords: *Edwardsiella tarda*, Fusion DNA Vaccine, *Labeo rohita*

TRPSF-HEALTH-P-1

An Integrative Assessment of the Intersection of Fish Diseases, Human Health, and Environmental Sustainability: Adopting a One Health Framework

Praseed Sarkar¹, Suraj Saha¹, Samiran Mukherjee¹

¹ICAR-Central Institute of Fisheries Education, Mumbai 400061, Maharashtra, India

*Corresponding author: praseed.fptmb208@cife.edu.in

Abstract

With the world's growing population and potential global trade of aquaculture and fish, the risk of environmental contamination and development of fish and aquatic-derived zoonosis in humans are increasing. In the present scenario, an integrative approach is required to observe the intersection of fish disease, human health and environmental sustainability. Adopting a One Health framework can help to address this issue by considering the interconnectedness of human, animal, and environmental health. There are some key aspects in relation to one health approach in present aquaculture scenario like disease prevention and control, antibiotic use and resistance, safety of sea-food product for human consumption and environmental sustainability. Ensuring safe, secure, affordable, and quality food for all in this growing global context is pragmatically difficult. In this context, it is quite imperative to understand the ecology and dynamics of these hazards throughout the entire production chain in a One health approach which obtains optimal health of people, aquatic animal and plants and the environment. It discusses the environmental sustainability of aquaculture and the need for responsible management practices to minimize negative impacts on the environment. Effective disease management strategies that promote the health and welfare of farmed fish are essential for sustainable aquaculture production. Recent outbreaks of COVID-19 are an eye opener for

humanity and demands one health in a stronger way than before. Improving early warning systems, strengthening biosecurity, effective emergency preparedness and response are some measures to be taken to lay the framework of one health system to create all-inclusive mode of operation. In a nutshell, by adopting one health approach we can counter many dreaded situations the world is facing right now and can be a game changer for future as well.

Keywords: Aquaculture, Zoonosis, One-Health, Disease Management, Environmental Sustainability, COVID-19

TRPSF-HEALTH-P-2

***Acacia catechu*: An antimicrobial treatment remedy for fish diseases**

Aslasha Shraborni*, Pritisha Saikia, Arvind Dansena
College of Fisheries, Central Agricultural University, Lembucherra, Tripura

*Corresponding author: aslasha12345@gmail.com

Abstract

The advent and use of chemicals in every sector has been matter of concern since all these chemicals ultimately lead to bioaccumulation and biomagnification causing severe health hazards. To stop or pause these chemical racing action, we come across natural remedies. One such remedy can be Phytoextract treatments. Phytoextracts contains phytochemicals (plant-based chemicals) such as flavonoids, terpenoids, alkaloids, gossypol, tannins, having various medicinal properties can be used to cure diseases. *Acacia catechu* also known as khair is recognised as an important antimicrobial medicine yielding plant containing the phytochemical tannin. It is found to have resistance activities against both pathogenic and non-pathogenic microbes. Hence fishes affected with microbial diseases can be treated using this plant extract which also increases their immune enhancement. This abstract signifies the importance of medicine yielding plant *Acacia catechu*, the advantages of tannin and highlighting the treatment of fish microbial diseases in an environment friendly manner. This can be a farmer's friendly method on farm because it contains tannin extracts that is applied along with feed. Furthermore, it can assist optimisation of treatment in an efficient way, since tannins also have properties against inflammation, fungal diseases. Thus, it is hope to solve farmer's problems regarding treatment of fishes. And increase the survivability of fishes in the aquatic environment.

Keywords: *Acacia catechu*, Antimicrobial, Tannin

TRPSF-HEALTH-P-3

Bioassay study: Toxicity study of castor leaf aqueous extract on goldfish for 96 h (LC₅₀)

Samad Sheikh*, R.P. Raman, Saurav Kumar
ICAR-Central Institute of Fisheries Education, Mumbai, 400061

*Corresponding author: samad.ahmpb207@cife.edu.in

Abstract

Castor leaf (*Ricinus communis*) extract, has been reported to possess potential anti-parasitic properties, making it a potential candidate for controlling argulus infestation in goldfish. However, the toxicity of castor leaf extract on goldfish has not been thoroughly studied. The present study investigated the acute toxicity of castor leaf extract on goldfish (*Carassius auratus*) using aqueous solvents in a 96-hour bioassay to determine the lethal concentration 50 (LC₅₀). The LC₅₀ range finding for the toxicity study of castor leaf extract was conducted using an aqueous solvent, with concentrations ranging from 0 to 2.5 g L⁻¹. Subsequently, a definitive test was performed based on the results obtained from the range-finding test. The goldfish were subjected to periodic observations at 3-hour intervals for the first 24 hours to monitor for any mortality. Subsequently, observations were made at 6-hour intervals up to 48 hours, and then at 24-hour intervals until the completion of the experiment. The results showed that the toxicity of castor leaf extract on goldfish was dependent on the concentration and duration of exposure. The LC₅₀ of castor leaf aqueous extract for goldfish on 24, 48, 72 and 96 h were 1.9, 1.7, 1.6 and 1.5 g L⁻¹, respectively. The aqueous extract exhibited concentration-dependent toxicity, with higher concentrations resulting in increased mortality rates. Significant differences were observed in mortality rates between the concentrations tested. During the acute toxicity study, the goldfish exhibited behavioural responses such as profuse secretion of mucus, hypersensitivity, erratic swimming, loss of reflex, air gulping etc. These findings suggest that the aqueous extract of castor leaf at an optimal concentration may be considered safer for goldfish. However, further research is needed to elucidate the underlying mechanisms of toxicity and to optimize the use of castor leaf extract aqueous extract as a potential treatment for argulus infestation in goldfish.

Keywords: Bioassay Study, Lethal Concentration, Goldfish, Aqueous Extract, Ricinus Communis, Concentration-Dependent Toxicity

TRPSF-HEALTH-P-4

Attachment characteristics of *Salmonella enterica* on fish surfaces through contaminated waters

Sahna Don*, Sanath Kumar H. and Vignaesh D.

Department of Post-Harvest Technology, ICAR- Central Institute of Fisheries Education, Mumbai-400061, Maharashtra, India

*Corresponding author: sahnadon@gmail.com

Abstract

Seafood contamination with *Salmonella* bacterium is a global concern. Presence of *Salmonella* in seafood is a resultant of secondary contamination. Contaminated waters coming in contact with seafood is one of the prominent sources of *Salmonella* contamination. The attachment and detachment characteristics of *S. Typhimurium* on seafood, when in contact with contaminated waters were studied. To sterile seawater samples, 5Log CFU/g of *S. Typhimurium* (ATCC 14028) was spiked. Unit weight of *Harpadon neberus* (10g) was made to dip in these artificially contaminated waters for different time intervals (30 sec, 45 sec, 1 min) and their attachment concentration was recorded by enumeration on selective agar plates. The attachment rates on the fish samples were between 3.6 – 4.16 Log CFU/g. Subsequently, fish samples were washed in sterile freshwaters for three-time intervals (30 sec, 45 sec, 1 min). The bacterial counts obtained, indicated no significant reduction in the *Salmonella* counts after dipping in sterile waters. The results obtained in this study, suggests that *Salmonella* can instantly attach to the fish surfaces when contacted with contaminated waters. The washing of contaminated fish samples in sterile waters does not assure their detachment from the surfaces.

Keywords: *Salmonella enteric*, *Harpadon neberus*, Contaminated Waters

TRPSF-HEALTH-P-5

Assessment of hemato-biochemical indices of *Pangasianodon hypophthalmus* reared in different culture systems

Madhulika^{1*}, Sujata Sahoo², G.H. Pailan²

¹ICAR-Central Institute of Fisheries Education, Mumbai-400061

²ICAR-Central Institute of Fisheries Education, Kolkata Centre- 700091

*Corresponding author: madhulika.tripathi1010@gmail.com

Abstract

Pangasianodon hypophthalmus farming is considered one of the fastest-growing aquacultures worldwide. Over the years it has contributed to the fishery economy and livelihood of the communities that depend on it. The overall homeostasis and health of fish are highly influenced by their surroundings and culture environments. Knowing how the culture conditions and environmental parameters affect the health of stock is very important for growth and sustainability in production. Standard physiological indices are very useful for the proper monitoring of cultured fish. The health status of fish stock can be assessed by observing the hematological and stress parameters. Reference intervals of *Pangasianodon hypophthalmus* from three different culture systems (extensive, semi-intensive, and intensive culture system) were established to study these parameters following standard methodologies and non-parametric statistics. The result indicated that hemoglobin (7.42 ± 0.03 mg/dl), TEC ($2.45 \pm 0.56 \times 10^6$ /mm³), and PCV (24.24 ± 1.64 %) were found to be higher in the semi-intensive culture system; while TLC ($5.20 \pm 3.01 \times 10^3$ /mm³) and MCH (30.86 ± 0.22 pg) were higher in the intensive culture system, MCV and MCHC did not vary significantly in all culture systems. Glucose (169 ± 4.11 g dl⁻¹) and cortisol (12.50 ± 0.18 ng ml⁻¹) were found to be significantly higher in intensive culture system followed by semi-intensive culture system. SOD and catalase values did not vary significantly in all three culture systems. The study suggested that hemato-biochemical parameters can be good indicators of the health status of fish and can be assessed in a minimally invasive way and this normometric database can be used to observe and study the stress conditions and well-being of cultured pangasius.

Keywords: *Pangasianodon hypophthalmus*, Hematology, Biochemical indices, Stress, Health assessment

TRPSF-HEALTH-P-6

Effects of Guava (*Psidium guajava* Linn) leaf meal on Growth and Digestibility of rohu, *Labeo rohita* (Hamilton, 1822) Fingerlings

M.L. Ojha, Pawan Kumar, B.K. Sharma, S.K. Sharma and Virendra Singh

College of Fisheries, MPUAT, Udaipur

*Corresponding author: mlojha2005@yahoo.co.in

Abstract

The research was conducted to effects of Guava (*Psidium guajava* Linn) leaf meal on growth and digestibility of rohu, *Labeo rohita* (Ham.) fingerlings. Research was performed on five levels of guava leaf meal and monitored for a period of

60 days. The different treatments used in present study were i.e., T₀ (without guava leaf meal) and treatments: T₁ (0.05 %), T₂ (0.1 %), T₃ (0.15 %), T₄ (0.2 %) replacing equal amount of basal diet. Fingerlings were fed at the rate of 3 per cent of their body weight in split doses in the form of pellets. Feeding was done 2 times in a day. During the study, the diet supplemented with guava leaf meal did not have any detrimental impact. water temperature from 25.0°C to 28.7°C, electrical conductivity from 1460 to 1990 (µS.cm⁻¹), pH from 8.12 to 8.5, dissolved oxygen from 5.3 to 7.6 mg/l, total alkalinity from 99 to 154 mg/l, TDS from 829 to 946 mg/l and total hardness from 500 to 666 mg/l. On the other hand, during the experimental period growth parameters were significantly (P<0.05) highest as weight gain (82.293 ± 800 g) in comparison to T₁ (Cn) experimental fishes (62.213 ± .421), percent weight gain (167.040 ± 1.908 %), net gain in length (8.950 ± .015 cm) specific growth rate (1.161 ± .002 %) and gross conversion efficiency (GCE) (.592^d ± .005) in T₅ and lowest value was recorded in T₁ (control). Compared to other treatment, T₅ indicates better food use with a low food conversion ratio (FCR) (1.689 ± .014). The average value of digestibility (65.868 ± .778) was lowest in T₁ (Cn) and highest (73.365 ± .316) in T₅. These results show that guava leaf meal powder has a beneficial effect on the growth and digestibility of *Labeo rohita* fingerlings at a rate of 0.2% in the fish diet.

Keywords: *Psidium guajava*, *Labeo rohita*, Growth, Digestibility

TRPSF-HEALTH-P-7

Development of Recombinant Phage Lysins as Novel Antimicrobials against Multidrug-Resistant Bacterial Pathogens

Prapti Sudan, Naveen Kumar B. T., Anuj Tyagi*

^aCollege of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana 141004, Punjab, India

*Corresponding author: anujtyagi@yahoo.co.in

Abstract

Though having been around for several decades, phage-based control of bacterial pathogens (phage therapy) has re-emerged as an attractive alternative due to the global emergence of antibiotic-resistant bacterial pathogens. Besides whole phages, several of their products could also be used to kill the bacteria. During their lifecycle, phages produce cell wall lytic proteins (commonly known as lysin) to gain entry into or escape from the bacterial host. In the present study, three genes encoding for potentially antimicrobial lysin proteins were identified from the phage genomes sequenced in our laboratory after *in silico* analysis. Primers containing *EcoRI* and *HindIII* restriction sites were designed for polymerase chain reaction (PCR) amplification of these genes. After purification, the PCR amplicons, as well as the prokaryotic expression vector (pET28a(+)), were subjected to overnight restriction digestion with *EcoRI* and *HindIII* restriction enzymes. The prokaryotic expression vector (pET28a(+)) was also linearized similarly. The digested PCR amplicons were ligated into pET28a(+) vector followed by transformation into chemically competent *E. coli* Mach1 cells and selective plating on kanamycin-containing Luria Bertani (LB) agar plates. After confirmation of insert by PCR and restriction digestion, the recombinant plasmid was transformed into chemically competent *E. coli* BL21 (DE3) pLysS cells followed by selective plating on kanamycin and chloramphenicol containing LB agar. For the production of recombinant proteins, the log phase cultures of recombinant *E. coli* BL21 clones were induced with 1 mM concentration of isopropyl β-D-1-thiogalactopyranoside (IPTG). The purification and characterization of recombinant proteins are in progress. The study will result in the discovery and recombinant production of novel phage lysins with potential antimicrobial properties. After proper characterization of antimicrobial properties, these phage lysins could be used to control the pathogenic bacteria of human/fish health significance which will help to minimize the use of antibiotics.

Keywords: Pathogenic Bacteria, Antimicrobial Resistance, Phage, Lysin, Gene Cloning, Expression.

TRPSF-HEALTH-P-8

Characterization of Integrin gene in Mudcrab *Scylla serrata*

S. Thanuja*, K. V. Rajendran

ICAR-Central Institute of Fisheries Education, Mumbai-400061

*Corresponding author: thanuja.aahmb109@cife.edu.in

Abstract

Integrins are heterodimeric proteins comprising α and β subunits, forming receptors connecting the extracellular matrix with intracellular signalling pathways. They are integral membrane proteins that play vital roles in cell adhesion, migration, and signalling, contributing to various biological processes. While integrins have been extensively studied in various organisms, limited information is available regarding their characterisation in *Scylla serrata*, a commercially important crustacean species commonly known as the mud crab. Studies have implicated integrins in regulating immune cell adhesion, agglutination activity and phagocytosis in crustaceans, suggesting their relevance in maintaining host defence mechanisms. Characterising the gene integrin in the commercially valuable crustacean species, *Scylla serrata* will provide valuable insights into their functional significance like physiological and pathological processes. Molecular

cloning of Integrin gene involves isolating and amplifying specific integrin genes from complementary DNA (cDNA) polymerase chain reaction (PCR) and DNA sequencing. The sequencing of integrin genes has allowed for detailed structural characterisation. These findings have opened avenues for developing diagnostic tools, targeted therapies, and novel therapeutic strategies based on integrin modulation.

Keywords: Integrin, *Scylla serrata*, cDNA

TRPSF-HEALTH-P-9

Evaluation of Dietary Supplementation of Paraprobiotic *Lactobacillus rhamnosus* on Growth and Immune Responses in *Labeo rohita* (Ham.) Against *Edwardsiella tarda*

Venerability Dhar¹, Samad Sheikh¹, Ram Prakash Raman*¹, Saurav Kumar¹, Jeena K. ¹, K. Pani Prasad¹, Rajeev Kumar Brahmachari¹, Arpit Acharya¹, Chandana Dinakaran¹ and Banlam J. Marbaniang²

¹Aquatic Environment and Health Management Division, ICAR – Central Institute of Fisheries Education, Mumbai Aquaculture, ICAR – Central Institute of Fisheries Education, Mumbai, Andheri W., 400061, Maharashtra

*Corresponding author: venedhard5@gmail.com

Abstract

The present study evaluated the paraprobiotic effect of heat-inactivated *Lactobacillus rhamnosus* on growth, immunological response and disease resistance against *Edwardsiella tarda* infection. Heat inactivation of viable cells of *L. rhamnosus* was done at 75°C for 1 h. For preparation of paraprobiotic supplemented diet, the heat-inactivated bacteria were added to the basal diet (control) at three different inclusion levels i.e., 10⁶, 10⁷ and 10⁸ cells g⁻¹ diet. Fish of 10.34 g were fed with these diets for ten days and the feed was changed to un-supplemented diet (basal diet) thereafter. From the onset of feeding with different diets blood and serum samples were taken to assess the immunological parameters. Fish were challenged intraperitoneally with virulent strain of *E. tarda* on the fourteenth day of the feeding trial and the relative percent survival was recorded for the next 15 days. Immunological parameters viz., Nitroblue tetrazolium (NBT) activity, myeloperoxidase activity (MPO) and total serum protein content showed significant difference ($p < 0.05$) in all the dietary groups compared to control during the feeding period with the paraprobiotic. Wherein they were fed with un-supplemented basal diet. After challenge with *E. tarda*, the highest relative percentage survival was recorded in T₃ groups incorporated with 10⁸ cells g⁻¹ of paraprobiotic, whereas the lowest RPS was recorded in the T₁ group with the least paraprobiotic inclusion i.e., 10⁶ cells g⁻¹. The specific immunity was significantly influenced by the paraprobiotic *L. rhamnosus* feeding as evident from the bacterial agglutination titre. Percentage weight gain, specific growth rate and FCR showed no significant difference ($p > 0.05$). The results obtained from the present study indicates that the application of heat-killed *L. rhamnosus* at a concentration of 10⁶ cells g⁻¹ resulted in higher total serum protein concentration, a concentration of 10⁷ cells g⁻¹ resulted in higher MPO activity, whereas a concentration of 10⁸ cells g⁻¹ resulted in increased NBT activity, nevertheless it is undeniable that the incorporation of different levels of paraprobiotic have no significant impact on growth parameters but positively enhances immunological parameters of *Labeo rohita*.

Keywords: Paraprobiotic Supplemented Diet, Nitroblue Tetrazolium, Myeloperoxidase Activity

TRPSF-HEALTH-P-10

Biochemical characterization and antibiotic resistance profile of isolated *Citrobacter freundii* from *Carassius auratus*, Goldfish

Harpreet Kaur*, Simran Kaur, Naveen Kumar B T* and Anuj Tyagi¹

¹Department of Aquatic Environment, College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University, 141012

*Corresponding Author: naveenkumarbt2022@yahoo.com

Abstract

Aquaculture is an emerging fast-growing food-producing industry globally because of the increasing demand for fish food consumption. However, the intensive culture of fish or unscientific management practices led to the outbreak of various bacterial infections, resulting annually in billion-dollar economic losses to the aquaculture industry. Therefore, the present study includes the biochemical characterization and antibiotic resistance profile of the bacterium (COF-D-B1C1) isolated from the infected Goldfish. The biochemical characterization with methyl red, H₂S production lipase and protease activity showed a corresponding profile to the *Citrobacter freundii*, which was further confirmed by MALDI-TOF. Analysis revealed that the isolate (COF-D-B1C1) found to be resistant to ampicillin and tetracycline out of 14 tested antibiotics with a 0.14 MAR index. This study concludes that, the isolated bacterium had a significant effect on fish, representing clinical importance not only to goldfish culture but also has high risk of contamination among different fish.

Keywords: Aquaculture, Goldfish, *Citrobacter Freundii*, Antibiotic Resistance

TRPSF-HEALTH-P-11

Isolation and Identification of *Citrobacter freundii* from suspected food fish during a disease outbreak

Simran Kaur, Harpreet Kaur, Naveen Kumar B.T.* , Anuj Tyagi

¹College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, 141004, Punjab, India

*Corresponding author: naveenkumarbt2022@yahoo.com

Abstract

Fish farmers now face a significant challenge to their sustainability and expansion due to the culturable fish species' increased susceptibility to infectious diseases brought on by rapid vertical and horizontal expansion, unscientific management practices, etc. Therefore, controlling the spread of the disease or disease outbreak depends on early diagnosis, effective treatment, and best management practices. In this connection, under the National Surveillance Programme on Aquatic Animal Diseases; farmed food (carp) fish samples were received from the fish farm located in Ludhiana district of Punjab (30.918478173163006, 76.18939256573998) through passive surveillance approach. Case history information such as running mortality (1-2% fish per day), lethargy, fishes were moving at the surface and sides were documented. Further, Fin rot, tail rot, hemorrhages, scale loss, and swollen belly due to edema were observed in the level-I diagnosis. Further, kidney samples were enriched overnight and streaked on selective media (Rimler-Shotts agar) which exhibited green-colored black-centered colonies (Level-II). Furthermore, the pathogen was confirmed through matrix assisted laser desorption ionization-time of flight mass spectrometry (MALDI-TOF MS) method (level-III). The results of the current study conclude that *Citrobacter freundii* was the cause of the disease outbreak in the fish pond of the Ludhiana district of Punjab. Therefore, the fish farmer was advised to follow good management practices and use the appropriate aqua medicine.

Keywords: Food fish, Disease Outbreak, Bacteria, *Citrobacter freundii*

TRPSF-HEALTH-P-12

Klebsiella pneumoniae as a cause of infection in Nile tilapia, *Oreochromis niloticus*

Supradhnya Meshram* and Thangapalam Jawahar Abraham

Department of Aquatic Animal Health, Faculty of Fishery Sciences, WBUAFS, Kolkata - 700 094, West Bengal, India

*Correspondence author: sailjameshram@gmail.com

Abstract

Klebsiella pneumoniae is a rod-shaped, Gram-negative, and facultative anaerobic bacterium. It is widespread in nature and found in many environments such as soil, plants, industrial effluent, sewage, surface water and drinking water. It is one of the important human pathogen, causing most commonly pneumonia, typically bronchopneumonia and bronchitis. However, there are few reports suggesting its potential role as aquatic pathogen. It is an opportunistic pathogen and is usually present in normal microbiota of fish but causes diseases in favourable condition such as low water quality. The present study reports the occurrence of disease in *Oreochromis niloticus* caused by *K. pneumoniae*. The infected fish showed clinical sign such as lethargy, anorexia, gill discoloration, fin/tail rot, subcutaneous haemorrhages and ascites. Bacteria were isolated from kidney and confirmed as *K. pneumoniae* (Accession no. OQ789963) by morphological evaluation, biochemical tests and nucleotide sequence of 16S rDNA. To observe pathological changes in tissue level, kidney and brain were selected for histopathology. The kidney sections showed melano-macrophage aggregate, glomerulopathy, inflamed nephritic tubules, degeneration of nephritic tubules, cellular hypertrophy, hypoplastic haematopoietic tissue. The brain exhibits inflamed neurons, haemorrhage, granuloma-like structure, and cerebellum with sponge-like appearance. With the findings of this study, the systemic pathogenesis both on the external body parts as well as in internal organs of *O. niloticus* by *K. pneumoniae* infection could be elicited.

Keywords: *Klebsiella pneumoniae*, *Oreochromis niloticus*, Biochemical Test, 16s rdna, Histological Changes

TRPSF-HEALTH-P-13

Nanotechnology for Fish Welfare and Health

Krishna Kumar

College of Fisheries, Kishanganj, Bihar Animal Sciences University

*Corresponding author: k.kvindhya4007@gmail.com

Abstract

The ability of the particles with the special features that work as a unit within the size range is made possible by nanoscience, where objects are measured at one billionth of a metre. Nanotechnology has numerous uses in aquaculture, from the delivery of drugs, nucleic acids, peptides, feed, nutraceuticals, etc., to the water treatment system. In general, the outdated fish production systems have begun to be replaced by nanotechnology, particularly in the

areas of breeding, disease control, and postharvest technology. The nanostructured materials are employed as immunomodulatory substances in the fish illness management system to more effectively alter or distribute immunologically active chemicals to the target region. From disease-causing bacteria to lethal viruses, nanomedicine has been utilised at a lower dosage to quickly stop all types of illnesses.

Keywords: Nanotechnology, Breeding, Disease, Immunomodulatory Substances, Vaccines

TRPSF-HEALTH-P-14

Effects of Bay Laurel (*Laurus Nobilis*) Diet on Immunological Indices in Nile Tilapia (*Oreochromis Niloticus*) Culture

Jayashri Mahadev Swamy¹, Sanjay Rathod², Monica K.S³, Manjulesh Pai⁴ and Ganapathi Naik³

¹Directorate of Research, KVAFSU, Bidar

²College of Fisheries, Chhattisgarh

³College of Fisheries, Mangalore

⁴ICAR-Central Institute of Fisheries Education, Mumbai

*Corresponding author: jayashriswamy22@gmail.com

Abstract

The study was carried out to investigate the supplemental effects of dietary Bay laurel on immunological indices in Nile tilapia (*Oreochromis niloticus*) culture. A total of 225 numbers of Nile tilapia fingerlings were randomly divided into five groups each in triplicates. The control group T₀ was fed with a basal diet, while the T₁, T₂, T₃ and T₄ were fed with basal diets supplemented with bay laurel at the doses of 10, 15, 20 and 25 g/kg respectively. In the present study, significantly increased NBT, lysozyme activity, Phagocytic activity, total serum protein, albumin and globulin were observed in fish fed supplemented with the 15 g/kg of diet. Whereas significantly declined albumin-globulin ration were observed in fish fed supplemented with the 15 g/kg of diet. The findings suggested that the dietary inclusion of bay laurel at dose rate of 15 g/kg diet improved the immunological indices in Nile tilapia culture.

Keywords: Bay Laurel, Tilapia, NBT, Lysozyme, Serum Protein, Globulin

TRPSF-HEALTH-P-15

Preparation, Characterization, and Antibacterial activity of Silver Nanoparticles Synthesized Using Papaya Leaf Extract: A Promising Approach for Combating Bacterial Infections

Surya Teja Samanthula^{1*}, K. Pani Prasad^{1*}, Rupam Sharma², Megha K Bedekar¹, Jeena K.¹

¹Aquatic Animal Health Management, ICAR- Central Institute of Fisheries Education, Mumbai, 400061

²Fish Genetics and Breeding Division, ICAR- Central Institute of Fisheries Education, Mumbai, 400061

*Corresponding author: suryatejasamanthula31@gmail.com

Abstract

The intensification of aquaculture practices worldwide has led to the indiscriminate use of antibiotics as a means to control bacterial infections. This alarming trend has resulted in the emergence of antimicrobial resistance, posing significant risks to human and environmental health. To combat this issue, the present study. Therefore, this study aimed to prepare and characterize the silver nanoparticles synthesized using papaya leaf extract. The DLS, Zeta potential, TEM, SEM, FTIR, and antimicrobial analysis were performed to analyse size, charge, shape, and functional groups respectively. The DLS results revealed CPL-AgNPs (papaya leaf silver nanoparticles) size of 93.6 nm. Subsequently, zeta potential of synthesized nanoparticles was -33.9 mV indicating the moderate stabilised nature of synthesized silver nanoparticles. According to SEM analysis, the CPL-AgNPs have a rounded form, are tightly packed, and are successfully conjugating with the extract. The TEM results showed the nanoparticles were spherical in shape ranging from 20-40 nm. The functional groups in the CPL-AgNPs revealed dominant OH, C-H and C=O groups by FTIR analysis. The anti-bacterial evaluation of CPL-AgNPs was evaluated on *E. tarda* bacteria by minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC). The data showed MIC and MBC as 50 and 100 µg/mL respectively. In summary the synthesized silver nanoparticles from papaya leaves showed acceptable size and shape of nanoparticles and effective bactericidal activity.

Keywords: Silver nanoparticles, Papaya leaf extract, Antimicrobial activity

TRPSF-HEALTH-P-16

Role of Microbiome in Fish Disease Diagnosis

Testimona A.¹, R. Bharathi Rathinam², Arpit Acharya¹, Amulya S.G.¹ and Gayatri Tripathi^{1*}

¹ICAR-Central Institute of Fisheries Education, Mumbai – 400061

²ICAR-Indian Agricultural Research Institute, Jharkhand-825405

*Corresponding author: gayatrit@cife.edu.in

Abstract

The intensification, expansion and transboundary movement of live aquatic animals are some of the major barriers to the aquaculture industry. A range of new diseases and rising rates of antibiotic resistance have increased the demand for improved disease management strategies that also supports the one health concept. Most of the microbes in a fish gut are symbiotic and some might be pathogenic which can promote disease if given favourable conditions. Coexistence of symbiotic and pathogenic microbiota is very important for a healthy fish. Therefore, understanding the relationship between potentially good and pathogenic bacteria is beneficial to elucidate the pathogenesis. Some of the recognized useful bacteria can be transformed into biomarkers for the prevention, diagnosis and treatment of diseases. As per the recent reports of next generation sequencing data, the altered microbiome can impact the host's metabolism, immune system and level of resistance. Fish gut microbiome plays an important role in maintaining fish health; however, there are numerous intrinsic or extrinsic causes that might lead to disruption or imbalance in the microbiome. Therefore, the health condition of fish should be recorded by assessing the microbiome status, including the quantity of beneficial microbiota, the existence of opportunistic microbiota and the diversity of microbiome. Recent studies have proved the importance of metagenomics in a variety of microbial diseases. Although the role of the microbiome has not yet been fully determined in several diseases, mounting evidences and research in this area are accumulating. The current topic will provide an insight of the research undergoing in this area and shall discuss applications and prospects of metagenomics in fish gut microbiota research.

Keywords: Fish Microbiome, Indicators, Factors, Disease Diagnosis, Disease Prevention

TRPSF-HEALTH-P-17

Prevalence of *Flavobacterium Columnare* Infection in Ornamental Fishes of Tiruvallur District, Tamil Nadu

A. Gokul Raj* and A. Uma

Department of Aquatic Animal Health Management, Dr. M.G.R. Fisheries College and Research Institute, Ponneri, Tiruvallur District-601204, Tamil Nadu, India.

*Corresponding author: gokul.aqcpb204@cife.edu.in

Abstract

Columnaris is a disease of freshwater ornamental and food fishes. The disease is caused by *Flavobacterium columnare*, which belongs to the family Flavobacteriaceae. *F. Columnare* are Gram- negative rods that are motile on agar media by a creeping or flexing motion. In India, Columnaris disease causes huge loss to freshwater ornamental fish farmers. Kolathur market in Chennai, Tamil Nadu is an important ornamental fish trading hub of India as more than 2% of the Indian ornamental fish are traded here. The objective of this study is to understand the prevalence of columnaris in ornamental fishes cultured and traded in Tiruvallur district, Tamil Nadu. Freshwater ornamental fishes that are highly susceptible to columnaris were selected for sampling, which include *Carassius auratus* (Gold fish), *Cyprinus carpio* (koi carp), *Poecilia sphenops* (Black molly), *Xiphophorus maculatus* (Platy) and *Poecilia reticulata* (Guppy). Random samples of fishes (n=100) were collected from ornamental fish farms and outlets of Tiruvallur district and transported in live condition to the lab facility. Fishes were anaesthetized with the high dose of clove oil, dissected and tissue sample were inoculated in specific bacteriological media plates of HP6 agar, Tryptone yeast extract agar (TYES) and Cytophaga agar. *Flavobacterium* sp. were identified based on the yellowish colonies with a convoluted centre and rhizoid edges, tightly adhered on HP6 agar and absorption of congo red. The prevalence of columnaris recorded in this study was 20% in the total of 100 fish samples screened. Molecular confirmation of *Flavobacterium* sp. was done by Polymerase Chain Reaction (PCR) amplification of 16s rDNA gene that yielded 1188bp products. The GenBank, NCBI accession number for the *Flavobacterium* sp. sequence which was isolated from koi carp is MN218415. Mortality during infection may be acute, sub-acute, or persistent, depending on the particular situations of the epizootic and the mortality rate could reach as high as 60 - 90%. Stress is a primary factor which stimulates the columnaris disease; the aquatic system may contain any one stressor or combination of stressors, which facilitates the disease spread. Hence, adoption of good management practices in culture ponds so as to reduce the stress would help to prevent the onset of the disease and the associated production and economic losses due to columnaris.

Keywords: Ornamental Fish, *Flavobacterium columnare*, Tiruvallur District

TRPSF-HEALTH-P-18

Study on the healing effect of *Ayapana triplinervis* leaf as a feed supplement on the major organs of *Labeo rohita* infected with *Aeromonas hydrophila*

Ankita Saha*, Koel Bhattacharya Sanyal, Debapriyo Mukherjee, Abhisek Bardhan and Gadadhar Dash
West Bengal University of Animal and Fisheries sciences, 5 Buderhat road, Chakgaria, Kolkata-700094

*Corresponding author: sahaankita121@gmail.com

Abstract

The present study was aimed to evaluate the effects of dietary *Ayapana triplinervis* on the major organs of *Labeo rohita* (weight 20 ± 5 g, length 13 ± 2 cm) infected with *Aeromonas hydrophila*. *A. triplinervis* is a popular herb used as human medicine and was used in this experiment for the first time as a curative agent for fish. The fishes were first intramuscularly injected with LD50 dose of *A. hydrophila* and after appearance of disease symptoms they were fed with different doses of *A. triplinervis* enriched diet (1 gm Ayapana leaf powder/kg feed, 10 gm Ayapana leaf powder/kg feed and 100 gm Ayapana leaf powder /kg feed) at 2% of bodyweight for 14 consecutive days. The changes in the major organs (gill, kidney, liver, spleen, skin) were evaluated through determining the histopathological alterations on day 7 and day 14 through random sampling in different treatment group by qualitative assessment on a five-point ordinal scale. The results indicated that *A. triplinervis* supplemented diets can significantly improve the impairments in gill, kidney, liver, spleen, and skin caused by *A. hydrophila* than the untreated fish. Both 10 g *A. triplinervis* leaf powder/kg feed and 100 g *A. triplinervis* leaf powder/kg feed supplementation resulted in faster healing of the damages caused by *A. hydrophila* infection in the major organs and after 14 days with these two doses the histopathological alterations almost resolved and became normal. The present results confirmed the beneficial effects of *A. triplinervis* as a natural alternative of antibiotics for *A. hydrophila* infected *L. rohita*.

Keywords: *Aeromonas hydrophila*, *Ayapana triplinervis*, Enriched Diet, Histopathology, *Labeo rohita*, Qualitative Assessment

TRPSF-HEALTH-P-19

Prevalence of disseminated neoplasia among black clam *Villorita cyprinoides* from the Vembanad backwaters of Kerala, India.

Abhiram A^{1*}, Rahul Krishnan¹, Adarsh M A²

¹Department of Aquatic Animal Health Management, Faculty of Fisheries Science, Kerala University of Fisheries and Ocean Studies, Kochi, Kerala India, 682506.

²Department of Fish Nutrition and Feed Technology, Faculty of Fisheries Science, Kerala University of Fisheries and Ocean Studies, Kochi, Kerala India, 682506.

*Corresponding author: ram98abhiram@gmail.com

Abstract

Disseminated neoplasia (DN), also known as hemic, hematopoietic, or hemolytic neoplasia (HCN), is a proliferative disorder of the hemolymph in several bivalve species. The condition progresses by the transition of normal hemocytes to redundant neoplastic cells, rendering bivalves sensitive to pathogen insults and growth. The prevalence of disseminated neoplasia in bivalves has been documented in *Crassostrea madrasensis*, *Magallana bilineata*, and *Perna viridis* in the study area. In the present study, *V. cyprinoides* were collected from various sampling points along Vembanad Lake and evaluated for the presence of DN. Hemolymph samples from the anterior adductor muscle were collected, fixed using methanol, and stained with Giemsa. Preparations were observed for anisocytosis and anisokaryosis, defined by a high N:C ratio, mitotic figures, and binucleated, multinucleated, and indented cells. The hemocytes from the black clam displayed varying degrees of changes in hemocyte morphology, with binucleated cells, mitotic figures, and cells with a high NC ratio. This study describes the first case of DN in *V. cyprinoides* and provides further insights into this disease.

Keywords: Neoplastic Cells, Proliferative Disorder, Multinucleated Cells, Hemocyte

TRPSF-HEALTH-P-20

The potential effects of indigenous herbs on immunity of fish through haematological parameters in Common carp (*Cyprinus carpio* L.) Challenge to *Aeromonas hydrophila*

Shivam Pandey^{1*}, Gajender Singh¹, Ajay Kumar¹, Tejpal Dahiya², Ravikant²

¹Department of Aquatic Animal Health Management, College of Fisheries Science, CCS Haryana Agricultural University, Hisar, Haryana

²Department of Aquaculture, College of Fisheries Science, CCS Haryana Agricultural University, Hisar, Haryana

*Corresponding author: karateshivam97@gmail.com

Abstract

This study conducted for 90 days to evaluate the effects of neem and tulsi leaf extracts on immunity and growth parameters of common carp challenged with *Aeromonas hydrophila* infection. The fishes were fed for 30 days with an experimental diet containing different herbal extracts, including T1 (Basal diet + 5% neem leaf extract), T2 (Basal diet + 5% tulsi leaf extract), T3 (Basal diet + 5% combined neem and tulsi leaf extract) and Control diet. After 30th day T4 having the highest RBCs ($10^6/\text{mm}^3$) count 1.68, WBCs count ($10^3/\text{mm}^3$) 69.00, haemoglobin content 8.47 g/dL, PCV 24.26% followed by T2 and T1 as compared to the control group. All the haematological parameters decreased after infection and after challenged the WBCs count slightly increased in all treatments due to infection and after continue feeding with experimental diets the recovery phase is shows decreasing trend. Overall, the findings of this study concluded that the positive effects of neem and tulsi herbal extracts, both individually and in combination, on the haematological parameters of common carp infected with *A. hydrophila*.

Keywords: Haematology, Common carp, Phytotherapy, *Aeromonas hydrophila*

TRPSF-HEALTH-P-21

The present study of Efficacy of phage treatment for control of *V. parahaemolyticus* in food matrix at Ludhiana

Shiwam Dubey^{*1}, Anuj Tyagi², Jyoti Saroj³

¹Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar, Karnataka-585226

²Guru Angad Dev Veterinary and Animal Sciences University Ludhiana, Punjab-141012

³Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya-224229

*Corresponding author: shivamfisco@gmail.com

Abstract

The present study of Efficacy of phage treatment for control of *V. parahaemolyticus* in food matrix, conducted at Ludhiana, *Vibrio parahaemolyticus* is the most significant bacterial pathogen from the perspective of shrimp and human health among the different bacterial pathogens connected to the aquaculture environment. A variety of brackish bacterial pathogens, such as *Vibrio parahaemolyticus* and *Vibrio harveyi*, are relevant in human health aspects. In brackish water, *Vibrio parahaemolyticus* and *Vibrio harveyi* are found, that mostly affect prawns. Phage-based control of bacterial pathogens (phage therapy) has lately re-emerged as an appealing alternative due to the availability of contemporary phage characterization technologies and the global rise of antibiotic-resistant bacteria, despite having been around for several decades. In this research, 264 water samples collected from inland saline shrimp culture farms resulted in a total of 12 *V. parahaemolyticus* specific phages. Lytic activity was found against 2.3–45.5 % of tested *V. parahaemolyticus* isolates during the host range analysis against standard/field isolates of *V. parahaemolyticus* and other bacterial species. Other bacterial species were also not found to have lytic activity. Phage V5 was found to have a filamentous structure during transmission electron microscopy studies, indicating that it belongs to the Inoviridae family. Within 1 hour of phage treatment, a 78.1 % drop in bacterial counts was seen in shrimp during an efficacy study of the phage against *V. parahaemolyticus*. These results indicate that phage therapy could be used to control *V. parahaemolyticus* in shrimp. *V. parahaemolyticus* reduction by V5 phage in the present study. Further research is required to isolate and characterize strongly lytic phages for effective control *V. parahaemolyticus* infection in shrimp.

Keywords: Lytic Phages, Efficacy, Host Range, Phage Therapy, Lytic Activity

TRPSF-HEALTH-P-22

The use of seaweed or extruded seaweeds to create novel food products with improved shelf life

Payel Debbarma*, Suparna Deb, Aresh Das, Shivbhajan, Naresh Kumar Mehta

Department of Fish Processing Technology, College of Fisheries, Central Agricultural University, Lembucherra, Tripura- 799210

*Corresponding author: loyepa1997@gmail.com

Abstract

Seaweed is a vital component of marine ecosystems and appears in a range of hues, including green, brown, and red. Over 800 different kinds of seaweeds, including *Ulva lactuca*, *Gracilaria edulis*, *Sargassum wightii*, and *Padina tetrastromatica*, found in India. In recent years, there has been a growing interest in using seaweed to create novel food products that offer health benefits and have an improved shelf life. One approach to achieving this is through the use of extrusion technology. Noodles, crackers, and chips are just a few of the goods that may be produced by extruding seaweed. By decreasing water activity and raising the product's density, which can assist stop microbial development and oxidation, the extrusion technique can extend the shelf life of these items. Additionally, seaweed includes bioactive substances that have been demonstrated to have antibacterial and antioxidant effects, such as polysaccharides and peptides. In the Pradhan Mantri MatsyaSampada Yojana, the government has out Rs. 640 crores just to encourage seaweed farming, with a planned production of more than 11.2 lakh (1.12 million) tonnes by 2025 (PMMSY). In conclusion, the incorporation of seaweed or seaweed that has been extruded into food items offers the potential to produce unique, healthful goods that have a longer shelf life. Seaweed extrusion has to be improved, and further study is needed to determine whether seaweed can be used as a useful food ingredient.

Keywords: Seaweeds, Bioactive compounds, Extrusion Technology, Antimicrobial properties

TRPSF-HEALTH-P-23

Environmental nucleic acids: a new tool for disease surveillance in aquaculture

Satkar Sagar Gorakh¹*, Gurphale Nikita Narsing², Bhusare Saiprasad Prakash³, Tejaswini Karale³, Ashish Sahu¹

¹Faculty of Fisheries, Kerala University of Fisheries and Ocean Studies, Panangad, Kochi, Kerala 682506, India.

²Dau Shri VasudevaChandrakarKamdhenuVishwavidyalaya, Durg, College of fisheries, Kawardha, Chattisgarh, 491995, India.

³ICAR-Central Institute of Fisheries Education, Versova, Mumbai- 400061, India

*Corresponding author: sagarsatkar1996@gmail.com

Abstract

Aquaculture has been expanding remarkably over the years and is one of the fastest-growing food production industries. It needs more attention in terms of health. One of the major challenges faced by aquaculturists around the world is the variety of diseases that occur in aquaculture. In aquaculture, diseases occur due to a chain of interconnected circumstances, including the host, environment, and the presence of a pathogen. Environmental nucleic acid is defined as "nucleic acids of pathogenic agents extracted from 'true' environmental samples (such as water, soil, sediment, biofilm)." Environmental DNA/RNA monitoring of aquatic systems is a rapidly developing scientific field that offers the potential for low-cost, non-destructive technologies to test for pathogenic agents, particularly those of wild aquatic populations where samples may be difficult or undesirable to obtain. These methods are being used in different areas, including surveillance, history, and conservation. Using this technique, several diseases and parasites have been detected in aquaculture. This review focuses on the potential of eDNA/eRNA-based detection of pathogens in aquaculture and the wild. It is also useful to predict a potential outbreak before it occurs and to help people understand the factors that can degrade and hamper the detection of these nucleic acids.

Key words: eDNA, eRNA, Pathogen, Fish Health

Theme V: Fisheries Value Addition & Supply Chain for Sustainable Consumption

TRPSF-FPT-O-1

Assessment of the Blending of Fish Protein powder with Wheat Flour on the Quality Characteristics of Cookies

Tanushri Ghorai*, Anirudh Kumar, Adita Sharma and P. P. Srivastava
College of Fisheries, Dholi, Muzaffarpur - 843 121, Bihar

*Corresponding author: tanushri.cof@rpcau.ac.in

Abstract

To improve the nutritional quality, Pangasius fish protein powder was incorporated to a certain extent. In this study, we have replaced wheat flour with fish protein powder at different levels such as, 0 % (Control), 5% (T₁), 10% (T₂) and 15% (T₃) and determination of proximate composition and texture profile analysis of cookies were done. Different incorporation level of fish powders significantly increased the protein content of fish cookies and reached up to 7%, 10%, 14% and 19% for Control, T₁, T₂ and T₃ respectively and also significantly ($p < 0.05$) effected the texture of cookies and 15% incorporation showed the lowest hardness (0.052 kg) and control showed the highest (0.066 kg). During sensory evaluation, it was observed that there was no significant development of fish flavour in fresh cookies even after 15% incorporation and overall acceptability was not affected. Fish powder can be introduced to cookies preparation which can improve the nutritional quality of cookies as well as textural profile and sensory acceptance.

Keywords: Fish Cookies, Nutrition, Proximate composition, Texture, Sensory evaluation

TRPSF-FPT-O-2

Carboxy methyl cellulose, Xanthan gum and Carrageenan Coatings Reduced fat uptake, Protein Oxidation and Improved Functionality in Deep Fried Fish Strips: An Application of Multi-Objective Optimization (MOO) Approach

Kumar Gaurav¹, Naresh Kumar Mehta^{1*}, R. K. Majumdar¹, M. Bhargavi Priyadarshini¹, and Prasenjit Pal²

¹Department of Fish Processing Technology and Engineering, ²Department of Extension and Social Sciences, College of Fisheries, Central Agricultural University, Lembucherra, Tripura, India -799210

* Corresponding author: nareshfishco@gmail.com

Abstract

In this study multi-objective optimization (MOO) approach for effective decision making was applied to evaluate three hydrocolloids viz. Carboxy methyl cellulose (CMC), Xanthan gum & Carrageenan for oil reduction and protecting the protein oxidation during the frying of fish strips. Different concentrations (0.25 - 1.50 % (w/v)) of CMC, Xanthan gum & Carrageenan were applied over fish strips and its coating, oil uptake, textural and protein oxidation parameters were studied. Pickup of the strips increased significantly with increasing concentration. Accordingly, proteins oxidation during deep frying shows lower carbonyl and sulfhydryl contents. The hardness, toughness and cutting force of coated fish strips found to be declined significantly with increasing coating concentrations in all coated strips. The MOO approach is utilized to arrive at the best possible solution when several variables are changing simultaneously. The moisture (max), lipid (min), toughness (min), hardness (min), cutting force (min), Oil uptake reduction (max), Oiliness (min), carbonyl (max), sulfhydryl (min) were considered as multiple criteria for MOO technique fried fish coated with CM4 (1 % CMC), followed by XG3 (0.75 % xanthan gum) and CG3 (0.75 % carrageenan) were emerged as the best optimal coating.

Keywords: CMC, Xanthan gum, Carrageenan, Fat Absorption, Frying, Fish products.

TRPSF-FPT-O-3

Coconut husk extract as natural preservative for shelf life enhancement of chilled stored *Labeo rohita*

Pooja Saklani¹, K.C. Dora², Supratim Chowdhury² and Swarnadyuti Nath²

¹Department of Fish Processing Technology, College of Fisheries Kishanganj, BASU- 855107, Bihar

²Department of Fish Processing Technology, Faculty of Fishery Sciences, West Bengal University of Animal and Fishery Sciences

* Corresponding author: poojasaklani100@gmail.com

Abstract

Coconut husk represents a good source of phytochemicals used as functional ingredients. The present study was conducted to evaluate the efficacy of green coconut shell extracts as natural preservatives during chilled storage of *Labeo rohita*. Green coconut husk was extracted for phenolic compounds using ethanol, hot water and a mixture of

ethanol and hot water as solvent. The results showed that total phenolic content (TPC) was highest in ethanolic extract (331.44±0.26mg GAE/g), followed by mixture of ethanol and hot water (300.35±0.23mg GAE/g) and hot water extract (269.76±0.25mg GAE/g). In-vitro antimicrobial study revealed that the crude extract had antimicrobial properties toward selected pathogenic bacteria. The fish was divided into 4 lots and labeled as ethanol coconut husk extract (ECHE) (400mg/l), a mixture of ethanol and hot water coconut husk extract (MEHCHE) (500mg/l), hot water coconut husk extract (HWCHE) (600mg/l), and control sample. Conventional ice made of potable water was used as the control. The ice stored fish was evaluated for the changes in pH, volatile basic compounds, oxidative parameters and total viable counts. Fish stored in ice, prepared with different concentrations of coconut husk extracts significantly reduced the values of total volatile basic nitrogen, peroxide value, thiobarbituric acid reactive substances and total viable counts compared to conventional icing. According to biochemical and microbiological evaluation, shelf life of *Labeo rohita* was determined to be 15 days for fishes stored under conventional icing system, 21 days for fishes stored in ice containing ECHE and MEHCHE, while 24 days for the fishes kept in ice containing HWCHE.

Keywords: Phytochemicals, Antimicrobial Properties, Microbiological Evaluation

TRPSF-FPT-O-4

Prevalence & Existence of Antimicrobial genes in *Vibrios* spp. Isolated from Seafood Market of Mumbai

Dr. Abhishek Thakur¹, Dr. B. Chrisolite², Dr. Faisal Rashid Sofri³ & Dr. Kawkabul Saba³

¹Department of Fish Processing Technology, College of Fisheries, (Bihar Animal Sciences University, Patna) Kishanganj – 855107;

²Department of Fish Pathology and Health Management, Fisheries College and Research Institute, (Tamil Nadu Dr. J. Jayalalithaa Fisheries University), Thoothukudi – 628 008;

³Division of Post Harvest Technology, Faculty of Fisheries, (Sher e Kashmir University of Agricultural Science and Technology, Srinagar), Jammu & Kashmir-190006.

* Corresponding author: abhia229@gmail.com

Abstract

Vibrios are Gram -Ve, slightly curved, fermentative rods widely distributed in the coastal marine environments. *Vibrios* can contaminate seafood and pose a significant risk to human health. Three main *Vibrio* species, *V. cholerae*, *V. parahaemolyticus* and *V. vulnificus*, are potentially pathogenic to humans. They cause infection to human ranging from gastroenteritis to septicemia and wound infection. The emergence of antimicrobial and multidrug-resistant bacteria is another serious public health threat worldwide. The high prevalence of *Vibrios* and multi drug resistant isolates could pose a potential risk to consumers. This study focused on prevalence, antibiotic resistance pattern and antibiotic resistance genes associated with *Vibrios* spp in shrimp from Mumbai fish market. A total of sixteen *Vibrios* spp. were isolated from shrimp and characterized. All isolates of *Vibrios* spp. were shown positive against oxidase test and O/129 susceptibility test except isolate no. V8G & V9G (O/129). Ten different antibiotics were tested against the isolates viz V1G, V2Y & V3G and found resistant against antibiotics namely Cefotaxime, Cefpodoxime, and Ceftadizime & Amoxicillin. Presence of *Vibrios* Spp. in shrimp which showed resistance to 3rd generation cephalosporins and Penicillins broad spectrum antibiotics is very serious issue for Seafood producer & consumer. All sixteen isolates were tested for production of Extended B-lactamase (ESBL) by using chromogenic medium & double disc synergy test which showed positive response among the isolates namely V1Y, V2Y, V3Y, V6Y, V1G, V3G, V5G and V6G. These isolates were further studied for Metallo β lactamase (MBL) production by using combination disk method and none of the isolates showed positive results. This indicates none of the isolates of *Vibrio* spp. are multidrug resistance in nature. Besides, β-lactamase encoding genes namely blaTEM & blaSHV were also detected which confirmed the isolated *Vibrios* that produce ESBL are having blaTEM & blaSHV genes. Presence of β lactamase encoding genes in isolated *Vibrios* confirms the resistance against 3rd generation cephalosporins and Penicillins broad spectrum antibiotics. This study suggests that contamination of *Vibrios* to Seafood may cause savour health risk to consumer. Therefore, contamination of *Vibrios* to Seafood must be prevented, eliminated or reduced to zero level.

Keywords: *Vibrios*, Seafood, Antibiotics, ESBL, MBL blaTEM & blaSHV.

TRPSF-FPT-O-5

Enhancing Refrigerated Storage Stability of Pangasius Emulsion Sausage through Haloarchaeal Bacterioruberin Incorporation

P Ramakrishna Reddy, K.A Martin Xavier, Amjad K Balange, Sanath Kumar H, Binaya Bhushan Nayak*.

Department of Post-Harvest Technology, ICAR-Central Institute of Fisheries Education, Versova, Mumbai-400061, Maharashtra,

* Corresponding author: nayakbb@cife.edu.in

Abstract

In this study, the efficacy of haloarchaeal bacterioruberin (BR), a carotenoid pigment, was investigated for its potential to improve color stability and reduce fat oxidation in pangasius emulsion sausages. The sausages were incorporated

with bacterioruberin at three different concentrations: 10 mg/kg (T1), 25 mg/kg (T2), and 50 mg/kg (T3). As a positive control, sausages containing 200 mg/kg of BHT were used (T4), while sausages without any antioxidant served as the control group (C). During refrigerated storage, various parameters were assessed at 7-day intervals, including pH, color attributes, fat oxidation products, protein degradation products, microbial counts, and sensory analysis. The control sausages were deemed unacceptable by sensory panelists by the 28th day, whereas the sausages treated with antioxidants could be stored for an extended period, lasting until the 42nd day. Instrumental color measurements revealed that the sausages with the highest bacterioruberin concentration (T3) exhibited the greatest redness (a^* value of 2.03). Moreover, bacterioruberin-added treatments demonstrated lower levels of peroxide value (PV), free fatty acids (FFA), and thiobarbituric acid reactive substances (TBARS) during storage, indicating reduced lipid oxidation. The findings of this study indicate that the incorporation of bacterioruberin successfully improved the color stability of pangasius emulsion sausages and effectively inhibited lipid oxidation without compromising the gel strength.

Keywords: Bacterioruberin, Peroxide Value (PV), Free Fatty Acids (FFA)

TRPSF-FPT-O-6

Influence of degree of hydrolysis on functional and structural properties of *Acetes* spp. protein hydrolysate

Vignaesh D.¹, K.A. Martin Xavier², K. K. Asha², Narasimhamurthy L.³, Neethu Narayanan⁴, Parshant Kaushik⁴, AmjadBalange⁵, Binaya Bhusan Nayak⁵

¹Paraprofessional Institute of Fisheries Technology, Madhavaram, Chennai – 600 051, India

²ICAR Central Institute of Fisheries Technology, Navi Mumbai, India

³National Fisheries Development Board, Hyderabad, Telangana – 500052, India

⁴Division of Agricultural Chemicals, ICAR-Indian Agricultural Research Institute, New Delhi-110012, India

⁵ICAR-Central Institute of Fisheries Education, Mumbai-400061, Maharashtra, India

*Corresponding author: vignaeshd@gmail.com

Abstract

Acetes is an unexploited tiny shrimp that is mostly caught as by-catch and is an excellent source of protein. In the present study, *Acetes* protein hydrolysates were prepared with four commercial proteolytic enzymes independently and the influence of degree of hydrolysis (DH) on functional properties and structural properties of hydrolysates were determined. The significant changes in the secondary derivative structural components of protein hydrolysates such as α -helix, β -sheet, β -turn and random coil could be related with the Peptide Chain Length ratio that has shown decreasing trend with the increase in DH. These results demonstrated the potential of using FTIR for monitoring the changes in the secondary structures taking place during protein hydrolysis and also paving the way for determination of these changes in other applications. The solubility at 30% DH in the pH of 8 was found to be highest (97.5 ± 0.17) in alcalase assisted hydrolysis whereas the lowest value of 58.17 ± 0.02 in the pH of 12 at 5% DH in trypsin assisted hydrolysis. Highest and lowest emulsifying capacity were observed at 5% DH (42.44%) and 30% DH (6.28%) in protein hydrolysates produced using alcalase. Foaming capacity was significantly different as a function of DH and the highest capacity obtained was 30.67% at 5% DH in pH 8 produced using alcalase while the lowest foaming capacity of 1.60% was obtained in trypsin hydrolysis. The study of relationship between the extent of hydrolysis on functional and structural properties of protein hydrolysates will assist the understanding of incorporation of hydrolysate as functional ingredient in foods

Keywords: Degree of Hydrolysis (DH); Functional Properties; Secondary Derivative, Protein Hydrolysates

TRPSF-FPT-O-7

Process optimization and evaluation of the effects of different time-temperature sousvide cooking on physicochemical, textural, and sensory characteristics of white leg shrimp (*Litopenaeus vannamei*)

Rupali Das^a, Naresh Kumar Mehta^b, Amjad K. Balange^a, Binaya Bhusan Nayak^a, Lakshmi Narasimha Murthy^c and K. A. Martin Xavier^{a*}

^aICAR-Central Institute of Fisheries Education, Mumbai-400061, Maharashtra, India

^bCollege of Fisheries, Central Agricultural University (Imphal), Agartala-799210, Tripura, India

^cICAR Central Institute of Fisheries Technology, Matsyapuri P.O, Kochi- 682029, Kerala, India

*Corresponding author: martinxavier@cife.edu.in

Abstract

Sous vide (SV), or vacuum cooking, is a promising technique in the preparation of safe, convenient, and nutritious seafood products. This study aimed to optimize and evaluate the impacts of SV cooking on the physicochemical, textural, and sensory quality of white leg shrimp (*Litopenaeus vannamei*). To optimize the SV cooking conditions, a

response surface methodology (RSM) approach utilizing a central composite design was adopted. Optimum SV cooking conditions to acquire minimum texture (hardness) of 7235gforce was 13.48 min and 81.87 °C, expressible moisture of 18.48% was 14.5 and 84.5°C, and cook loss of 5.58% was 5 min and 75 °C. Texture (hardness) and expressible moisture decreased while cooking loss increased with increasing time-temperature treatment. Increasing SV cooking time-temperature increased ($p < 0.05$) redness and yellowness values while lightness values remained almost constant in all treatments. TBARs and total carotenoid content increased ($p < 0.05$) indicating lipid oxidation and release of carotenoid from carotenoprotein complex in shrimp. However, TBARs values were in the range of 0.05-0.08 mg malonaldehyde/kg and thus were within acceptable limits. Sensory evaluation indicated that all SV cooked samples were well accepted, with overall scores ≥ 7 . Therefore, the textural, physicochemical, and sensory properties of shrimp were significantly influenced by the cooking temperature and duration of SV cooking. This study also suggests that although higher time-temperature caused higher cooking and moisture loss, hardness reduced and sensory scores increased making the product more acceptable to consumers.

Keywords: Response Surface Methodology, Vacuum Packaging, Cooking Loss, Carotenoid Content, Tbars.

TRPSF-FPT-O-8

Relationships between quality parameters and storage days on fish ball stored at refrigeration temperature

Ajeet Singh*, Vijay Kumar Reddy, Siddhnath Kumar

Department of Fish Processing Technology

College of Fisheries, Guru Angad Dev Veterinary and Animal Science University, Ludhiana (Punjab) 141004

*Corresponding Author: drajeetsingh76@gmail.com

Abstract

In recent times, consumption of fish and fishery items has witnessed a steady increase due to various reasons including change in lifestyle, perception about fish as a healthy food as its consumption helps to lower the blood cholesterol level, reduces heart attack risks, reduces blood pressure, manages heart rhythms and hence reducing possible heart failures. In processed food, protecting changes in biochemical characteristics, texture, culinary and sensorial properties and microbial growth are major challenges required to be maintain during its storage. Storage of food/ products for short duration under chilled conditions is most common practice to preserve the food including fish. Quality of food product is an important issue which declines with storage time and a consumer always shows concern about it. The present study was conducted to evaluate proximate composition, oxidative stability and sensory characteristics of ready to eat fish balls prepared from rohu (*Labeo rohita*) mince stored at refrigeration temperature. Significant ($p < 0.05$) change in Biochemical characteristics like pH (5.24 to 5.58), Titratable Acidity (0.38 to 0.63% lactic acid), Peroxide Value (1.52 to 3.7 meq/kg), free fatty acid (0.18 to 0.42%) and Thio-barbituric Acid Residual/ Reactive Substances 0.86 to 1.32 mg malonaldehyde/kg recorded. Textural changes as hardness, fracturability, springiness, chewiness, shear force and work of shear showed significant ($p < 0.05$) change with progress of storage period. Ready to Eat fish balls showed better acceptability upto 14th day at refrigerated temperature. Further, Principal component analysis (PCA) was performed to assess the relationships between quality parameters and storage days of fish ball samples. The results of the PCA analysis indicated a significant relationship between quality parameters and storage days. PC1 explained 70.4% of the variations, while PC2 explained 14.6%. Overall, the quality of the fish balls deteriorated with increasing storage time, as evidenced by a decrease in pH, moisture, chewiness, and shear force, and an increase in springiness, fat, hardness, PV, titratable acidity, FFA, carbohydrate, ash, protein, TBARS, and factorability.

Key words: Fish Balls, Biochemical Parameters, Shelf Life

TRPSF-FPT-O-9

SPI-Encapsulated Fish Collagen Peptides used as Anti-osteoporotic Functional Food

Anil Kewat, Dr. R. Jeya Shakila, Prof. G. jeyasekaran, Dr. M. Rosalind George and Dr. Ajit Pratap Singh
Nanaji Deshmukh Veterinary Science University, College of Fishery Science, 482001, Madhya Pradesh, India

*Corresponding author: Kewatani64@gmail.com

Abstract

Osteoporosis is a serious problem in aged old people. Drugs (bisphosphonates) applied for treatment are often accompanied by adverse side effects. Thus, collagen hydrolysates/peptides from marine source could be a safe source of anti-osteoporosis agents. In this study, fish bone waste was hydrolyzed using 1% alcalase and lyophilized to obtained fish bone collagen peptides (FBCP) having < 3 KDa molecular mass and $74.31 \pm 2.1\%$ protein. The total

amino acids of FBCP contained 82.791mg/100mg protein, constituted mainly Gly, Pro and Asp amino acids. The major minerals were Ca, Mg and Fe. The FBCP were encapsulated using soy protein isolate (SPI) as carriers by a spray drying. The zeta potential and glass transition temperature (T_g) of the SPI encapsulated CP (SPI-ECP) were -20.5 and 70°C, respectively. Thereafter, mouse pre-osteoblast cell line ME3T3-E1 was used to test the anti-osteoporotic properties of SPI-ECP based on cell proliferation, cell differentiation, and alkaline phosphatase and bone mineral assays. The results showed that SPI-ECP (100 µg/mL) could promote cell proliferation. Nevertheless, SPI-ECP at 100 µg/mL had enhanced differentiation, ALPs activity and increased mineralization during the 21 days of culture. Moreover, SPI-ECP cells had higher calcium depositions than the control. The SPI-ECP showed the better results than the FBCP alone. *In-vitro* gastrointestinal digestion study proved the bio-accessibility of SPI-ECP showed 61.5% *in vitro* digestibility. Therefore, this indicated the ECPs prepared with SPI utilizing fresh bones accelerated bone growth and shall serve as a functional food to treat bone loss. In addition, this is the best way to utilize the fish waste and to save the environment.

Keywords: Osteoporosis, Cell Proliferation, Cell Differentiation, Alkaline Phosphatase, Bone Mineral Assays

TRPSF-FPT-O-10

Study the shelf life of fish pickle stored at room temperature and refrigerated temperature

Jitender Kumar Jakhar*, Kamalesh panda, Hinglaj Sahu, Roshani Chandravanshi, Karan Biswas, Nihal Sahu, Nilesh Kumar Sahu

LSPN College of Fisheries (Dau Shri Vasudev Chandrakar Chhattisgarh Kamdhenu Vishwavidyalaya), Kawardha

*Corresponding author: cofk12@gmail.com

Abstract

Fish pickle was prepared from *Pangasius (Pangasianodon hypophthalmus)* fish, and samples were kept at room temperature (28° to 32°C) and at refrigeration temperature (5°C and 8°C) for checking the shelf-life and cost-profit analysis. The quality parameters of fish pickle stored at room temperature was analyzed at every 15 days of interval and the quality parameters of the fish pickle samples stored at refrigeration temperature is analyzed initially at 30 days of interval. The pH value of pickle was found in decreasing order from 4.5±0.2 to 4.3±0.1. The bacterial loads of fish pickle were found gradually increased from zero to 2.0×10³ CFU/g during storage at room temperature. In the present study, a clear increasing trend was observed into TVB-N content with the lapse of storage period irrespective of storage temperature and value reached to 3.9±0.12 mg/100g. During storage at room temperature, the initial peroxide value of pickle was estimated 0.46±0.06 meq/kg of oil and was found in increasing trend with increasing storage time. The initial titratable acidity value of pickle was 1.2±0.14 mg/100g and not much change during initial period of storage. The result of present study showed that fish pickle stored at room temperature is safe for consumer for six months with all the permissible limit of quality parameters.

Keywords: Fish Pickle, *Pangasianodon hypophthalmus*, TVB-N value, Microbial Load.

TRPSF-FPT-P-1

Alternatives to synthetic preservatives

Shikha Singh Thakur¹, Gajender Singh¹, Ajeet Soni¹, Jayesh R. Mer²

¹Department of Fish Processing Technology, College of fisheries science, Chaubhary Charan Singh Haryana Agricultural University, Hisar, Haryana

²College of fisheries science, Kamdhenu University, Veraval, Gujarat

*Corresponding author: thakur.shikha.2510@gmail.com

Abstract

Preservatives are substances that enhance the shelf life of food and prevent spoilage. In this era, people are concerned about the negative impact of synthetic preservatives used by the food industry. Synthetic antioxidants such as Butylated Hydroxy Anisole, Butylated Hydroxy Toluene, and Propyl gallate are used to prevent the oxidation of food. Antimicrobials such as nitrate, nitrite, sulfur dioxide, and benzoate delay the growth of microbes. Natural preservatives such as salt, sugar, vinegar, and spices have been utilized since the dawn of time. The vast majority of preservatives in use today are synthetic rather than natural. Synthetic preservatives are toxic to human health and also have serious life-threatening side effects. Synthetic preservatives can cause various health hazards such as asthma, allergy, hypertension, hyperactivity, neurological disorder, cancer, etc. The scientist has revealed that several natural preservatives which are obtained from animal, plant, and microbes contain antioxidant and antibacterial properties. Plant and animal-based

preservatives are potentially able to be alternatives to synthetic preservatives. This study intends to raise awareness about the detrimental consequences of synthetic preservatives and advises the use of natural preservatives to increase food safety as well as improve the overall health of the consumer.

Keywords: Preservative, Antioxidant, Shelf Life, Spoilage, Food

TRPSF-FPT-P-2

Application of pH shift method to Produce Functional Protein Isolates from Mudskipper (*Boleophthalmus dussumieri*).

Sharath S P*, Layana P, K.A Martin Xavier, Binaya Bhusan Nayak, Amjad K. Balange .

Ph.D. Scholar, Department of Fish Processing Technology, ICAR-Central Institute of Fisheries Education, Versova, Mumbai-400061, Maharashtra, India

*Corresponding author: sharath.ftpb204@cife.edu.in

Abstract

Mudskippers (*Boleophthalmus dussumieri*) are small unique fishes that are amphibious and considered endemic. Despite its potential to cure many nutrient deficiency diseases such as malnutrition and frequent urination by children, these fishes are largely untapped as a food source and its protein characteristics have not been investigated yet. This study sought to determine the impact of acid (ACPI) and alkaline extraction process (ALPI) on mudskipper protein isolates in terms of yield, physico-chemical and functional characteristics. Alkaline extraction resulted in higher protein recovery (87.47%) than acid extraction (83.05%). At pH 12, ALPI showed a significantly higher level of solubility (91.03%) than ACPI (81.25%). However, in the least concentration endpoint technique, both ACPI and ALPI demonstrated excellent gels at lower concentrations of 3%. Foam stability and capacity were found to be superior in ALPI (59.6% and 49.53%) than in ACPI (51.67% and 40.67%). Stability was unaltered in both isolates even after 60 minutes. While ALPI and ACPI exhibited different emulsion activity indices of 35.0 and 33.16 m²/g, respectively, ACPI had good emulsion stability. Water and oil-holding capacity, and whiteness were superior in ALPI, whereas ACPI had more bulk density. Due to their functionality, the mudskipper muscle protein isolates have significant relevance for product development and have the potential to be used as functional ingredients in the food sector.

Keywords: *Boleophthalmus dussumieri*, pH-shift processing, Protein Isolates, Functional Properties

TRPSF-FPT-P-3

Effect of curry and moringa leaf extract conjugated with copper sulfide nanoparticles on quality changes of Pacific white shrimp (*Litopenaeus vannamei*) during 15 days of chilled storage

Ajeet Soni^{1*}, Rachna Gulati¹, Praveenkumar Pandiyan², Shikha Singh Thakur¹, Domendra Dhruve¹, Pragya Mehta³, Saiprasad Bhusare⁴, Ramkumar kurmi⁴, Mohammed Rizwan¹

^{1,3}Department of Fish Processing Technology College of Fishery Science, Chaudbary Charan Singh Haryana Agriculture University Hisar

Department of Fish Processing Technology (Biochemistry), Kerala University of Fisheries and Ocean Studies, Panangad, Kochi 682 506,

⁴ICAR- Central Institute of Fisheries Education, Mumbai

*Corresponding author: ajitsoni3459@gmail.com

Abstract

This study aimed to evaluate the effect of curry and moringa leaf extract conjugated with copper sulfide nanoparticles on quality changes of Pacific white shrimp during 15 days of chilled storage. Biochemical indices, microbial count, and sensory analysis were done at 3 days intervals. At 15 days of storage, the Total volatile base nitrogen, Trimethylamine, and Peroxide value of the control group was 36.23±0.29 mgN/100 g, 16.58±0.01 mg/100g, 15.97±0.224 milliEquivalent/kg, whereas (CLE+MLE+CuSNPs) was 18.71±1.6 mgN/100g, 9.19±0.77 mg/100g, 7.82±0.053 milliEquivalent/kg, respectively. At the 15 days of storage, the biochemical, and microbial sensory scores of the treated group were significantly lower (P<0.05) compared to the control group. These results suggested that CLE+MLE+CuSNPs could be used as an effective natural alternative to synthetic preservatives that could inhibit the post-mortem changes in shrimp.

Keywords: Copper Sulfide Nanoparticles, Curry Leaves Extract, Moringa Leaves Extract, Melanosis, Pacific White Shrimp, Quality Changes

TRPSF-FPT-P-4

Effect of Rosemary extracts on *Hypophthalmichthys molitrix* (Valenciennes, 1844) fillets during refrigerated storage (4±1 °C)

Rajesh Mondal, K. C. Dora, Pooja Saklani, Sayani Roy*, S. Chowdhury, P. Murmu, S. Nath,
Department of Fish Processing Technology, Faculty of Fishery Sciences, WBUAFS, Kolkata-700094
*Corresponding author: sayani24roy@gmail.com

Abstract

Fish is a very perishable commodity that needs to be stored at low temperature and chemical techniques are frequently used for controlling the changes taking place in fish which is a very common practice nowadays. The chemical preservatives used can be dangerous from public health point of view and hence the use of natural preservatives in food has gained more attention. Plant polyphenol extracts have been employed as natural preservative because of their excellent antioxidant and antibacterial properties. In the present study, a plant extract such as rosemary was used to study its effect on the shelf-life of silver carp (*Hypophthalmichthys molitrix*) fillets during refrigerated storage (4±1 °C) for a period of 15 days. The total phenolic content (TPC) as well as antimicrobial properties of rosemary extract using ethanol (ERE), hot water (HWRE), and a mixture of ethanol and hot water (EHWRE) was estimated. The total phenolic compounds (TPC) in ERE, HWRE, and EHWRE were found to be 126.70±1.77 mgGAE/g, 74.89±1.42mgGAE/g, and 136.99±0.76mgGAE/g, respectively. From the different solvent extracts, the maximum antimicrobial properties were shown by ethanolic hot water rosemary extract (EHWRE) followed by ethanolic rosemary extract (ERE) and hot water rosemary extract (HWRE). The proximate composition of silver carp for moisture, crude protein, crude fat and ash were 76.2±0.92%, 18.09±0.51%, 2.98±0.35% and 1.86±0.35% respectively. The different chemical parameters like TVBN, PV and pH were within the acceptable limits except control sample and it was found that EHWRE proved to be superior over other two treated samples like ERE and HWRE. It also maintained the same trend in case of Aerobic plate count (APC). Rosemary extract had significant impact on different textural parameters of silver carp fillets during the refrigerated storage condition. The findings of the present study reveal that dipping the Silver carp fish fillets in rosemary extract is an efficient and effective technique to preserve quality and extend the shelf life.

Keywords: Rosemary, Shelf Life, Silver Carp, Aerobic Plate Count, Total Phenolic Content

TRPSF-FPT-P-5

Emerging Pathogens in Seafood and its Prevention

Rahul Kumar Verma¹, Chandan Aarya¹, Dr. Abhishek Thakur*¹
¹Department of Fish Processing Technology, College of Fisheries, Kishanganj- 855107
*Corresponding author: abhiat229@gmail.com

Abstract

Seafood consumption has been an essential part of human diets worldwide, providing valuable nutrients and contributing to global food security. The globalization of seafood industry and the increasing consumption of seafood products have raised concern regarding the emergence and spread of pathogens associated with seafood. This review aims to provide an overview of the emerging pathogens that pose risks to seafood safety and human health. The emergence of seafood pathogens can be attributed to various factors, including contamination during harvesting, processing, transportation, and consumption. These pathogens can be bacterial, viral, or parasitic in nature, and their presence in seafood can lead to outbreaks of food-borne illnesses. Bacterial pathogens such as *Vibrio spp.*, including *Vibrio parahaemolyticus* and *Vibrio vulnificus*, have been associated with seafood-related infections. These pathogens are known to thrive in warm seawater conditions and can cause severe gastrointestinal symptoms, wound infections, and, in some cases, life-threatening complications. Viral pathogens, particularly noroviruses and hepatitis A virus, can contaminate seafood through faecal contamination and can lead to gastroenteritis and hepatitis, respectively. Parasitic infections linked to seafood consumption include *Anisakis spp.* and various species of tapeworms. These parasites may be transmitted to humans upon ingestion of raw or improperly cooked seafood. Infection with these parasites can cause gastrointestinal symptoms and, in severe cases, intestinal obstruction. Moreover, this abstract addresses the potential health risks associated with the consumption of contaminated seafood, which causes gastrointestinal illnesses, food-borne outbreaks, and allergic reactions. It also emphasizes the importance of effective surveillance, monitoring, and preventive measures at all stages of the seafood supply chain to ensure food safety and public health.

Keywords: Seafood, Emerging Pathogen, Safety, Health, Illness, Gastroenteritis, Preventive Measure

TRPSF-FPT-P-6

Fish oil extraction using Supercritical fluid extraction: A review

Nidhi Dhansukhbhai Patel*¹, Rachna Gulati¹, Varsha Likhar², Ajeet Soni¹ and Shikha Singh¹

¹Department of Fish Processing Technology, College of Fisheries Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana

²Department of Fish Processing Technology, LSPN College of Fisheries Science, Kawardha, Chhattisgarh

*Corresponding author: nidhi25.np@gmail.com

Abstract

Supercritical fluids have very much importance in the modern chemical technologies among the different extraction techniques used at analytical and preparative scale, supercritical fluid extraction (SFE) is one of the most used techniques. It has great potential to be used in variety of fields. One of the most important aspect of supercritical fluids is that they are classified under the green technology and thus they are considered as environmentally friendly. Green extraction method is based upon the findings and the development of the extraction process which can reduce the energy consumption, allows the use of alternative solvents, renewable natural substances and provides a secure high-quality product, thus fulfilling the circular bio-economy principles. They are mostly used in the chemical industries for extraction purposes as they provide excellent results because of their unique properties. Other applications are in the pharmaceutical industry. Most commonly used supercritical fluid is carbon dioxide which is popularly used in Decaffeination. The review covers the importance and method of the SFE and its future prospective.

Keywords: Supercritical Fluid Extraction (SFE), CO₂

TRPSF-FPT-P-7

Muscle quality of farmed fish: Influence of culture practices and environment

Vijay Kumar Reddy Surasani*, Siddhnath and Ajeet Singh

Department of Fish Processing Technology, College of Fisheries, Guru Angad Dev Veterinary, Animal and Fisheries Sciences University, Ludhiana, Punjab, India 141004

*Corresponding author: vijayreddy.surasani@gmail.com

Abstract:

Fish muscle quality is a crucial aspect as it has a big impact on the flavor and nutritional value of the finished product. Fish culture practices and the culture environment are the two important variables that affect fish muscle quality. Fish raised for food can grow and develop at different rates depending on culture practices like feeding schedules, stocking densities, and water quality. By altering muscle composition, texture, color, and flavor, these practices can have an impact on muscle quality. The muscle's fatty acid and amino acid composition can change as a result of changes in feeding practices. High stocking densities can also increase the risk of disease outbreaks and stress, which lowers the quality of the muscle. The metabolism and stress levels of the fish may be impacted by many elements. According to studies, warm water can result in decreased protein content and higher levels of lipid oxidation, which can lead to a decline in muscle quality. Low dissolved oxygen concentrations may also cause muscle deterioration and damage, as well as a reduction in the general quality of the muscle. The purpose of this paper is to shed light on the relationship between environmental factors and culture practices in determining the quality of fish muscle.

Keywords: Fish Muscle, Culture Practices, Environment, Quality, Composition

TRPSF-FPT-P-8

Nutritional Value and Acceptability of Carp Meat Incorporated Nutrition Bar

Parmreet Kaur and Ajeet Singh*

Department of Fish Processing Technology, College of Fisheries, Guru Angad Dev Veterinary and Animal Science University, Ludhiana

*Corresponding author: drajeetsingh76@gmail.com

Abstract

Nutrition bars offer a readily available convenient food source that requires no preparation, cooking, holds a reasonable extended shelf life at ambient temperature and easy to carry. Hence bars are popular as a convenient snack food and are consumed by the people of all age groups. In recent past, demand of nutrition bar has increased tremendous as people became aware about health but most of the existing confectionary bars available in the market are either nutritionally poor or provide carbohydrate in high quantity. Keeping in view the convenient bar along with

nutrition, the present work was conducted to assess the nutritional value and acceptability of nutrition bar adding meat from carp fish, which will help to provide an additional option of snack bar for health conscious people. Carp meat was added at different levels i.e. 2.5% (T1), 5% (T2), 7.5% (T3), 10% (T4) and 12.5% (T5) whereas in control (C) no fish meat was added. The results of proximate composition showed that the protein content was 13.05% in Control, 15.26% in T1, 16.44% in T2, 18.45% in T3, 22.01 in T4 and 25.46 in T5 fish meat incorporated nutrition bar. Fat content varied from 12.42% in control, 14.60% in T1, 15.15% in T2, 15.90% in T3, 15.80% in T4 and 14.64% in T5, Ash content varied from 1.31% in control, 1.59% in T1, 1.42% in T2, 1.49% in T3, 1.52% in T4 and 1.58% in T5 and Carbohydrate content varied from 63.62% in control, 59.30% in T1, 57.42% in T2, 55.21% in T3, 48.63% in T4 and 46.80% in T5. Sensory evaluation of fish meat incorporated nutrition bar was conducted using nine point hedonic scale and the samples were evaluated for the sensory attributes viz, Aroma, Sweetness, Hardness, texture, Softness, Taste liking and overall acceptability. Among all the treatments, T4 (10 % protein powder) scored maximum for overall acceptability. Considering the quality attributes and acceptability, it can be concluded that nutrition bar supplemented with carp meat may help to improve the nutritional value of the nutrition bar without compromising with sensory acceptability to the consumers.

Key words: Nutrition Bar, Proximate Composition, Carp Meat, Sensory Properties

**Theme VI: Fisheries Science-Society Linkage
and Rural Prosperity**

TRPSF-FSS-O-1

Economic assessment of incorporating Pabda and Amur Carp as bottom feeder fish in polyculture system in Tripura

Biswajit Debnath*¹, Biswajit Das², Amulya Kumar Mohanty³ and Vinay Kumar Mishra⁴

¹Krishi Vigyan Kendra, South Tripura

²ICAR Research Complex for NEH Region, Tripura Centre

³ICAR-Agricultural Technology Application Research Institute (ATARI), Zone VII

⁴ICAR Research Complex for NEH Region, Umiam, Meghalaya

*Corresponding author: debnath_biswajit@rediffmail.com

Abstract

An economic assessment was done on production, gross income and net income achieved through incorporation of Pabda and Amur Carp as bottom feeder fish in polyculture. It was compared with conventional composite fish culture, where Mrigal or Common Carp was used as bottom feeder fish. The primary data for this study was collected from farmers field where KVK, South Tripura conducted relevant assessment or demonstration programmes in recent past. Three combinations of bottom fish diversification were followed in pond fish farming viz. Catla: Rohu:Mrigal (termed as *Conventional Composite Culture*), Catla: Rohu:Pabda (Termed as *Pabda Polyculture System*), and Catla:Rohu:Amur Carp (Termed as *Amur Carp Composite culture*). Mean Values of Productions (in kg per acre) were 563.30 (SD = 80.18) in *Conventional Composite Culture*, 543.55 (SD = 53.71) in *Pabda Polyculture* and 626.46 (SD = 39.68) in *Amur Carp Composite Culture* system respectively. Significant difference ($p=0.002$) in fish production was observed among the three systems. Observed mean values and Post hoc test showed the production from Amur Carp Composite Culture as a different subset in comparison to the production from other two systems. It can be stated that incorporation of Amur carp found to be effective in fish production enhancement in Tripura. But Net Income (NI) showed different pattern. The Net Income values (in Rs. per acre) were Rs. 63,437 (SD = Rs. 17,086) in Conventional Composite Culture, Rs. 1,21,672 (SD Rs. 12,935) in Pabda polyculture system and Rs. 77,816 (SD = Rs. 12,234) in Amur Carp Composite Culture system respectively. NI values were significantly different ($p < 0.001$) among three systems, and interestingly, NI means plot of Pabda Polyculture System showed a peak as compared to the NI values of other two systems. It might be due to existing high price of Pabda in local market. Overall, the study revealed that Amur Carp boosted the level of production whereas incorporation of Pabda in polyculture system was economically beneficial.

Keywords: Economics, Income, Pabda, Amur Carp, Krishi Vigyan Kendra (KVK)

TRPSF-FSS-O-2

Enhancing scampi fisheries in inland open waters of India

A K Das* and B K Das

ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata 700120

*Corresponding author: archandas@yahoo.com

Abstract

While Indian export earnings through export of shrimps have been boosted to Rs. 43, 415 crore in 2022-23 out of Rs. 63,969 crores (17 lakhs 30,000 metric tonne) marine products with major share occupied by *Penaeus vannamei* followed by *P. monodon* (black tiger prawn, 31,213 mt), the giant freshwater prawn, *Macrobrachium rosenbergii* widely known as 'scampi', an indigenous freshwater prawn species of India inhabiting rivers, canals, estuaries including coastal waters and their production is in declining spree. Though it is one of the most preferred cultivable species in freshwater systems due to its large size, high price, faster growth rate, good taste and high export demand, its overall production has been shattered drastically during last decade. It can be cultured alone (monoculture) or with compatible fish species like catla, rohu and exotic carps like silver carp and grass carp (polyculture). Scampi farming picked up in early nineties with the collapse of tiger shrimp farming due to white spot virus diseases. Its farmed production has shown phenomenal increase from mid-nineties, increasing from 500t in 1997 to >42,000 t in 2005. Aquaculture production of scampi was centred around Nellore of Andhra Pradesh in late nineties and early 2000; the production was declined substantially since 2006. The reasons behind such declines were the reduction in economic viability, decline in the profit margin, lack of quality seeds for stocking leading to slow growth and poor survival thereby decreasing production. With the introduction of pacific white legged shrimp *Penaeus vannamei* in 2009 having higher production rate >6t/ha, wider adaptability in salinity regime, higher remunerative prices and market demand attracted scampi farmers to switch over and opted for vannamei farming in AP followed by other states resulting in drastic reduction of area under scampi culture and production; it is revealed that scampi production in 2020-21 was only 8,303 tonnes in India, which is nearly 80% less than the highest production of 42,800 t in 2005. Major scampi farming states are in West Bengal, Gujarat, Maharashtra and Odisha of which. production from Maharashtra is of mostly reservoir based. Recently, there is a renewed interest in enhancing scampi fisheries in inland open waters especially in reservoirs of smaller dimensions and floodplain wetlands due to increased peoples' preference over shrimp (especially *P. vannamei*) as

has been noticed in MP, UP, Chhattishgarh, Jharkhand and Bengal, ICAR-CIFRI has been promoting its enhancement in reservoirs of Jharkhand as a token of initiation. Involving tribal women folk of Jharkhand, enhancement of scampi was carried out in a small reservoir of 2 ha area with the stocking of 40,000 nos. juveniles 21 PL (15 mm) of scampi seeds in July 2022 along with 6000 nos. IMC fingerlings of 100 mm size; sinking pelleted feed @2 kg was dropped around the littoral areas of the reservoir in the evening hours; a phenomenal growth and recovery of 4.2 t IMC (>1.3 kg size) and 1.7 t of scampi (>68 g size) was made after a production period of 11 months. During heavy shower, a bulk quantity of scampi juveniles was escaped through dead-sluice ware from the reservoir due to faulty net cover on the ware. More scientific interventions in attaining sizeable production from such small reservoirs including check dams with rocky bottom would definitely pave the way of generating additional and assured livelihood of tribal folk in the days to come in Jharkhand and the lessons learned could be replicated/disseminated in such type of water bodies of other states through active co-participation of the fishers' folk thriving therein. Even. Enclosure cultures also could be made as viable option either for production of fingerlings from juveniles or grow out, installing in reservoirs or wetlands maintaining a sustainable production flow of scampi from these precious inland open waters of India which would target of doubling of farmers income besides ensuring nutritional security for vast array of rural mass of India

Key words: Inland Open Waters, Enhancement, Scampi, Livelihood, Nutritional Security

TRPSF-FSS-O-3

On-Farm testing on comparative evaluation of different diets for carp nursery rearing: Implications for socio-economic empowerment

Abhilipsa Biswal^{1*}, Ravindra Kumar Tiwari¹, Madhu Sudan Kundu², Anupma Kumari², Vinita Kashyap¹, Bharati Upadhaya¹, Sumit Kumar Singh¹, Sanchita Ghosh¹, Varsha Kumari¹

¹*Krishi Vigyan Kendra Birauli, Dr. Rajendra prasad Central Agriculture University (848115), Bihar, India*

²*Directorate of Extension Education, Dr. Rajendra prasad Central Agriculture University (848125), Bihar, India*

*Corresponding author: abhilipsabiswalluin@gmail.com

Abstract

Carp seed survival is one of the most critical aspects of seed rearing in nursery phase. In field condition the recovery of spawn to fry stage is usually very less which is 25- 30%. For addressing this issue, a comparative evaluation of 3 different diets have been done in different farmers' field of Samastipur district, Bihar and their efficacy has been measured in terms of FCR, FCE, Net survival of carp fry, Net yield and benefit cost ratio. Different diets were evaluated in three treatments such as in Control group (Farmers' practice group) the feed was Comprised of mustard oil cake and rice bran, in T₁ group the feed was basically comprised of oil cake & rice bran which was fortified with vitamin- mineral mixture and then T₂ group a commercially produced diet was used. Within the 21 days of experimental duration no significance difference observed in the water quality parameters of various treatments in terms of temperature, pH, and TAN concentration and plankton density. It was indicated that the commercially produced feed of T₂ group showed increased fry survival of 65%, which is significantly higher than the control group which is 40%. The commercially produced feed also showed significantly higher feed conversion efficiency and lower feed conversion ratio in comparison to the control group. However, in terms of Benefit-Cost ratio T₁ was observed to be the best treatment among all. Thus, in presence of abundant plankton density, farm made feed fortified with vitamin mineral mixture can be recommended for nursery phase of fish rearing.

Keywords: Carp Nursery, Benefit-Cost Ratio, Survival, Vitamin, Mineral

TRPSF-FSS-O-4

Geospatial Analysis for Sustainable Aquaculture Expansion in Peechi Reservoir, Kerala

Mohammed Meharoof^{1,2}, Vinod Kumar Yadav^{1*}, Arpita Sharma¹

¹*Fisheries Economics, Extension and Statistics Division, ICAR-Central Institute of Fisheries Education, Versova, Mumbai-400061, Maharashtra, India*

²*Fisheries Extension, Economics, and Statistics Department, College of Fisheries, Payyanur-670307*

*Corresponding author: vinodkumar@cife.edu.in

ABSTRACT

Understanding and modeling water dynamics of reservoirs will help in the expansion of aquaculture in a sustainable way. This research study aimed to evaluate the land use/land cover changes and water spread dynamics of Peechi reservoir situated in Kerala in order to better understand and model the freshwater resource dynamics. The research utilized Land sat and Sentinel images to conduct a change detection analysis and assess the water spread and fish culture area. The study also estimated the fingerling requirement and fish production potential of the reservoir, as well as identified suitable areas for cage and pen culture using the seasonal water spread area. The majority of the vegetative land has been turned into settlement areas, which has caused a considerable change in the settlement area between

2000 and 2020, according to the study. The extent of bare land has significantly expanded from 245.98 ha in 2000 to 519.04 ha in 2020 when compared to other land cover types. With a potential fish production of 196.45 metric tons, the average number of fingerlings needed to exploit the water present in the water bodies of Peechi reservoir has been calculated to be 0.49 million. Perennial water spread area available in Peechi reservoirs is estimated as 310.22 ha which comprised of 34.63 per cent of their maximum water spread area which is suitable for cage culture. Seasonal water spread area of Peechi reservoirs was estimated as 30.40 per cent (272.25 ha) of total area, which is suitable for pen-based enclosure culture. Based on the results a research framework named "Fish Culture Area Mapping, Efficient Ranching Assessment, and Change Detection for Reservoirs (FISHCAMERA-CDR)" was developed. The framework provides a useful tool for policy makers, researchers, academicians, and fisheries department officials in instituting appropriate development plans and prioritizing reservoirs with fish culture potential. The proposed framework can be applied to assess change detection in and around any reservoir, estimate effective water spread area and stocking density for scientific ranching, and identify potential fish culture sites.

Keywords: Land Use Land Cover, Supervised Classification, Normalized Difference Water Index, Reservoir, Water Spread Dynamics, Reservoir

TRPSF-FSS-O-5

Intensification of Inland Low Saline Shrimp Culture and Consequences

Dhande Kranthi Kumar¹ and Rama Sharma¹ and Ravi Shankar Kumar*²

¹ICAR-Central Institute of Fisheries Education, Mumbai-400061

²College of Fisheries, Kishanganj, Bihar-855107

*Corresponding author: ravikul1992@gmail.com

Abstract

Shrimp culture in India has emerged as a highly commercial enterprise due to the dynamic shift from a traditional coastal farming to the inland low saline shrimp farming with the introduction of *L. vanammei*. Many agricultural farmers have been fascinated by the profits in shrimp culture and converted their agricultural land into shrimp farms and freshwater resources into saline water. Despite of yielding higher profits, the rapid rise of low salinity shrimp farming has raised concerns about potential environmental resource impacts. The actual and potential consequences of uncontrolled and unregulated dosage of inputs such as antibiotics, chemicals, minerals, and feed ingredients and their residuals were not adequately treated before release into the surrounding environment reaping up the cumulative negative effect on latter. This study had collected data from 60 paddy farmers adjacent to shrimp farms in West Godavari district, AP. The data was analyzed using factor analysis. The findings revealed that approximately 58.34% of paddy farmers believed that adjacent shrimp culture systems had a high impact on decline inland fertility, while 35% of farmers believed they were moderately affected. About, 53.34% and 35% of the farmers responded that water quality parameters changed moderately and highly impaired, respectively. Similarly, problems such as fluctuation in paddy production, seepage problem, and pollution of drinking water, vegetation destruction and disease outbreak were addressed by the paddy farmers. Effective management measures to mitigate the negative environmental impact of inland low saline shrimp farming is utmost important.

Keywords: Inland Low Saline Shrimp Farming, Paddy Farmers Factor Analysis, Land Fertility and Pollution

TRPSF-FSS-O-6

Training Evaluation of ICAR- CIFE's "Fish Farming and Hatchery Operation" Program

Beemalla Samatha*, Shivaji Argade, Ananthan P.S, and Karthireddy Syamala

¹Fisheries Economics, Extension and Statistics Division and Department of Aquaculture

²ICAR-Central Institute of Fisheries Education, Mumbai - 400061, Maharashtra, India

*Corresponding author: beemalla.fexpb201@cife.edu.in

Abstract

Evaluation is indeed crucial for identifying any gaps or weaknesses in training programs and improving their effectiveness. By assessing the outcomes and impact of skill development initiatives, sponsoring and host institutions can make informed decisions for better planning, implementation, and restructuring of future programs. The current study focuses on evaluating the effectiveness of one year certificate course on fish farming and hatchery operation conducted by CIFE (Central Institute of Fisheries Education) for trainees between 2016 and 2019. The study used a structured interview schedule and employed an ex-post facto study design. The effectiveness of the training program was assessed using a four-level Kirkpatrick model, which includes reaction, learning, behavior, and results. The overall effectiveness mean unit score of the program was found to be 0.79, indicating that the one-year certificate course was very high effective. The trainees' responses falls mostly in the "very high" category, with 94.12% (32) in the reaction level, 73.53% (25) in the learning level, 58.82% (20) in the behavior level, and 70.59% (24) in the result level. These

findings suggest that the trainees had positive reactions to the training, acquired new knowledge and skills, and demonstrated positive outcomes in terms of their behavior and results. The fact that 70.59% of trainees are employed indicates that the course had a beneficial impact. The primary training needs identified by the trainees were improved fish culture techniques (25%) and vannamei culture techniques (20%). The study emphasizes the importance of organizing training in these specific areas based on the trainees' perceived needs. However, it also highlights that the level of behavior, which refers to the application of learned knowledge and skills in practice, was less effective. Therefore, the host institution needs to develop strategies to improve the effectiveness of the program in terms of trainees' behavior, aiming to enhance the transfer of acquired knowledge and skills in a sustainable manner. The study's findings have practical implications for the development of future training programs. By understanding the effectiveness of the training, the sponsoring and host institutions can plan and implement more effective training programs. The results also suggest the need for further investigation into the effects of training on trainees' job performance, which can contribute to enhancing the overall impact of training initiatives. Overall, this study provides insights into the effectiveness training and highlights areas for improvement. By considering these findings, future training programs can be designed to better meet the needs of trainees and maximize their learning outcomes.

Keywords: Evaluation, Effectiveness, Kirkpatrick Model, Knowledge, Skill, Training Need

TRPSF-FSS-O-7

Unveiling the Transformation in Fish Consumption Patterns with Modern Fish Retail

Tenji Pem Bhutia^{*1,2}, Vinod Kumar Yadav² and Ravi Shankar Kumar¹

¹College of Fisheries, Kishanganj, BASU

²ICAR-Central Institute of Fisheries Education, Mumbai

*Corresponding author: tenzipem2@gmail.com

Abstract

In recent markets development, fish has been made available in many multi-format retail outlets. Consumers' purchase decision is the result of many factors, specificities and characteristics that influences the individual consumer. Studies in India on consumer behavior are mostly focused on unorganized fish market. Hence, due to lack of literature in modern retailing of fish, study was conducted in Kolkata, to assess the changes in consumption pattern for fish and fish products due to modern retail. Data was collected from 300 fish consumers randomly selected using well-structured pre-tested interview schedule. A significant difference was observed in the average quantity of most commonly consumed fish purchased per visit among traditional fish market and modern retail outlet. For understanding the relationship between expenditure on fish and fish products and other factors, multiple linear regression analysis was done. The results showed that monthly income of the head of household, frequency of visiting fish market, cost/visit and market type had a significant influence on the expenditure on fish and fish products per month. With respect to reference category (0=fortnightly), expenditure on fish and fish products per month increases by Rs. 1084.7, Rs. 1683.8 and Rs. 2392.9, if the frequency of visiting fish market by the consumer changes to once in a week (1), twice in a week (2) and more than twice in a week (3) respectively. So, for a unit increase in income and cost / visit (transportation cost), expenditure on fish and fish products per month increases by Rs. 0.22 and Rs. 4.07 respectively. Concerning the reference category (0=traditional fish market), if a consumer changes the place of purchase of fish from traditional to modern retail outlet, monthly expenditure on fish and fish products are likely to increase by Rs. 893.83. The R² value (0.7518) indicated that 75 percent of the variation in the dependent variable was explained by the model. Regression adjustment was done in STATA 13.1 using treatment effects regression adjustment taking expenditure on fish and fish products per month as a proxy for consumption. Market type was taken as treatment, and all other were taken as control. The results revealed that average treatment effect (ATE) was 980.22, which indicated that expenditure of consumer was Rs 980/ month more in the modern retail outlet than in traditional fish market. The Potential outcome means (PO mean) was 3816 which implies that mean expenditure of consumer in the traditional fish market was Rs. 3816/ month. Hence, price of fish being very high in modern retail outlet compared to the traditional fish market, if a person changes the place of purchase from traditional to modern retail outlet, his expenditure on fish and fish products increases. The findings of the study can be used by policy makers to improve the traditional fish markets in the city which will help to increase the acceptability and accessibility of fish in a better quality and at a cheaper price and can also serve as a guide to both the buyers and sellers of fish and fish products to produce products of desired quality, with a good price in a hygienic condition.

Key words: Consumer Behavior, Traditional Fish Market, Modern Retail Markets

TRPSF-FSS-P-1

An overview of the socio-economic status of mud crab fishers in Krishna District of Andhra Pradesh

Karthik Palsam¹, Swadesh Prakash^{*}

¹Department of Fisheries Economics, ICAR-Central Institute of Fisheries Education, Mumbai, Maharashtra-400061, India

^{*}Corresponding author: swadeshprakash@cife.edu.in

Abstract

The mud crab, also known as the mangrove crab, is a portunid crab species that are economically significant and is regarded as a source of food and income generation through its fishery in many tropical countries in the Indo-Pacific region. Mangrove forests are generally regarded as the best natural habitat for mud crabs. Andhra Pradesh has a mangrove cover area of 404 sq. km. Krishna district was purposively selected on the basis of prevalence of high mud crab harvesting activities. Proportionate random sampling was carried out to select the fishers from the 9 villages making their sample 152. The data was collected through personal interview method with the help of pre-tested interview schedule and was analyzed using the standard tools and techniques. The results of socio-economic profile of the fishers revealed that 76.32 % of the fishers age was in range of 28-42 years, most of the fishers (57.89%) never attended formal education, 83.55% belonged to the Hindu community, 59.87% of the fishers belonged to the Other Backward class (OBC) community, and 40.13% of the fishers belonged to the Scheduled Tribe (ST) community. Nearly 96.05% of the fishers had family size less than or equal to 5, 85.53% of the fishers reported that they resided in nuclear type of family, nearly 40.13% of fishers were involved in crab catching alone, while 44.07% were involved in both crabs catching and fishing activities. 80.9% of the fishers had monthly income in category range of 9000-14000, and 84.21% of the fishers reported their experience in crab fishing was between 6-19yrs.

Keywords: Socio-Economic Status, Mud Crab, *Scylla Spp.*

TRPSF-FSS-P-2

Economic Assessment of various fishing systems in Pulicat region of Tamil Nadu

Mani Selvam J^{*1}, S Prakash¹

¹ICAR – Central Institute of Fisheries Education, Mumbai – 400 061

^{*}Corresponding author: manishjagan1998@gmail.com

Abstract

Fishing activity plays an ever greater role in providing a high degree of economic and social stability for coastal communities. The Pulicat region is located in the Thiruvallur district of the Coromandel coast, Tamil Nadu. Around 52 villages are located in the Pulicat region; among them, 12 villages under Ponneri Taluk exclusively concentrate on marine fishing. The present study was conducted to assess the economic performance of various fishing systems, viz., Single-day Gill net (SDG), Multi-day Gill net (MDG), Single-day Long line (SDL), Multi-day Long line (MDL), and purse seine (PRS) operated in the Pulicat region of Tamil Nadu. The primary data was collected based on the fishing gears operated in these regions by adopting a proportionate stratified random sampling method through a pre-tested interview schedule. A total of 109 respondents were used in this study, consisting of 20 in SDG, 16 in MDG, 31 in SDL, 17 in MDL, and 25 in PRS. On comparing different fishing systems, the initial investment was lower (₹1.22 lakhs) for the single-day long line system and higher (₹3.09 lakhs) for the purse seine system. The average total cost was higher (₹47.06 lakhs) for the multi-day gill net and lower (₹ 6.9 lakhs) for the single-day gill net. The annual gross revenue was found to higher (₹ 96.5 lakhs) for the purse seine system and lower (₹ 14.4 lakhs) for the single-day gill net system. Fuel cost contributed a major share to the total operating cost for all fishing systems. Analysis of labor productivity showed that the multi-day long line system was earning ₹8,594/- per labor man day, while the single-day gill net earned less ₹1499.1/- per labor man day as compared to other fishing systems. The benefit-cost ratio in all the fishing systems was found to be more than one, indicating that all the five types of fishing systems were economically viable; higher profit was observed in Single-day Long line with the BCR 3.08, and less profitable was in multi-day gill net with the BCR 1.50. Factors influencing the economic returns of different fishing systems were identified through linear regression approach which helps to improve the production performances. Therefore, the data of the present study suggest that economic benefit was higher in single-day longline compared to all other studied fishing systems in the Pulicat region.

Keywords: Economics, Fishing Systems, Discounted Measure, Cost And Returns

TRPSF-FSS-P-3

Evaluating the Effectiveness of CIFS's SCSP Trainings on Aquaculture in Andhra Pradesh

Gobika K¹, Dr. Swadesh Prakash¹

¹ICAR – Central Institute of Fisheries Education, Mumbai – 400 061

Corresponding author: gobika.fecmb102@cife.edu.in

Abstract

The Schedules Caste Sub-Plan (SCSP) serves as a comprehensive strategy to channel targeted financial and physical benefits from various developmental sectors for the advancement of Scheduled Castes. As part of this scheme, a range of training programs are conducted to enhance the livelihoods of Scheduled Caste individuals. Training not only boosts productivity but also fosters motivation and inspiration among participants. The Central Institute of Fisheries Education (CIFE) in Kakinada plays a crucial role in providing specialized training under the SCSP scheme, particularly in the field of aquaculture. CIFE Kakinada offers training programs on various aspects of aquaculture and value addition to empower farmers. Since 2020, four aquaculture programs and two value-addition programs have been conducted. The objective of this study is to evaluate the effectiveness of the "Aquaculture" training program under the SCSP scheme. A total of 100 individuals who had undergone aquaculture training were identified from CIFE Kakinada's records, and a random sample of 45 participants was selected for analysis. The evaluation of training effectiveness was conducted using the Kirkpatrick model, which assesses four levels: "reaction," "learning," "behavior," and "results". Each response was scored on a scale where 1 represented disagrees, 2 denoted partially agree, and 3 indicated fully agree. The scores were normalized and classified as low, moderate, or high. The effectiveness of the training was evaluated based on the trainees' responses. The study revealed that the trainees ranged in age from 19 to 72 years, with a majority having limited or no formal education. The findings indicated that a significant proportion of farmers (71.01%) considered the Aquaculture training highly effective. Regarding the first level, "reaction towards training," 83% of participants expressed a positive response. In terms of the second level, "learning," 74% reported positive outcomes. Specifically, 75% and 74% of trainees acknowledged gains in knowledge and skills, respectively. For the third level, "behavior," 71% of the trainees reported positive changes, including a favorable attitude (81.11%) towards sharing the acquired knowledge and skills with fellow farmers. In relation to the fourth level, "results of training," 59% of participants displayed a positive outlook. While both the Aquaculture and Value Addition Programs exhibited high effectiveness, the Mann-Whitney rank test revealed a significant difference at the 1% level in terms of reaction and results between the two programs. In conclusion, the Aquaculture training program conducted by ICAR-CIFE, Kakinada, has been proven effective, as evidenced by favorable changes observed across all four levels of the Kirkpatrick Model.

Keywords: Effectiveness, Training, SCSP Programs, Kirkpatrick Model

TRPSF-FSS-P-4

FFPO- A Collective Action for Poverty Alleviation in Rural Areas

Ritika Karjee*, Shilpa Sau, Shyam Sundar Dana, Abdul Hannan Mondal

Faculty of Fishery Sciences, Kolkata, WBUAFS

*Corresponding author: karjeeritika6@gmail.com

Abstract

Poverty remains a persistent challenge in rural areas, where limited access to resources and economic opportunities which hinder progress. However, a ray of hope emerges in the form that initiative has proven to be instrumental in addressing poverty by empowering fish farmers and driving sustainable development in rural communities. By fostering collaboration and providing essential support, FFPO has become a catalyst for poverty alleviation and rural empowerment. FFPO recognizes the potential of fish farming as a viable means of income generation and food security. By organizing fish farmers into producer organizations, FFPO enables collective action and empowers small-scale fish farmers to overcome challenges that would be daunting individually. Through capacity building programs, training sessions, and access to necessary infrastructure, FFPO equips fish farmers with the knowledge and resources to enhance their productivity, reduce post-harvest losses, and achieve higher profitability. This not only improves the living standards of individual farmers but also contributes to the overall economic development of rural areas. One of the key strengths of FFPO lies in its ability to create linkages between fish farmers and market opportunities. By establishing networks and partnerships with government agencies, NGOs, and relevant stakeholders, FFPO facilitates market access for fish farmers, ensuring fair prices for their products. Moreover, FFPO assists in value chain development by providing training in processing, packaging, and marketing techniques. This empowers fish farmers to add value to their products, diversify income streams, and break free from the cycle of poverty. FFPO places significant emphasis on knowledge exchange and capacity building, recognizing that empowering fish farmers goes beyond providing financial support. Topics covered include sustainable farming practices, water management, disease

prevention, and market trends. By equipping fish farmers with the necessary knowledge and skills, FFPO ensures the long-term sustainability of the sector and empowers farmers to adapt to changing circumstances. As such, the organization promotes environmentally friendly techniques, such as the use of efficient feed, proper waste management, and ecosystem conservation. By instilling a sense of responsibility towards the environment, FFPO ensures the preservation of aquatic ecosystems, contributing to the overall sustainability of fish farming in rural areas. FFPO, the Fish Farmer's Producer Organization, has emerged as a powerful force for poverty alleviation in rural areas. Through its collective action approach, FFPO empowers fish farmers by providing access to resources, markets, and knowledge. As a shining example of how collective action can transform lives, FFPO stands as a beacon of hope, offering a pathway out of poverty for rural communities and demonstrating the immense potential of fish farming in improving livelihoods and fostering economic growth.

Keywords: Poverty, Fish Farmer's Producer Organization (FFPO), Empowerment, Knowledge, Sustainable Farming Practices, Linkage

TRPSF-FSS-P-5

Fish Farmers Producer Organization (FFPO)–As Farmers Collectives: A Case Study from West Bengal

Abdul Hannan Mondal*, Shilpa Sau, Shyam Sundar Dana, Ritika Karjee
Faculty of Fisheries Sciences, Kolkata, WBUAFS

*Corresponding author: hannanmondal99@gmail.com

Abstract

In India, fish farming has significantly grown over the past decade with small-scale farmers comprising a significant portion of the sector. However, those fish farmers often face huge challenges, including limited access to markets, credit, and technical support. To address these challenges, a special wing in the fisheries sector for empowering the fish farmers, the Fish Farmers Producer Organization, was established to provide a platform for collective action that can help them to achieve economies of scale, negotiate better prices for their products, and share knowledge and resources. The study highlights the importance of collective action in supporting small-scale farmers and the potential benefits of establishing farmers' organizations. The FFPO has been established to support small-scale fish farmers by providing them with access to markets, finance, and technical support. Fish Farmers Producer Organization (FFPO) is a generic term for a legal entity that refers to a group of fish farmers, fishers, or other people involved in the fisheries sector who work together to make sure their businesses are sustainable and profitable. In the past, fish growers affiliated with FPOs and did business, but now the Indian government has placed a sole focus on fish production, this FFPO has the potential to mobilize small and marginal farmers to restructure and leverage the economy. This has proven to be one of the best methods for addressing many issues in aquaculture and related industries while enhancing access to capital, technology, inputs, finance, and markets. This case study explores the strategies employed by the FFPO to overcome challenges and improve the livelihoods of its members. The FFPO's success highlights the potential of collective action in the fishery sector and the importance of empowering small-scale farmers to achieve economic prosperity in rural areas. Through initiatives like the FFPO, sustainable fisheries practices can be promoted while also addressing poverty in rural communities, improving the livelihoods of its members, and providing them with a stronger voice in policy discussions related to fish farming. So, it can be said that FFPO is an instrument in transforming rural poverty into prosperity through sustainable fisheries.

Keywords: Fish Farmers Producer Organization (FFPO), Small-scale fish farmers, Sustainable fisheries, Collective action

TRPSF-FSS-P-6

Innovative Extension Strategy for Adoption of Better management Practices and Marketing System of Asian Sea bass in West Bengal

Abdul Hannan Mondal*, Shilpa Sau, Shyam Sundar Dana, Himadri Prasad Jarh, Ritika Karjee
Faculty of Fisheries Sciences, Kolkata, WBUAFS

*Corresponding Author: hannanmondal99@gmail.com

Abstract

In West Bengal, the Asian Seabass (*Lates calcarifer*) is highly favoured as a diet choice due to its greater amount of meat and higher commercial value compared to the Indian major carp. The Asian Seabass is a fast-growing, euryhaline fish that can be raised in various habitats such as coastal marine, inland saline, brackish water, and freshwater environments. A case study was conducted in the coastal region of Purba Medinipur district of West Bengal, with a sample size of 30 fish farmers as respondents, to assess the current status of sea bass farming and the marketing system. The study concluded that sea bass cultivation and marketing hold immense potential for improving the livelihoods of fish farmers and promoting sustainable aquaculture practices. To capitalize on this opportunity, an innovative extension strategy is essential for the widespread adoption of better management practices and an efficient

marketing system for sea bass. This extension strategy focuses on multiple aspects of sustainable sea bass farming, including the adoption of Better Management Practices (BMPs). The adoption of BMPs would lead to improved production, productivity, while also addressing environmental and social responsibilities. The strategy emphasizes crop planning, crop calendaring, pond preparation practices, water quality screening and fertilization, seed selection, biosecurity practices, feed management, health and disease management, as well as better harvest and post-harvest practices. The study found that only 30 percent of the respondents collected seeds from natural resources, and approximately 65 percent practiced polyculture of sea bass. The majority of respondents (95%) recognized the importance of feed management in sea bass culture. Furthermore, the study revealed that farmers who adopted better management practices, such as regular water monitoring, maintaining proper stocking density, using high-quality seed and protein-rich feed, disease prevention, and grading of sizes, achieved higher yields and profits. Regarding the marketing system, the majority of fish farmers (80%) sold their produce through middlemen in large markets. In this context, the extension system collaborates with farmers to provide them with suitable technologies, knowledge, and skills for effective management of their farm resources and utilization of scientific production methods to achieve the desired production levels for marketing their produce. The innovative extension approaches employed include the Asset-Based Community Development (ABCD) approach, Rural Advisory Services (RAS), Model Village System of Extension (MVSE) approach, Farmers Field School (FFS) approach, Digital Extension System approach (introducing ICTs and computer-based web portals), and Disruptive Extension approach. These approaches aim to disseminate knowledge about modern sea bass farming practices, disease prevention, and improved feed management practices through personal contact methods, mobile units equipped with display materials and soil-water testing laboratories, group contacts such as demonstrations and capacity building, as well as mass contacts like exhibitions, distribution of extension literature, and audio-visual aids including radio and TV talks. Additionally, the strategy acknowledges the significance of marketing systems in ensuring fair and remunerative prices for sea bass produce. It aims to strengthen the marketing linkages between fish farmers and various stakeholders, including wholesalers, retailers, and consumers. By facilitating market access, improving value chain efficiency, promoting branding, and implementing quality certification, the strategy intends to enhance the marketability of sea bass products and increase the income of fish farmers. Successful implementation of this innovative extension strategy requires collaboration between government agencies, research institutions, non-governmental organizations, and local fishery associations. Empowering fish farmers with improved knowledge and skills and strengthening market linkages, this strategy has the potential to boost productivity, profitability, and the overall development of the sea bass farming sector in the region.

Keywords: Asian sea bass, Sustainable aquaculture, Better Management Practices (BMPs), Innovative extension strategy

TRPSF-FSS-P-7

Methodological Perspectives and Scientometric Examination of Fisheries Sustainability

Abhilash Thapa and Neha W. Qureshi*

Fisheries Economics, Extension & Statistics Division ICAR-Central Institute of Fisheries Education, Mumbai - 400 061, India

*Corresponding author: nehaq@cife.edu.in

Abstract

Approximately one-third of global fish stocks are believed to be overexploited, as their populations are dwindling due to excessive fishing practices that surpass their reproductive capacity. We are in a global fisheries crisis, and India is not exempted from it, as too many fishers/vessels create excessive fishing pressure in both inland and marine fisheries, thereby questioning the sustainability of fisheries. In the early days, evaluating the sustainability of fisheries proved challenging, mainly due to the need for comprehensive integration of ecological and socio-economic information as tools used in the sustainability assessment included life-cycle assessment, benefit-cost analysis, ecosystem-services valuation, integrated assessment models, sustainable impact assessment, etc., with a focus on only specific factors. This challenge has been overcome by RAPFISH (Rapid Appraisal for Fisheries). A method used to assess the sustainability of fisheries that provides a systematic framework for evaluating multiple aspects of a fishery, including ecological, social, and economic factors. This study aims to decipher the methodological perspectives involved in RAPFISH and to conduct a scientometric analysis of RAPFISH research worldwide from 2001 to 2023. Articles' bibliographies taken from the Web of Science (WoS) database were analyzed to conduct the scientometrics. Several relevant word combinations of 'RAPFISH', 'Rapid Appraisal Technique for Fisheries', and 'RAPFISH ANALYSIS' were used as search keywords in WoS. It was observed that the standard version of RAPFISH evaluates fisheries sustainability in six evaluation fields: ecological, technological, economic, social, institutional and ethical, each of which can be assessed directly with a set of scored attributes. The RAPFISH technique employs a constrained multidimensional ordination scaled to situate data points within the evaluation space. The results may be presented as a two-dimensional plot or in one-dimensional rank order. Each fishery is categorized based on the sustainable development score obtained from the

RAPFISH ordination. The final RAPFISH score for each evaluation field ranges from 0% (bad/worst) to 100% (good/best). Results from scientometrics revealed that the total population consists of 66 research contributions covered in the WoS database. The compound annual growth rate (CAGR) for publications was 10.5%. 259 authors, 96 institutions, 20 countries and 20 research areas were involved in RAPFISH research worldwide. Out of 66 articles, 80% were research articles, followed by proceeding papers (13.6%). Indonesia was the top publishing country, and environmental sciences ecology was the major research area. Between 2001 and 2023, RAPFISH articles received 883 citations, with an average citation per article of approximately 13. The top publisher was Elsevier, with 20 publications, followed by Wiley (10). Most articles (36.36%) have four author collaborations, and the average collaboration index was 3.73. The correlation coefficient between the year and the number of articles is 0.64, which means that the number of articles published on RAPFISH has steadily increased. Studies relating to sustainability of fisheries in the Indian context are very few. Modifying the RAPFISH methodology to suit different fisheries resources ICAR-CIFE, has conducted studies on marine fisheries (Adiga et al. 2015), reservoirs (Chrispin et al., 2017), lakes (Regu et al., 2019) and estuaries (Thapa et al., 2023). In summary, this study provides valuable insights into the research pattern of RAPFISH. It highlights the need for further research in India and the world for measuring fisheries' sustainability using RAPFISH, which provides a holistic assessment, identifies priorities, promotes transparency and stakeholder engagement, enables adaptive management, and allows international comparisons. These aspects contribute to more effective and sustainable fisheries management, supporting the long-term viability of fisheries resources and the well-being of fishing communities.

Keyword: RAPFISH, Sustainability, Fisheries, Scientometrics, Web of Science

TRPSF-FSS-P-8

Multidimensional study of Fisheries Cooperative Societies in Hardoi district of Uttar Pradesh

Narendra Kumar Verma*¹ and Shyam Sundra Dana²

¹College of Fisheries, Bihar Animal Sciences University, Kishanganj-855107

²Faculty of Fishery Sciences, Kolkata, WBUAFS

*Corresponding author: fishyrenarendra@gmail.com

Abstract

A study was conducted in the year 2017 in Hardoi district of Lucknow subdivision to know the socio economic, level of scientific knowledge for scientific fish practices, economic motivation etc. Lucknow subdivision and Hardoi district was purposively selected because Lucknow subdivision had second highest number (138) of active fishery based cooperative societies and Hardoi had highest number (29) of active fishery based cooperative societies in Lucknow subdivision. Further 13 cooperative societies and 5 respondents from each society, altogether 65 respondents were randomly selected for the study from the Hardoi district. Prestructured interview schedule was used to collect the data. Study revealed that "Matsya Jivi Shkaari Samiti Lit. Khaddipur Chainsingh" was the member wise largest cooperative society in Hardoi district with total 103 members and "Imalipur Matsya Jivi Shkaari Samiti Lit." was the aquatic area wise largest cooperative society with total 43 hectare of aquatic area. Study showed that in Hardoi district majority (76.92) of the ponds were seasonal, 49.67 percent of the respondents were young (up-to 35 years), more than half (53.85%) of the respondents were educated from high school to college level, 61.54 percent of the respondents were from OBC category, 95.38 percent of the respondents had no pond this could be the reason of fish farmers to join the cooperative society, 41.54 percent of the respondents were got training related to fishery activity. Study also revealed that in Hardoi district family members and Cooperative members were most credible source of information. The result also concluded medium level of economic motivation, risk orientation and innovativeness by 64.62 percent, 61.54 percent, and 72.31 percent respondents respectively. The study also revealed medium level of organizational atmosphere and organizational commitment. Knowledge level of farmers regarding scientific fish practices was also examined and found to be of medium level for 72.31 percent of respondents. Poor budget for infrastructure and mobility was the social constraint encountered by 69.23 percent of the respondents. Further study revealed that no cooperative society was practising fish breeding. The information collected from the study will help the policy makers for formulation of location and target specific strategy for socio-economic upliftment of the members of fishery cooperative society in Hardoi district.

Keywords: Hardoi District, Fisheries Cooperative Society, Organizational Atmosphere, Organizational Commitment.

TRPSF-FSS-P-9

Overview of a social network analysis conducted on the KVK (Krishi Vigyan Kendra), KVK Farmers Club and the adoption of technology among fish farmers

Sourav Debnath*¹, Shivaji Argade¹, Arpita Sharma¹, Biswajit Debnath²

¹ICAR-Central Institute of Fisheries Education, Mumbai

² Krishi Vigyan Kendra (KVK), Birchandramanu, South Tripura

*Corresponding author: debnathsourav33@gmail.com

Abstract

Social network analysis (SNA) is employed to understand the structure, interactions, and information flow within the network of farmers, facilitating the study of technology adoption patterns. The KVK Farmers Club serves as a platform for knowledge dissemination and fostering community engagement among farmers. The study was done in the KVK, Birchandramanu, South Tripura where 45 fish farmers, 12 KVK farmers' club members and 3 Subject matter specialists were interviewed. The study aims to identify key actors within the network who play crucial roles in influencing technology adoption among fish farmers. The study explores the social relationships, information-sharing patterns, and communication channels within the network. Network metrics such as degree centrality, betweenness centrality, and closeness centrality are utilized to understand the network's structural characteristics. The study also investigates the role of opinion leaders and influential individuals in driving technology adoption. The findings indicate that the KVK Farmers Club network exhibits a high degree centrality of interconnectedness and knowledge-sharing. Central actors within the network are identified as influential sources of information and innovation, facilitating the spread of technology adoption. The study reveals the presence of information gaps and barriers to adoption, highlighting the importance of targeted interventions to enhance technology diffusion. Understanding the social network dynamics and technology adoption patterns among fish farmers provides valuable insights for policymakers, agricultural extension agencies, and development organizations. The findings can inform the design and implementation of interventions aimed at promoting technology adoption, strengthening social networks, and fostering sustainable agricultural practices.

Keywords: Technology Adoption, KVK Farmers Club, Fish Farmers, Knowledge Dissemination, Innovation Diffusion, Social Relationships

TRPSF-FSS-P-10

Perceptions and Social Implications of Aqua-Drugs and Chemicals in Fish Disease Management by the fish farmer in Purba Medinipur District of West Bengal

Shilpa Sau* and Biswarup Saha

Faculty of Fishery Sciences, Kolkata, WBUAFS

*Corresponding author: shilpasau@gmail.com

Abstract

The Moyna block in Purba Medinipur District of West Bengal has been recognized as a thriving fishery hub by the State Government, with the 'Moyna Model' being hailed as a successful example of freshwater fish culture across the state. Carp farming in Moyna focusing on cultivating large-sized major carp in semi-intensive or intensive systems within out stretched, shallow water bodies. Aqua chemicals and drugs are utilized to manage water quality and combat disease outbreaks. This study aimed to assess the condition of chemical usage among fish farmers in the block for fish disease management, as well as to examine associated concerns. The research involved selecting 80 fish farmers from five different gram panchayats of the concern block. Data collection employed a semi-structured interview schedule and multiple focus group discussions. The findings revealed that approximately 22% of respondents possessed over 20 years of experience in fish farming. The majority of participants (72%) reported annual fish production ranging from 4.46 to 8.15 tons per acre. Fish diseases such as argulosis, columnaris, dropsy, tail and fin rot, and gill rot were prevalent in the study area, as reported by the respondents. To combat fish diseases and maintain fish health, farmers employed a variety of chemicals and antibiotics or combinations of chemicals from different companies. The study identified sixteen types of chemicals from nine different companies being utilized for disease treatment. Antibiotics were primarily used to address bacterial diseases, but their usage was often indiscriminate, with farmers lacking a clear understanding of the underlying causes of the diseases. Additionally, some farmers deviated from prescribed dosages for treatment. The major constraint reported by farmers was the expenses associated with aqua chemicals and drugs. Other challenges included issues related to antibiotic resistance and the lack of diagnostic facilities for accurate disease identification. The study emphasized the urgent need for a fully equipped fish disease diagnostics laboratory, staffed with trained personnel capable of promptly identifying various fish diseases and providing appropriate recommendations for aqua chemical and drug usage. Such measures are crucial for ensuring sustainable aquaculture management, as perceived by the farmers. The study highlights the need for sustainable practices and informed decision-making regarding chemical usage to mitigate potential risks and promote rural prosperity through effective fish farming practices for sustainable development of the fish farming community..

TRPSF-FSS-P-11

Quantifying the Value of Human Capital in Fisheries Colleges of the Himalayan Regions of India: An Empirical Study

Naila M. Bhat, Neha W. Qureshi, Ananthan P.S, Abhilash Thapa
ICAR-Central Institute of Fisheries Education, Mumbai, 400061

*Corresponding author: nehaq@cife.edu.in

Abstract

Human Resource Accounting (HRA) is a crucial process for identifying and evaluating investments in an organization's human resources. Valuing human capital produced by Universities and Colleges is imperative for improving education quality and justifying the budgetary allocation that goes into producing skilled human resource. In the context of fisheries education in India, there is a need to capture the investment / expenditure being made for generating human capital so that the macro-perspective of the benefits of fisheries higher education in India is quantified. This study focuses on the valuation of professional human capital in fisheries colleges located in cold-water regions of India, namely Faculty of Fisheries (FoFy), SKUAST-K, Kashmir, and College of Fisheries (CoF), GB Pant University, Uttarakhand. A methodology developed and copyrighted by ICAR-CIFE for valuing human capital in academia (HCVaf) has been used to evaluate the investment, cost, and contribution of professional fisheries human capital to the development of the fisheries sector. The results revealed that the net investment/expenditure made by GBPUAT on each B.F.Sc. student for 4 years, M.F.Sc. student for 2 years and Ph.D. student for 3 years were Rs. 3,56,969, Rs. 8,93,046 and Rs. 14,16,129 respectively while as SKUAST-K has made an expenditure of Rs. 96,181, Rs. 5,26,816 and Rs. 6,79,975 on each B.F.Sc., M.F.Sc. and Ph.D. students respectively. After mapping the career path of students from 2010-20 and discounting the value generated for next 30 years of their service it was seen that Entrepreneurship has the highest net worth i.e., 13,25,305 followed by Industry/ Private sector (Rs. 6,23,732) in GBPUAT. Similarly, in SKUAST-K entrepreneurship has also seen the highest net worth i.e., Rs. 5,67,607 indicating greater scope for entrepreneurship in the near future. One alarming fact about SKUAST-K is that almost 50% students are still unemployed whereas the unemployment is 27% in GBPUAT. Hence it was surmised that there is a dire need for jobs among fisheries graduates for these 2 colleges. The total expenditure made on GBPUAT's human capital in between 2010-2020 was Rs. 17.37 crores while the total value of students was found to be Rs.366 crores, thereby making a contribution of Rs. 348 crores to the nation, which is almost 21 times of the investment made while for SKUAST-K the total expenditure made on human capital was Rs.11.78 crores, the total value of students was found to be Rs.185 crore, thereby making a contribution of Rs. 173 crores to the nation, which is almost 15.7 times of the investment made. As calculated using Total Factor Productivity and decomposing the contribution of HRD to fisheries economy, GBPUAT contribution to the Fisheries economy through its human capital was found to be Rs. 61.89 crores during 2020-21 and that of SKUAST-K was Rs 98.90 crores in 2020-21 (if contribution of professional fisheries HR to total fisheries HRD is taken as 50%). It can be also concluded looking at the unemployment data that colleges should introduce entrepreneurship programs and incubation units to handhold the students with innovative ideas and enhance their interest in setting up their own business.

Key words: Human Resource Accounting, Valuation, Fisheries Higher Education, Cold Water, India

TRPSF-FSS-P-12

Gender Roles in Freshwater Fish Production: A Case Study of Gadchiroli District, Maharashtra

Rajiv H. Rathod*, Satyajit S. Belsare , Sachin W. Belsare, P.A Telvekar and S B Gore
College of Fisheries, Nagpur, Maharashtra, India

*Corresponding author: rajivrathod@mafsu.in

Abstract

Gender plays a crucial role in the production and management of freshwater fish farming, particularly in rural contexts. This study examines the gender dynamics and roles in freshwater fish production in the Gadchiroli district of Maharashtra, India. By analyzing qualitative data gathered through interviews and focus group discussions, this research aims to explore the involvement of women and men in different aspects of freshwater fish farming and the challenges they face. The findings provide insights into the gendered division of labor, access to resources, decision-making power, and the potential for empowering women in this sector. The study adopts a qualitative research design, employing purposive sampling to select participants from different communities engaged in freshwater fish farming in Gadchiroli district. Semi-structured interviews and focus group discussions were conducted to gather data on gender roles, responsibilities, and experiences related to fish production. The results reveal that freshwater fish farming in Gadchiroli district is predominantly a male-dominated activity. Men primarily engage in activities such as pond construction, fish stocking, feeding, and harvesting. They typically hold decision-making authority and have access to resources such as land, credit, and technical knowledge. Women, on the other hand, are often involved in subsidiary

roles such as fish sorting, cleaning, and marketing. Their participation is often limited to tasks considered "light" or "less skilled." However, the study also highlights the significant contributions and potential of women in freshwater fish production. Women play a crucial role in post-harvest activities such as processing, value addition, and marketing. By actively engaging women in the entire value chain of freshwater fish farming, their empowerment and economic independence can be enhanced. Despite their contributions, women face several challenges in accessing resources and decision-making power. Limited access to credit and extension services, lack of training and technical support, and social norms that restrict women's mobility and participation hinder their active involvement in fish production. Addressing these challenges requires targeted interventions, including gender-responsive policies, capacity-building programs, and improved access to resources and markets. Increased participation of women can enhance productivity, diversify income sources, and contribute to rural economic development. Moreover, empowering women in the sector can improve household nutrition, food security, and overall well-being.

Key words: Processing, Value Addition, Marketing

TRPSF-FSS-P-13

Small Wonders: The Fascinating World of Indigenous Fish Species

Shiva Rajak*, Asha T. Landge, Shashi Bhushan
ICAR-Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Versova, Mumbai 400061, India
*Corresponding author: shiva.frmfb005@cife.edu.in

Abstract

Small indigenous fish species (SIFS) is a population of a very important group of total finfish and shellfish that significantly contribute to the nutritional as well as livelihood security of the rural mass. Small indigenous fishes (SIF) species usually attain a maximum length of 25-30 cm in the mature or adult stage of their lifecycle. They inhabit rivers, tributaries, floodplains, beels, wetlands, paddy fields, ponds and tanks, lakes, streams, and lowland areas. In India, out of 877 native freshwater fish species, about 450 are Small Indigenous Fish Species (SIFS). The North East Region records the maximum diversity of SIFS in freshwater, followed by the Western Ghats and Central India. About 62 SIFS have been categorized as food fish, while 42 species as ornamental fish. Some cultivable SIFS are Mola, Climbing Perch, Barbs, Bata, etc. Small, indigenous fish are nutritionally very important because they are consumed whole, along with bone, head and eye, thereby providing a source of calcium and other micronutrients. They are nutritionally very dense and contain a rich source of micronutrients. The SIFS provide most of the essential minerals important in human nutrition as they are eaten whole, with bone, head and eye. Besides these micro-minerals, they are abundant in macro minerals like calcium and phosphorous. The SIF are rich sources of vitamins, particularly vitamins A, D and E and vitamins B1, B2 and B3 also. Some commonly consumed, small freshwater fish species like *Amblypharyngodon mola*, *Parambassis ranga*, *Osteobrama cotiocotio*, *Esomus danricus* have been found to contain high amounts of vitamin A in the form of retinol and 3, 4-dehydroretinol isomers. The SIFS play an important role in preventing protein-calorie malnutrition and, more specifically, the micronutrient deficiency, safeguarding the rural populations nutritional and livelihood security.

Keywords: Small Indigenous Fish, Nutrition, Biodiversity, Livelihood Security

TRPSF-FSS-P-14

Strategic Extension Campaign for Conservation of Fish Diversity in Kangshabati River of Paschim Medinipur District, West Bengal

Ritika Karjee*, Shyam Sundar Dana, Shilpa Sau, Abdul Hannan Mondal
Faculty of Fishery Sciences, Kolkata, WBUAFS
*Corresponding author: karjeeritika6@gmail.com

Abstract

There is a very high diversification of fish stocks in India. But global warming, climate change and various anthropological activities are responsible for losing diversity in fish fauna in this country. West Bengal also bears a special type of fish diversity according to the climate. The state's economy significantly depends on the work of fishing community. The strategic extension campaign consists of a problem-solving mindset, participatory planning methodology, rigorous extension staff training, the creation of multimedia products, and extension management, monitoring, and evaluation procedures. Its main aim is to solve or minimise problems that caused the non-adoption of such a recommendation by the intended target beneficiaries. This study provides insights that the expertise of fishermen can effectively supplement scientific data and enhance modelling techniques for fisheries research and management. The study was conducted among randomly selected 60 respondents from Phulpahari in Paschim Medinipur district of West Bengal. Data were collected using an observational method combined with a structured interview schedule. The results of the study indicated that the respondents participated in the population at a medium level, had little interaction with extension agencies, and had a medium level of knowledge about modern fishing practices. But the diversity and the number of fish species are diminishing day by day. Overfishing is the main reason

of the declining fish population. Additional factors included human involvement, the use of harmful equipment, habitat degradation from natural calamities, and others. One of the most significant factors in the decline of the fish population is pollution. Local fishermen claimed that the annual output is extremely low and has been declining year after year, which significantly affects their socio-economic profile. In order to enhance the level of productivity of fisherman, it is crucial to increase their knowledge. As a result of this topic's examination, there is an urgent need of training programme for capacity building of fishers on use of modern crafts technology and proper mesh-size gear that can help them catch the targeted fish without harming other species of fish and teach them to stop fishing during the closed season. This will increase diversification and reduce duplication. The diversification of fish species will rise if the government takes initiatives such as river ranching that can help to restore fish habitat as well as their socio-economic status, which will be developed in a sustainable manner and drive them to economic prosperity. As per the study's findings, the majority of the respondents were young, so if skill-oriented training is implemented properly which will ultimately help the farmers to adopt improve technology for conservation of biodiversity.

Keywords: Diversification, Fishing Community, Anthropological Activity, Strategic Extension Campaign, Knowledge, River Ranching, Biodiversity

TRPSF-FSS-P-15

The Contribution of Fisheries and Aquaculture to India's protein supply

Shyam Datta Waghmare*, Dr. Swadesh T., P, Arpita Sharma, Vinod Kumar Yadav, Neha Qureshi, Saba N Reshi, Kalidoss Radhakrishnan

Fisheries Economics, Extension, and Statistics Division, ICAR-Central Institute of Fisheries Education, Versova, Mumbai-400061,

*Corresponding author: shyamdattaw@gmail.com

Abstract

Livestock and fisheries are major animal sources of protein for human consumption in India. The relative significance of the fisheries sector compared to livestock in providing protein is crucial for assessments and decision-making regarding production and its security. The study was conducted to quantify the amount of human-consumed protein produced in 2020 by terrestrial animals, milk, eggs, marine fisheries, and inland fisheries. Data was sourced from the Food and Agriculture Organization, Handbook of Fisheries Statistics, and published literature for this. The total amount of crude protein was estimated using standard formulas by following Boyd et al., 2023. A log-log linear regression was applied for harvest weights and estimated amounts of crude protein of terrestrial animals, marine fisheries, and inland fisheries to obtain future estimates of protein from different animals. The estimated crude protein was remarkably greater for the meat of terrestrial animals, milk, and eggs (9,632 Kt) compared to the marine and inland fisheries (1,308Kt). Marine fisheries provided 284 Kt of crude protein, but freshwater fisheries contributed 1,024 Kt. of crude protein. Fish production in India has increased from inland fisheries through aquaculture activities. It was estimated that fish production would need to increase from 82,087 Kt in 2018 to 129,000 Kt by 2050 to meet the demand of the greater global population, which apparently indicates that marine and inland fish production significantly contributed to protein supply.

Keywords: Animal-source Protein, Aquaculture Production, Protein Production

TRPSF-FSS-P-15

The Silver Lining Of Indian Villages- An Incentive Pearl Culture Technique towards Rural Prosperity

Megha S Vinod*

ICAR-Central Institute of Fisheries Education, Mumbai

*Corresponding author: meghasindhuvinod@gmail.com

Abstract

Economy and ecology rarely meet and congruent. One such possible intervention which could bind both these sustainably and profitably will form the discussion of this article. Community ponds, the backbone of any village water supply system, could also serve as an income source for the village natives. The very idea of cultivating freshwater pearls in these tanks has been proved to reap huge profits to the tune of 50-60 % as exemplified by various instances across the country. Simple and cost-effective culture techniques have paved the way towards earning huge income. Necessary technical assistance is being offered by CIFA alongside monetary support from the GoI through Pradhan Manthri Matsya Sampada Yojana (PMMSY) in the form of subsidies and loans to pamper and promote the underprivileged and also the fisheries sector for income generation. The key attractants are the high market demand and value with less maintenance and labour, negligible feed cost, and minimum expenditure for culture setup. The final product being non-perishable can be stored to earn money out of it on a long-term basis. A strong supply chain and good fraternity within the village and outside will help establish a strong network for procuring seeds to collective

aquaculture work up to sales. Besides, the pond water quality will also get improved through bivalve culture with their innate filtering system, which adds to the list of advantages. Pradhan Manthri Sansaad Adarsh Gram Yojana entitles to diversify livelihood options to uplift the rural lifestyle for which the concept of pearl culture in community tanks serves true justice as the income generated here is in terms of lakhs and the market outreach is again unimaginably wider. Our farmers will expand their network on a global scale and with proper, timely, scientific and artistic interventions; they can also create milestones in developing an array of different variety pearls or maybe supporting tools and techniques for easy culture of mussels. An epitome is set for this by a farmer duo named Ashok Manwani and his wife Kulanjan Dubey Manwani from Maharashtra who has earned so far, many accolades for reinventing the pearl culture with their brainpower. For an unproductive drought-affected village in the Marathwada region of Maharashtra, the pearl culture has given revitalisation and around 4500 farmers from Maharashtra got inspired by this and have taken up pearl culture. Farmers from Odisha, Kerala, West Bengal and other places too have their own success stories to share of their pearl culture like Mr Abdullah from Hyderabad who started off his culture in his small backyard pond with an initial investment of just Rs 18,000 which after 18 months earned him a profit margin of Rs 3,80,000. Yet another positive attribute of pearl culture is that it can be practiced by even the women at home as it is simple to execute while the men go out for some other work. This way woman of the villages also gets empowered alongside subsidiary income being generated. Henceforth, on a parallel line, young minds from every village across the country are invited to execute a similar plan for a prosperous tomorrow for them as well as for the country, validating the words of the father of our nation, MK Gandhi.

Keywords: Economy, Pradhan Manthri Matsya Sampada Yojana (PMMSY), Pradhan Manthri Sansaad Adarsh Gram Yojana

Young Scientist Conclave

TRPSF-YSC-O-1

Application of remote Sensing and GIS to *Trichiurus lepturus* fishery in the north - west coast of India: A management approach

Dr. Abdul Azeez P.
ICAR-CMFRI, Veralal Regional Centre

Abstract

Ribbonfish, specifically *Trichiurus lepturus*, is one of the major marine capture fish in the northwest coast of India (NWCI) having significant commercial as well as ecological importance. The targeted fishery for ribbonfish using mid-water trawler began in the mid-2000s for international export. However, information on fishery bycatch, as well as environmental preferences of ribbonfish is sparse limiting precise prediction of the fishing grounds for efficient harvest and management of the resource. Therefore, the study used cutting-edge technology, such as geospatial and remote sensing tools, to examine fishery data from mid-water trawlers targeting ribbonfish in NWCI. The research included extensive onboard sampling of trawl catches and GPS positions of fishing grounds. The bycatch included 123 species and was estimated to account for 56.92% of total catch by weight. Teleosts accounted for 62.09% of bycatch, followed by cephalopods (35.88%), crustaceans (1.47%) and elasmobranchs (0.56%). Discards formed 6.32% of total catch and included 62 species belonging to 29 families. Bycatch per hour of fishing varied significantly between the seasons, with the lowest in summer and highest in post-monsoon. Bycatch rates were lower in offshore waters than inshore waters. Furthermore, major bycatch areas were mapped using geospatial tools to identify hotspots and the spatio-temporal distribution of bycatch, was influenced by ribbonfish abundance and indicated trophic competition. The ribbonfish catch rate in the region were influenced by both north-east and south-west monsoon. The study explored the biophysical links between catch rates of major resources such as ribbonfish and cephalopods in the fishery; found that satellite remote sensing environmental factors were significant in determining the abundance of these resources. The lower catch rates were located near cold core, high Chlorophyll-a (CHL) and turbid waters during winter whereas higher catch rates were found in post-monsoon months when Sea Surface Temperature (SST) ranged between 27°C and 29.5°C, CHL concentration lower than 1.5 mg m⁻³, Euphotic depth (Z_{eu}) between 35 m and 57 m, Sea Surface Height anomaly (SSHa) less than 0.1 m. Potential ribbonfish fishing grounds along the northwest coast were predicted and forecasted using machine learning technology for the mid-water trawl fishery. This reliable and short-term species-specific forecast will assist fishers in precisely targeting the desired resources. Furthermore, the findings of this study will enable fishers to achieve higher catch rates with reduced search time, resulting in a lower carbon footprint and reduced bycatch in the fishery, thereby minimizing the ecological impact. Moreover, the findings of this study will aid resource managers and policymakers in developing scientifically sound fishery management plans and decision support systems. These efforts will pave the way for an environmentally responsible and sustainable fishing industry.

Keywords: Remote Sensing, GIS, *Trichiurus lepturus*, Chlorophyll-a

TRPSF-YSC-O-2

Studies on pelagic fish eggs and larvae in nearshore waters of Gulf of Mannar, Tamil Nadu

Dr. Jyoti Saroj
College of Fisheries, Kumarganj

Abstract

The present investigation was conducted to study the diversity, distribution, spawning season of fishes, molecular identification of fish eggs and larvae and distribution of fish eggs and larvae based on GIS mapping at Mandapam, Thoothukudi and Punnakayal in Gulf of Mannar from September 2017 to May 2019. A total number of 26,092 fish eggs were collected and 48 species were identified from all the studied stations during the study period. Eggs of *Atherinomorus lacunosus*, *Callionymus* sp., *Amblygaster leiogaster*, *Hilsa kelee*, *Sardinella longiceps*, *S. jussieu*, *Carangoides maBabaricus*, *Decapterus russelli*, *Setipinna taty*, *Hirundichthys coromandelensis*, *Hemirhamphus* sp. *Planiliza macrolepis*, *Ophisurus macrorhynchus*, *Echelus* sp., *Pseudorhombus javanicus*, *Rastrelliger kanagurta*, *Scomberomorus commerson*, *Saurida tumbil*, *Arothron* sp. and *Sphyræna* sp. were collected for the first time in the nearshore waters of Gulf of Mannar. A total number of 5,100 fish larvae were collected and 23 species were identified from all the three stations in Gulf of Mannar. Larvae of *Hypoatherina valenciennesi*, *Oryzias dancena*, *Etroplus suratensis*, *Planiliza macrolepis*, *Alepes djedaba*, *Atule mate*, *Gerres erythrouros*, *Auxis rochei rochei*, *Katsuwonus pelamis*, *Pelates quadrilineatus*, *Terapon puta*, *Bothus* sp., *Cynoglossus arel*, *Cociella crocodilus* and *Halicampus grayi* were collected for the first time in the waters of Gulf of Mannar. The laboratory development of the Mugil cephalus from egg to the just hatched larval stage has been studied. The eggs were found to be abundant at Punnakayal and Thoothukudi and larvae were found to be more abundant at Thoothukudi. Maximum number of fish

eggs and larvae were recorded during 2018 compared to 2017 and 2019. During the study period, a total of 36 species of zooplankton representing 8 phyla, 10 classes, 13 orders, 20 families and 32 genera were recorded from all the three stations, Maximum zooplankton density 41624.2 no./100m³ was observed at Thoothukudi. The COI sequence of eggs of *Thryssa hamiltoni*, *Planiliza macrolepis*, *P. subviridis* and *Sardinella jussieu* and larvae of *Carangoides praeustus*, *Chanos chanos*, *Gerres erythrorus*, *Hypoatherina valenciennei*, *Pelates quadrilineatus* and *Terapon puta* were generated from the Thoothukudi and Punnakayal waters. GIS based distribution of fish eggs and larvae has been studied at all the three stations. The abundance of fish eggs was in higher proportions in the nearshore waters off Punnakayal during summer and the aggregations of larvae in Gulf of Mannar was the highest in the nearshore waters of Thoothukudi and Mandapam during summer. Considering all, the environmental parameters, zooplankton and fish eggs and larval diversity and distribution of the studied stations reflected good water quality with high potential fish eggs and larval yields. As per the study on fish eggs and larvae, Punnakayal and Thoothukudi are the most productive water body followed by Mandapam in Gulf of Mannar. In the Gulf of Mannar, fish eggs and larvae were observed almost in every month at Punnakayal and Thoothukudi compared to Mandapam, indicating that Punnakayal and Thoothukudi region is probably a suitable spawning ground for many species.

Keywords: Pelagic Fish, Gulf Of Mannar, GIS, COI Sequence

TRPSF-YSC-O-3

Impact of Climate Change on Small Pelagic Fishery Resources of South-West Coast of India

Dr. Vivekanand Bharti

ICAR-Research Complex for Eastern Region, Patna

Abstract

Keeping the view of climate change on marine fisheries, the present study was conducted along the south west coast of India to ascertain the extent of the impact of the change in climato-oceanographic features and biological aspect of the small pelagic resources. The monthly data on total 8 environmental parameters such as Sea Surface Temperature, Chlorophyll-a, Surface wind, Sea Current, Sea Level Anomaly, Rain rate, Southern Oscillation Index and Dipole Mode Index were collected from various open access sources to observe the climate-oceanographic features along the south west coast of India. Further, the monthly data on catch and effort data for selected fishes such as Indian oil sardine, Indian mackerel, *Stolephorus spp.* and *Thryssa spp.* Along the south west coast of India were collected from Central Marine Fisheries Research Institute, Kochi. Standardized catch per unit effort (catch per hour, CPH) for the entire south west coast of India in relation to selected fish was estimated. Further, data on all environmental parameters and CPH was segregated into three regions as southern region (Stratum_1), middle region (Stratum_2) and northern region (Stratum_3), and three seasons like pre-monsoon, monsoon and post-monsoon to observe the trend both spatially and seasonally. Also, the trend for gear-wise catch for all selected fishes was conducted in the present study. Time series analysis with the help of three homogeneity tests (Pettitt's test, Buishand range test and Standard normal homogeneity test) and changepoint analysis was performed to detect the change in the time series data of both environmental parameters and CPH of fish. Logistic regression and stepwise regression model were applied to establish the relationship in dynamics between climato-oceanographic features and small pelagic resources. This study revealed that the sea surface temperature (SST) is continuously rising over the south west coast of India. The rising SST led to a change in the trend of chlorophyll-a, wind and current speed, upwelling index, sea level anomaly and precipitation rate along the south west coast of India. Shifting in chlorophyll-a at the south west coast of India have been taken place during the period 2011-13. The present study shows spatial and seasonal changes in the pattern of all environmental parameters at the south west coast of India. Chlorophyll-a concentration has reduced at both southern and northern region, while the same has increased middle region. Both horizontal and vertical expansion of sardine, mackerel, *Stolephorus spp.* and *Thryssa spp.* are observed under the influence of changed pattern in oceanic features. Under the influence of climate change, the seasonal shift in the CPH of selected fish has been also found at the south west coast of India and the size of the first maturity of sardine and mackerel has been reduced in the recent 11 period. Climate change led both horizontal and vertical expansion of Indian oil sardine, Indian mackerel, *Stolephorus spp.* and *Thryssa spp.* The CPH of *Thryssa spp.* might be predicted up to 63% with the help of the stepwise regression model by using chlorophyll-a concentration, meridional current speed, sea level anomaly and precipitation rate.

Keywords: Climate Change, Pelagic Fishery, South-West Coast, Catch Per Hour

TRPSF-YSC-O-4

Recovery of proteins from freshwater fish (Pangas and Rohu) processing waste by use of pH shift method: Characterization storage and utilization of the recovered proteins

Dr. Vijay Kumar Reddy S.

College of Fisheries, GADVASU, Ludhiana

Abstract

The processing of Indian major carps and Pangas is bound to generate lot of waste and the best way to utilize these wastes is to recover the proteins for edible purpose. In the present study utilization of Rohu and Pangas processing waste for the recovery of fish protein isolates using pH shift process was attempted with reference to optimization of the process for protein isolation, characterization of protein isolates and their utilization in edible food products. During the protein solubilisation, pH 2.0 and pH 13.0 gave maximum protein yields ($p < 0.05$), which was 31.11-31.81 g/100 g, and 59.16-68.52 g/100 g, for Rohu and Pangas, respectively. Process variables like extraction time, temperature, etc. showed significant effect on protein solubility and yields ($p < 0.05$). Gel strength of acid and alkaline processed isolates (1127.46 and 1289.43 g cm) from Pangas were found to be higher than the gel strength of acid and alkali processed isolates from Rohu (967.00 and 927.89 g cm). When studied for frozen storage quality changes in Rohu and Pangas proteins, TBARS, total pigments and myoglobin content, folding test scores decreased with storage time ($p < 0.05$). While optimizing the Rohu and Pangas protein isolate content in the sausages, Pangas protein isolates at 10% level and Rohu protein isolates at 25% level significantly improved the cooking yield and other quality attributes. Textural quality of sausages without protein isolates was found to be superior to sausage with no significant difference in any of the sensory attributes ($p > 0.05$). Pangas mince sausages with 10 g/100g Pangas isolates and 25 g/100 g Rohu isolates, stuffed into cellulose and LDPE casings, were frozen stored and studied for the quality changes. Among the variations, emulsion without protein isolates showed highest G' and G'' values. Significant changes were observed in the attributes during the storage period ($p < 0.05$). Sausages incorporated with protein isolates were found to have low expressible moisture than the sausages without protein isolates ($p < 0.05$). Cooked frozen sausages were found to have better quality compared to raw frozen sausages in majority of the attributes tested. Sensory scores of these attributes showed a gradual decrease with an increase in storage period, and at the end of 3months frozen storage, sausages from 10PICL and 25RICL were still acceptable with a sensory scores of 5.2 and 5.4, respectively ($p < 0.05$), which showed advantage of sausages added with isolates and stuffed into cellulose casings than sausages without isolates and stuffed into LDPE casings. The study proved that Rohu and Pangas waste could be used to recover proteins with good yields and functionality. Freezing and frozen storage could severely affect the quality and functionality of recovered isolates, necessitating the addition of cryoprotectants before freezing/storage. Rohu and Pangas protein isolates could be used to enrich fish sausages, without compromising the quality. Cellulose casings could be a successful low-cost alternative for synthetic/ krehalon casings, which could help in keeping the quality of sausages, on par with synthetic casings.

Keywords: Proteins, Freshwater fish, pH, Freezing

TRPSF-YSC-O-5

Study on Occurrence of Microplastic in Water, sediments and selected fishes off Mumbai Coast

Dr. Udai Ram Gurjar

Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar

Abstract

Microplastics are anthropogenic pollutants that can adsorb toxic substances from surrounding water and enter the fish body. The water, sediments, and biota samples were collected from September 2018 to March 2020 to account for microplastics in the coastal ecosystem of Mumbai, India. λ The abundance of MP in water and sediment samples ranged from 149-547 MPs/liter and 4400-15300 MPs/kg dry weight (DW), respectively. The mean abundance of MP in surface waters, sediments and fishes was significantly ($P < 0.001$) to the total weight, total length, and GI tracts weight of biota. λ The mean abundance of MP particles per individual in shrimp species varied from 5.36 ± 2.81 to 7.40 ± 2.60 . MP size range of 100-250 μm was dominantly recorded in the GI tracts of all studied shrimp species, surface water and coastal sediments. Shape-wise, four types of MP were observed; fibers were predominant in the surface waters, sediments and all studied shrimp and fish species, except malabar sole fish, in which fragments were dominant. Seven different colors of microplastics (red, blue, black, translucent, brown, green, and yellow) were observed in the present study. λ Based on Raman spectroscopy analysis, eleven types of plastic polymers were identified from all the samples. Thus, the presence of MPs in biota indicates chances of transfer of MPs through interlinked food chain/web to higher trophic levels. The occurrence of MP in the fish and shrimp GI tracts underlines the need for further studies on processing intervention to reduce microplastic contamination in fish/shrimp before human consumption. λ These kinds of studies are essential to create awareness about microplastic pollution and plastic usage among different stakeholders and also vital to monitor and suggest ideal remedies for preventing or

reducing plastic (microplastic) pollution to improve the quality of the natural environment and human health. Eventually, such evidence may lead manufacturers and consumers to understand the outcomes of their choices of plastic use and the subsequent contamination of the food we put in our meals.

TRPSF-YSC-O-6

Modulating innate immune memory in brine shrimp (*Artemia franciscana*) and in giant freshwater prawn (*Macrobrachium rosenbergii*)

Dr. Suvra Roy

ICAR-Central Inland Fisheries Research Institute, Kolkata, West Bengal

Abstract

In this study, the possibility to create transgenerational innate immune memory using different priming agents was explored and further underlying molecular mechanisms were studied. The creation of transgenerational innate immune memory was studied using brine shrimp (*Artemia franciscana*) as a model. Hereto, a parental generation was primed with viable or inactivated *Vibrio parahaemolyticus* PV1 while another parental generation was primed with viable or inactivated *V. campbellii* LMG21363. Axenic larvae of three subsequent generations were exposed either to the homologous or heterologous *Vibrio* species and their survival was recorded. Protection in the infected offspring was more pronounced when they were infected with the homologous vibrio strain, so the one that was used to prime the parents. Disease resistance was associated with significantly increased transcription of immune genes (especially *pxn*, *propo*, *LGFB*, *HMGB1* and *hsp90* genes) and significant changes in histone acetylation and m6A RNA methylation. Overall, results might lead to procedures at shrimp brood stock level for parental conditioning and creation of transgenerational innate immune memory in offspring. Next, to understand the mechanisms behind transgenerational immune priming, the study was extended by performing proteomics (LC-MS/MS) analysis. Analyses of differentially produced proteins showed that, immune challenging F0 generation of *A. franciscana* with *Vibrios* resulted in the production of different proteins in F1 and F2 generations. It was shown that several mechanisms and pathways (cellular, metabolic and protein processing machinery/proteolytic cascade) are involved in the development of *Vibrio* resistance phenotypes in F1 and F2 generation. This novel finding facilitates a deeper understanding of immunometabolic mechanisms behind the transgenerational innate immune memory and host defence during reinfection. Here, using the brine shrimp (*A. franciscana*) as a model system and phloroglucinol treatment of the parental animals at early life stages resulted in transgenerational inherited increased resistance in their progeny against biotic stress, i.e., bacteria and abiotic stress. Increased resistance was recorded in three subsequent generations. Results showed that phloroglucinol treatment of the brine shrimp parents significantly enhanced the expression of a core set of innate immune genes in subsequent generations. Epigenetic mechanisms such as DNA methylation, m6A RNA methylation, and histone modifications might play a role in regulation of gene expression leading toward the observed transgenerational inheritance in the resistant brine shrimp progenies. To the best of our knowledge, this is the first report on transgenerational inheritance of a compound-induced robust protected phenotype in brine shrimp. Furthermore, a study was conducted to expand and validate the phloroglucinol-induced transgenerational transfer of acquired phenotype in *M. rosenbergii*. To this end, *M. rosenbergii* parental generation was treated with plant-based compound and their offspring was tested for resistance against biotic and abiotic stress challenge. Improved survival was observed later on in life following exposure to compound within the same generation and most interestingly in the next generation of *M. rosenbergii* F1 animals. To the best of our knowledge, this is the first validation study of parental conditioning and inheritance of a compound-induced resistance. This study will facilitate future research and application of parental conditioning as a unique and powerful management strategy against prophylaxis of infectious diseases in the shrimp farming industry.

Keywords: *Artemia franciscana*, *Macrobrachium rosenbergii*, phloroglucinol, *Vibrio parahaemolyticus*

TRPSF-YSC-O-7

Species Diversity, Reproductive Biology and Population Characteristics of Bivalves from the Coastal Waters of Southern Tamil Nadu

Dr. Suman Takar

The Neotia University, Kolkata, West Bengal

Abstract

The present study on Species Diversity, Reproductive Biology and Population Characteristics of Bivalves from the Coastal Waters of Southern Tamil Nadu which contributes to the knowledge about the bivalve species diversity and basic biological information on the three bivalve species and to evaluate the present status of the stock in the region of the southern coast of Tamil Nadu. Molluscs are one of the most important ecological elements as primary consumers within aquatic food chains and are considered as the most prominent members of marine faunal ecosystems (AM El Mekawy et al., 2019). Bivalves constitute the second-largest class of Mollusca and comprise about

7500 species worldwide (FAO, 2016). Bivalves are herbivores with a sustainable type of food web. During the study period, a total of 30 live species belong to 16 genera, nine families, and seven orders were recorded from three different stations along the southern coast of Tamil Nadu. Nine bivalve families were recorded from Ramanathapuram with a dominance of Veneridae (60.39%), six families from Thoothukudi with a dominance of Veneridae (68.95%), and six from Kanyakumari with a dominance of Carditidae (28.29%). Food and feeding indicate all three species are filter feeders and planktivorous in nature. In *M. casta* and *G. pectinatum*, phytoplankton was the dominant group, followed by detritus and zooplankton, whereas in *D. cuneatus* detritus was, the dominant group, followed phytoplankton and zooplankton. The *M. casta* had a continuous spawning with the peak in December to February and July to August. *D. cuneatus* had a prolonged spawning with peak spawning in December to February, and *G. pectinatum* also had a prolonged spawning with the peak in February, October, and June to July. The exploitation ratio (E) 0.44, 0.30, and 0.39 reported for *M. casta*, *D. cuneatus*, *G. pectinatum* respectively. The exploitation rate (U) 0.42, 0.27 and 0.34 were observed for *M. casta*, *D. cuneatus*, *G. pectinatum* respectively. The exploitation ratio (E) for *M. casta* was close to the optimum level, but in the case of *D. cuneatus* and *G. pectinatum*, exploitation is less than optimum levels (0.5); hence, further scope to harvest more *D. cuneatus* and *G. pectinatum* by increasing the fishing effort along the studied region.

Keywords: Diversity, Reproductive Biology, Bivalves, Exploitation Ratio

TRPSF-YSC-O-8

Elucidation of critical larval nutritional elements for the production of robust milkfish fry

Dr. T. Sivaramakrishnan

ICAR- Central Institute of Brackishwater Aquaculture, Chennai

Abstract

The present work was undertaken to elucidate the ontogeny of the digestive system of milkfish larvae, to optimize the dietary lipid and fatty acid composition for best growth, feed utilization, and survival of milkfish larvae, to ascertain the dietary requirement of natural antioxidant vitamins for optimal growth, survival, and stress tolerance of milkfish larvae and to examine the benefits of adding specific dietary additives for maximizing the growth and survival of milkfish larvae. The activity profile of key digestive enzymes viz., trypsin, chymotrypsin, leucine aminopeptidase, lipase, amylase and alkaline phosphatase during the early ontogeny of milkfish, *Chanos chanos* (0, 3, 6, 9, 12, 15, 18, 21, 25 and 30 days post-hatch). With respect to protein digestion, the specific activity of pancreatic enzymes trypsin and chymotrypsin, and intestinal brush border leucine amino peptidase showed two peaks at 3 and 15 dph. Overall, as most of the enzymes were found to have peak activities at 15 to 21 dph. This period can be potentially considered as the developmental window for weaning larvae from live to artificial feeds in milkfish hatcheries. The docosahexaenoic acid (DHA) content of egg, newly hatched larvae (NHL) and 21 dph larvae are 2.77, 1.36 and 1.94 mg g⁻¹ respectively. The reduction of fatty acids (Fas) is very high in newly hatched larvae (NHL), especially DHA (51%), ARA (26%) and EPA (24%), indicates the significance of these Fas during the embryogenesis of milkfish egg and those values are to be considered while formulating feeds for larval stages of milkfish. Dietary phospholipid content 52.5 g kg is optimum and more vital for milk fish larval development. Optimized vitamin C & E level in milkfish larval feed to 855.5 mg/kg and 243mg/kg of the diet, respectively. 0.52% of taurine and 1.12% of squid protein hydrolysate supplementation was beneficial in the diet of *C. chanos* early life stages. The results of the study gave an insight in the understanding of the ontogeny of the digestive enzyme activities of the milkfish larvae and the series of feeding experiments ascertained the optimal nutrients and additives for milkfish fry. The overall results would help in designing suitable larval diets for robust milkfish fry production.

Keywords: Larval Nutrition, *Chanos chanos*, Taurine, Squid Protein Hydrolysate

TRPSF-YSC-O-9

Dietary intervention for improving growth and immunophysiological responses in *Penaeus vannamei* (Boone, 1931) juveniles reared in inland saline water

Dr. Prasanta Jana

College of Fisheries Science, Gumla

Abstract

Four experiments were conducted for 60 days each to develop a cost-effective and eco-friendly feed for white-leg shrimp, *Penaeus vannamei* reared in inland saline water (ISW) of 15 ppt salinity. First experiment was conducted with seven semi-purified hetero-nitrogenous (200 to 500 g CP/kg), isocaloric (396 Kcal DE/100g) and iso-lipidic (60 g/kg) experimental diets viz., CP20, CP25, CP30, CP35, CP40, CP45 and CP50 in triplicates. Highest ($p < 0.05$) final body weight (FBW), weight gain (WG), specific growth rate (SGR) with lowest feed conversion ratio (FCR) were observed in CP40 group followed by CP35 and CP45 groups. Protease and amylase activities showed an inverse trend with highest ($p < 0.05$) protease activities found in CP40, CP45 and CP50 groups. Transaminases and antioxidant enzyme activities were higher ($p < 0.05$) in CP40 and CP20 groups, respectively. CP40 group exhibited highest ($p < 0.05$) prophenoloxidase (proPO), respiratory burst (NBT) and lysozyme activity. Therefore, 392.60-397.90 g CP/kg diet is

optimum for *P. vannamei* juveniles. Second experiment was conducted with six iso-nitrogenous (400 g CP/kg), hetero-lipidic (40 to 140 g lipid/kg), and heteroenergetic (376 to 426 Kcal DE/100g) semi-purified experimental diets viz., CL4, CL6, CL8, CL10, CL12 and CL14 in triplicates. Highest ($p < 0.05$) FBW, WG, SGR and PER were observed in CL6 group followed by CL8 and CL4 groups and lowest in CL14 group. CL8 group showed the highest ($p < 0.05$) hepatopancreatic lipase activities. CL6 group showed higher ($p < 0.05$) activities of transaminases and lower activities of oxidative stress enzymes. An increasing trend of ProPO, NBT and lysozyme were observed up to CL10 group then reduced gradually. Therefore, feeding 55.80-58.80 g lipid/kg diet is optimum for white-leg shrimp, *P. vannamei*. Third experiment was carried out with twelve LPHE practical hetero-nitrogenous (400 to 320 g CP/kg), hetero-lipidic (60 to 100 g lipid/kg), and heterocaloric (384 to 406 Kcal DE/100g) experimental diets viz., T1 (400 g CP/kg and 60 g lipid/kg), T1C (T1 + 0.5 g/kg L-carnitine), T1T (T1 + 5 g/kg taurine), T1ct (T1 + 0.25 g/kg L-carnitine and 2.5 g/kg taurine), T2 (360 g CP/kg and 80 g lipid/kg), T2C (T2 + 0.5 g/kg L-carnitine), T2T (T2 + 5 g/kg taurine), T2ct (T2 + 0.25 g/kg L-carnitine and 2.5 g/kg taurine), T3 (320 g CP/kg and 100 g lipid/kg), T3C (T3 + 0.5 g/kg L-carnitine), T3T (T3 + 5 g/kg taurine), and T3ct (T3 + 0.25 g/kg L-carnitine and 2.5 g/kg taurine) in triplicates. Two-way analysis revealed higher ($p < 0.05$) FBW, %WG, SGR, FER with lower FCR in T1 group and combinely nutraceutical fed (ct) group with highest ($p < 0.05$) values in T2ct group. PER and LER values were higher ($p < 0.05$) in T2 and T1 group, respectively. Higher ($p < 0.05$) hepatopancreatic lipase activities was observed in T2 group and mixed nutraceuticals (ct) fed group. T2ct group showed the highest ($p < 0.05$) transaminase enzyme activities. Higher ($p < 0.05$) antioxidant enzyme activities were recorded in T3 group and lower in L-carnitine and taurine combinely (ct) fed group. T2 group and combinely nutraceuticals (ct) fed group exhibited higher ($p < 0.05$) proPO, NBT and lysozyme activities with highest value in T2ct group. Therefore, it can be concluded that T2ct diet (360 g CP/kg and 80 g lipid/kg supplemented with 0.25 g/kg L-carnitine and 2.5 g/kg taurine) showed the best performance in terms of growth and health status of *P. vannamei* reared in ISW of 15 ppt. Furthermore, in the fourth trial under pond condition, based on production performance and economic analysis, T2ct diet exhibited additional 10% growth benefit and an additional profit margin of Rs. 3,27,100 (1 ha, 10,000 m²) in comparison to commercial diet (C). The outcomes of the study will help to develop a cost-effective feed for ISW shrimp culture and can generate extra income for the shrimp farmers of salt-affected regions.

Keywords: *Penaeus vannamei*, Inland Saline Water, Growth, Immunophysiological

TRPSF-YSC-O-10

Identification, expression profiling and functional analysis of gonadotropin inhibitory hormone (GnlH) gene in *Catla catla* (Hamilton, 1822)

Dr. Pravesh Kumar

College of Fisheries, Dholi, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar

Abstract

Indian major carps, contribute more than two-third of aquaculture production in the country. Among Indian major carps, *Catla catla* is one of the fast growing and most important cultivable freshwater fish species. But it takes longer duration to become sexually mature compared to other Indian major carps, which increases the time and cost of brood stock development for fish hatchery managers. Generally, *C. catla* took 2-3 years to become sexually mature compare to other Indian major carps which mature in 1+ year. The Hypothalamus Pituitary-Gonadal (HPG) axis contains both positive and negative regulators of reproduction in vertebrates. The well-established negative regulators of HPG axis are Dopamine and GABA which inhibit the reproduction by acting on GnRH neurons. In 2000, a new neuropeptide, GnlH was discovered from the brain of Japanese quail which unveils the negative effect on reproductive axis of birds and mammals. But in fishes GnlH showed both positive and negative effects on reproduction depending on the species, breeding phase etc. So, the knowledge about this peptide in reproduction of *C. catla* can provide some important information's about the delay in age at first sexual maturity. GnlH and its receptors and used GnlH antagonist, RF313 and GnlH peptide for its functional analysis was characterized during this study. The injection of GnlH-III peptide during the pre-spawning phase increased the mRNA expression of reproductive genes and serum hormones, while GnlH antagonist, RF313 significantly reduced the mRNA levels of reproductive genes. It indicates that GnlH had stimulatory effect in *C. catla*. So, to further confirm this stimulatory effect, we checked the synergistic effect of GnlH with LHRHa (GtH stimulator) and melatonin (GtH inhibitor). LHRHa alone increased the gonadotropins at hormone and gene expression levels and the combination of LHRHa with GnlH resulted in further increase in GtH levels. While melatonin alone reduced the GtH hormone and Mrna levels, while in combination with GnlH, hormones and mRNA levels were restored as per control. These studies confirmed the stimulatory effect of GnlH-III peptide on reproductive axis during the pre-spawning phase in *C. catla*. In India research on Gonadotropin inhibitory hormone (GnlH) peptide is lacking in fishes, even globally only limited studies were conducted on GnlH peptides in fishes. The role of GnlH is still inconclusive in fishes. So, this research is in noble area of neuro endocrinology and had given some insides of GnlH system in fishes or especially in carps which are most cultured species in India. Further this research also opens the field for future work in this area for enhancing our knowledge in fish endocrinology and reproduction. Future studies in this species may be carried out to elucidate the role of other

mature GnIH peptides at different reproductive stages to better understand the molecular mechanism of action of GnIH system.

Keywords: GnIH, *Catla catla*, Expression Profiling

TRPSF-YSC-O-11

Assessment of Bottom Trawl Fisheries along Veraval Coast, Gujarat

Dr. Rajan Kumar
ICAR-CMFRI, Veraval Regional Centre

Abstract

The present study is based on data from commercial trawlers operating from the Veraval fishing harbor in Gujarat. There were basically three types of trawling by Veraval's trawlers: pelagic trawling, cephalopod trawling and bottom trawling. The trawls used by Veraval's trawlers have five specific designs based on the target resource, namely: ribbonfish, cephalopod, perch, shrimp and *Acetes* trawl. The different trawl design mostly varies in the mesh sizes in wing and belly portion. The cod end mesh sized ranged from 8 mm in *Acetes* trawls to 20 mm in ribbonfish trawls. The recommended mesh size of 40 mm (square-mesh) for fish trawls is barely in practice. The bottom trawling formed only a sub-component of the multi-day trawl operation and accounted for 33.17% of the total effort spent by them. The percentages of juveniles landed for selected 15 species were in the range of 3.11 to 80.10%. The study period has witnessed the sudden rise and fall of Red-tooth trigger fish (*Odonus niger*) fishery along the west coast of India. The surface current anomalies might explain the phenomenon. The major demersal resources like threadfin breams, croakers and penaeid prawns were found to have a seasonal shift in their high abundance zones, with post-monsoon season being the most productive for the fishery. The study reported 380 species from the bottom trawl catches of Gujarat across 248 genera, 131 families, 37 order, and 10 class. The depths, latitudes and seasons showed significant difference in species richness, and other diversity indices. There were new distributional records for 22 finfishes and 18 crustaceans reported from trawl catches. Over capacity is the trawl sector was identified as the most evident problem. Poor implementation of mesh size regulation is another cause of concern. Operation of unauthorized trawlers poses additional challenges, both for assessment and the suitability of the resources. The strict implementation of mesh size regulation and strengthening of the fisheries department with more staffs dedicated towards implementation of MFRA is required to ensure sustainability of the resources. Implementation of Minimum legal Size (MLS) for species having significant juvenile landings should be implemented with immediate effect to avoid economic loss due to juvenile fishing. As bulk of juvenile landings are consumed by surimi or fish meal plants, a minimum legal size for procurement of raw materials for processing units should also be in place. It will be much easier to monitor MLS implementation at processing units than fishing units. Further, it would remove economic incentives for juvenile fishing. As trawl has diversified into its sub-component, dedicated research project should be formulated to estimate the efforts estimated by sub-components of trawl fishing to estimate realistic catch per unit effort for resources, the key indicator for the resource abundance.

Keywords: *Odonus niger*, Minimum legal Size, Veraval Coast, Bottom Trawl

TRPSF-YSC-O-12

Studies on monogenean parasite(s) infecting *Pangasianodon hypophthalmus*: Characterization, Pathology and Immune responses

Dr. Saurav Kumar
ICAR-Central Institute of Fisheries Education, Mumbai

Abstract

Disease outbreaks are a major bottleneck in the development of sustainable aquaculture practices including pangasius farming. Majority of reports of bacterial diseases in diverse aquaculture system of *Pangasianodon hypophthalmus* from various countries have been documented. In India, *P. hypophthalmus* is also noticed for infection with bacterial pathogens and several parasitic infestations is also found to have severe infection in early larval stages of pangasius fish which hampers the production. Gill fluke infection is commonly seen in *P. hypophthalmus* farms with prevalence ranging from 60% to 90% with intensity as high as 200 parasites per individual. Further, high mortalities due to gill fluke are generally noticed in early life stages of pangasius fish. Despite the fact that gill flukes contribute to significant losses due to the secondary bacterial infections that follow the initial infections with the parasite, this receives little attention. The investigation on the monogenean parasite infesting *P. hypophthalmus*, their pathogenicity and host-parasite interaction are important in terms of developing the guidelines for prevention, control and treatment of the disease epidemics. High level of prevalence of monogenean (*Thaparocleidus siamensis* and *T. caecus*) in *P. hypophthalmus* (both monogenean are exotic species in India) cultured in cages. Analysis of spatial distribution of parasite between 4 gill arches and 6 regions (anterior-posterior and dorsal-ventral) of gills revealed that *Thaparocleidus* spp. preferred to aggregate more on gill arch 1 and 2 and posterior-central and dorsal-medial regions of the gills. The degree of parasite infestation depends on host size rather its weight and most prefer site are gill arch 1 & 2 resulting severe biological

stress causing irritation and respiratory distress in infected fish. A significant ($p < 0.05$) increase in TEC, TLC, Hb, PCV, serum protein, SOD, CAT, sGOT, sGPT, LDH and lactate level and a decrease in MCH, MCV, MCHC and lymphocyte were detected in the infected fish. A clinical and histopathological result of parasitized fish reveals a negative effect on fish health expressed in terms of severe oxidative stress and poor health. Analysis of the markers of innate immune and stress in blood and serum showed significant increase in levels of Respiratory Burst Activity, Myeloperoxidase level, serum lysozyme, α -2 macroglobulin (α -2 M) and total serum immunoglobulin in moderate to high monogenean-infested group in compared to un-infested fish. Cellular oxidative biomarkers SOD, CAT, GST and Na⁺-K⁺-ATPase in gills and liver were significantly high ($p < 0.05$) in Thaparocleidus-infested fish in comparison to the control. However, decreased levels of albumin, A:G ratio, total serum antiprotease and ceruloplasmin level were observed in fish infested with low degree of Thaparocleidus, while no significant ($p > 0.05$) difference was observed between low to moderately infested, and the control group. The results of the present study also show that cellular oxidative biomarkers SOD, CAT, GST and Na⁺-K⁺-ATPase are potential biomarkers for monitoring the health of fish during parasite infection. The investigation on the monogenean parasite infesting *P. hypophthalmus*; their pathogenicity and host-parasite interaction are important in terms of developing the guidelines for prevention, control and treatment of the disease epidemics.

Keywords: *Pangasianodon hypophthalmus*, Gill fluke, Innate Immune, Cellular Oxidative Biomarkers

TRPSF-YSC-O-13

Isolation, Characterization and Biocontrol Efficacy of Potential Probiotic and Bacteriophage against *Aeromonas hydrophila* Infection in *Labeo rohita*

Md. Idrish Raja Khan

Lt. SPN College of Fisheries, Kawardha

Abstract

Globally aquaculture has emerged as one of the most promising suppliers of premium quality animal protein. With the ever-increasing global population and to meet nutritional necessity, there has been a transition from extensive and semi-intensive to modern intensive aquaculture practices. However, modern intensive culture practices are associated with certain drawbacks, most importantly, the vulnerability of fish to environmental stresses and numerous pathogenic organisms, which has led to frequent and substantial financial loss to fish farmers throughout the globe. To avoid or minimize the loss caused by disease, a plethora of chemotherapeutics especially antibiotics, has become a customary practice. However, the indiscriminate and negligent use of these constituents is plagued with negative consequences, and now the situation lies where the chemotherapeutics are at risk of running out of efficacy and giving rise to drug resistance and the emergence of AMR (anti-microbial resistance), and ultimately superbug development. To answer this very concern, the biological control approaches such as probiotics and bacteriophages have established their significance as an effective as well as sustainable strategy. Over the years, there has been significant research around the globe, including in India to support the adoption of these naturally available ready to mine alternatives as biocontrol agents to combat diseases. In this study, out of 67 screened endosymbionts from rohu gut, five were selected and identified as *Bacillus amyloliquefaciens* COFCAU_P1 (MN880150), *B. licheniformes* COFCAU_BLP2 (MK907598), *B. subtilis* COFCAU_BSP3 (MK907599), *Pseudomonas entomophila* COFCAU_PEP4 (MK907600) and *P. mosselii* (MK907601.1). The isolates showed an antimicrobial response, high tolerance to a wide range of pH and bile salt concentrations alongside significant *in vitro* adhesion attributes. The strains were non-haemolytic and could produce extracellular enzymes with substantial free radical scavenging activity whereas challenge studies revealed the strains were non-pathogenic. Based on the *in vitro* tests and challenge study, *B. amyloliquefaciens* was found most promising and was selected for further dietary evaluation. The presence of species-specific signature genes (2, 3 bisphosphoglycerate-independent phosphoglycerate mutase, arginine/ ornithine antiporter ArcD, Choloylglycine hydrolase, LuxS and E1 β -subunit of the pyruvate dehydrogenase complex) and putative probiotic-associated marker genes (BamHI and barnase) were also confirmed in *B. amyloliquefaciens*. Dietary administration of *B. amyloliquefaciens* (107, 108 and 109 CFU g⁻¹ diet) significantly modulated non-specific immune responses, biochemical indices, mRNA expression of immune genes *IL-1 β* and *TNF- α* , and survivability against *A. hydrophila* infection. *A. hydrophila*-specific bacteriophage, 24 phages were isolated which showed high titre value (109 to 10¹⁰ PFU ml⁻¹) and wide host range (12.5 to 75%). Among isolated phages, seven were chosen based on the host range and satisfactory cross-infectivity levels. The stability assay of selected phages revealed a sensitivity of phages at different pH, temperature, and bile salt concentrations and based on the results of *in vitro* analyses of all phages, AvP-2 was selected for further testing. One-step growth curve and MOI analyses revealed the biocontrol efficacy of AvP-2. Later, AvP-2 administration significantly enhanced the survival of rohu against *A. hydrophila* infection. Additionally, transmission electron microscopy and nucleic acid analyses revealed that the AvP-2 is an icosahedral DNA phage, presumably belonging to the order Caudovirales and family Myoviridae. The results of the present study collectively suggest that *B. amyloliquefaciens* COFCAU_P1 and AvP-2 are the potential probiotic and bacteriophage strains, respectively, with significant biocontrol attributes.

TRPSF-YSC-O-14

Valorization of *Acetes* spp. for the Bioactive peptides and Biopolymers

Dr. Vignaesh D.
PPIFT, TNJFU, Chennai

Abstract

The present study was aimed to screen the suitable enzyme and optimize the degree of hydrolysis and to characterize the structure and functionality of peptides obtained from the desired DH and to utilize the shell residue for the production and characterization of biopolymer for biomedical applications. It was found that *Acetes* protein hydrolysates with low DH contain potential functionalities which could be utilized in the application of functional foods. It also could be inferred that increase in DH significantly not only reduced the functional properties such as emulsion and foam formation and but also increased the bioactive properties. The *Acetes* protein hydrolysates were found to reveal a variable extent of antioxidant and ACE inhibitory activities. The differences between the antioxidant and ACE inhibition activities were related to the enzymes used and the hydrolysis degree. The effect of DH on the secondary structure showed the higher intensities of beta turn and beta sheet and lesser peaks for alpha helices structural components implying the exposure of hydrophobic amino acid residues. Also an increasing trend was obtained between beta turn and DH was noticed in trypsin, papain and pepsin assisted hydrolysis. These results therefore demonstrate the potential of using FTIR for monitoring the changes in the secondary structures taking place during protein hydrolysis and also paving the way for determination of these changes in other applications. It is also concluded that the degree of N-acetylation and crystallinity were better in enzymatically prepared chitin compared to chemically prepared ones, which confirmed that hydrolytic treatment significantly improved the physicochemical attributes of chitin. Further works on the development of an optimized process for chitin degradation is imperative for scaling up at industrial levels. It can minimize chitin degradation and decrease its impurity levels to a satisfactory level for specific applications

Keywords: *Acetes* spp., Bioactive peptides, Biopolymers

TRPSF-YSC-O-14

Acute hepatopancreatic necrosis disease (AHPND) in shrimp: virulence, pathogenesis and mitigation strategies

Vikash Kumar
ICAR-Central Inland Fisheries Research Institute, Kolkata

Abstract

Acute hepatopancreatic necrosis disease (AHPND), a relatively new farmed penaeid shrimp bacterial disease originally known as early mortality syndrome (EMS) has been causing havoc in the shrimp industry. The shrimp production in AHPND affected regions has dropped to ~60%, and has resulted in collective losses exceeding an estimated US \$43 billion across Asia (China, Malaysia, Thailand, Vietnam) and in Mexico. Hence, in the present thesis the AHPND-causing *V. parahaemolyticus* M0904 strain was used and virulence mechanism and pathogenesis were studied in both *in vitro* and *in vivo* conditions. Later, management/ mitigation solutions for acute hepatopancreatic necrosis disease (AHPND) with respect to shrimp aquaculture are investigated. The results demonstrated that *V. parahaemolyticus* secreted PirA^{VP} and PirB^{VP} toxins are primary virulence factor that mediates AHPND and mortality in shrimp. The PirAB^{VP} toxin binds to epithelial enterocytes in the midgut and hindgut and induce necrosis of cellular structure that leads to subsequent death of shrimp larvae. Additionally, the presence of PirAB^{VP} toxin in the aquatic environment were found to synergistically increased their *in vivo* virulence of *V. harveyi* MM30 and *V. alginolyticus* AQ13-91 strain, while additive effect was noticed in *V. harveyi* BB120, BB152 and JMH603 strains. In contrast, antagonistic interaction was observed with *V. campbellii* LMG21363, *V. proteolyticus* LMG10942, *V. parahaemolyticus* CAIM170 and *V. anguillarum* NB10 strain. Furthermore, the study showed that setting of phenotype switching in AHPND-causing *V. parahaemolyticus*, from virulent free-living planktonic form into a non-virulent biofilm producing phenotype, by culture environment manipulation could be an effective management strategy to control AHPND in shrimp farming, without necessarily removing the AHPND-causing bacteria from the culture system. And application biofloc system and bamboo powder that switch the virulent *V. parahaemolyticus* into non-virulent form or supplementation of heat shock inducing compounds are promising new methods to control *V. parahaemolyticus* infection and shrimp mortality. The study provides a basis for *V. parahaemolyticus* infection management strategy, but its further development, fine-tuning and implementation will need further research to make the suggested techniques a keystone in sustainable shrimp aquaculture.

Keywords: Acute Hepatopancreatic Necrosis Disease, Early Mortality Syndrome, *V. Parahaemolyticus*, Shrimp

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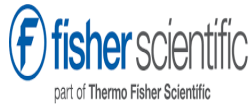


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TULSI APARTMENT
GOVIND MITRA ROAD
PATNA - 800 004

☎ : 2308327, 2301531(O)
FAX : 0612-2308327
email : angelscistores_1@yahoo.co.in

Mobile: 8969815327



SINGHAL FIBERS & WATERPROOFING SOLUTIONS

AN ISO 9001 : 2005 CERTIFIED COMPANY

MANUFACTURER & SUPPLIERS OF :-

**ALL KINDS OF FRP FISH REARING TANKS, FISHING
NETS/ EQUIPMENTS, BIOFLOC TANK, HYDROPONIC TANKS,
FRP BOATS, FRP FOUNTAINS AND SCIENTIFIC EQUIPMENTS.**

Also Deals in Solid Waste Management Handling Equipments



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PRADHAN MANTRI MATSYA SAMPADA YOJANA

ENTREPRENEURS MODEL IN FISHERIES & AQUACULTURE

Eligible beneficiaries

- Individual Entrepreneurs & Private firms
- Fishers, Fish Farmers, Fish workers, & Fish Vendors
- Fisheries Cooperatives/SHGs/JLGs/FFPOs

Eligibility

- Applicant having own land /leased land for a minimum period of 10 years.
- Should have necessary clearance/ permission etc required for the project.
- Should not have availed similar assistance/subsidy for any similar activity under any Government scheme/Government agency.

Subsidy/Funding patterns

- Back-end subsidy linked Scheme with the bank loan from nationalized/Scheduled banks.
- The total project cost for subsidy sanction is restricted up to 5 Crore.
- Ceiling limits of NFDB Subsidy (Central Assistance)- General- 25 % of TPC (Rs 1.25 Crores) & SC/ST- 30% of TPC (Rs 1.50 Crores).
- Bank loans can be availed (Max Limit)-General Category- up to 65% of TPC & SC/ST/Women- up to 60% of TPC
- Beneficiary Contribution-Min 10% & Max up to 40% of the Total Project Cost
- The eligible subsidy will be released in 3 Instalments- (20:50:30) to the bank directly.

GROUP ACCIDENT INSURANCE SCHEME

- NFDB is a nodal agency for implementing GAIS under PMMSY through M/s Oriental Insurance Company Limited (OICL).

Eligible Beneficiaries

- Fishers, Fishermen, Fisherwomen, Fish Workers, Fish Farmers, and person who are all directly involved in fishing and other allied activities in the age group of 18 to 70 years.

Eligible Insurance Coverage

- Rs.5.00 lakh against accidental death or permanent total disability (PTD)
- Rs.2.50 lakh against permanent partial disability (PPD)
- Rs. 25,000 against accidental hospitalization
- The premium amount of Rs 72.44/- per fisher is shared between Central and State.
- No beneficiary contribution

**Exclusive Portal
for claim
Intimation is.
gaispmmsy.com**



**National Fisheries Development Board,
Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying,
Government of India**

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AWYUK



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AMRIT BREEDER FARMS PRIVATE LIMITED

