Annual Report

2021

ICAR-CIFE
Mumbai

Azadi Ka Amrit Mahotsav

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Ranking of Agricultural Universities 2020

This is to certify that

ICAR-Central Institute of Fisheries Education, Mumbai

is ranked Number **7** amongst Agricultural Universities

7th RANK

(R.C. Agrawal)
Dy Director General (Ag. Edn)

3 December 2021, New Delhi

(Trilochan Mohapatra)
Secretary, DARE & DG, ICAR

वार्षिक प्रतिवेदन
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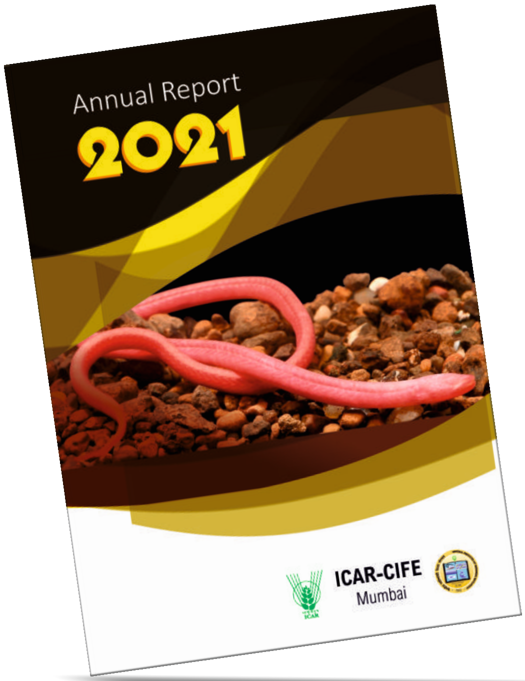

Cover Page

A new species of freshwater eel, *Rakthamichthys mumba* (Family: Synbranchidae) was discovered in a well from Mumbai. The scientists have described the species using morphological and molecular tools. The eyes of this fish have become vestigial organs as it inhabits underground aquifers. The new blind eel holds significance in studies on the evolution of traits in eels/fishes. These findings are published in the peer-reviewed journal *Aqua: International Journal of Ichthyology*. The multi-disciplinary and multi-institutional research team consisted of Dr. Pavan Kumar, ICAR-CIFE; Mr. Praveenraj, ICAR-CIARI; Mr. Tejas Thackery, Thackery Wildlife Foundation; and Dr. Anil Mohapatra, Zoological Survey of India.

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Foreword

I am pleased to present the Annual Report of the Institute for the year 2020, an unusual year in the wake of Covid-19 pandemic, that disrupted normal life and activities. Being **one of the top Agricultural Universities** (7th Rank), it continues to be the most preferred destination for fisheries graduates from across India and the Afro-Asian countries. This year ICAR-CIFE was bestowed with the "**Green and Clean Campus Award** - **3rd Position**". The award was announced in the presence of the Hon'able **Prime Minister of India** (online) on the occasion of the Vice-Chancellors' Conference held on **28 September, 2021** in recognition of the sustainable and eco-friendly practices adopted by the University campus.

The institute gives impetus to the overall development of students through national and overseas exposure. CIFE has organized several programmes that academically benefit students and expose them to wider aspects of science. CIFE scholars continue to corner most of the Assistant Professor placements in the NARS while making their presence felt across the globe through participation in many international conferences and prominent labs. Several students were placed as fishery development officers, fisheries inspectors, assistant directors of fisheries in state departments, teaching faculty in state fisheries colleges, private Universities and in banking sector.

CIFE has been engaged in frontline fisheries research with magnificent research contributions this year. Thirty-five institutional and 18 externally funded projects were in operation during 2021. The institutional projects are on pertinent subjects intended to solve the problems of fisheries sector such as developing bioflocs using multiple carbon sources for high-yielding and organic small-scale aquaculture systems; package of practices for application of biochar in inland saline aquaculture system; cost-effective recirculatory aquaponic system (*Pangasius* grown with Spinach) for small-scale farmers/ households; Use of novel biofilter - *natural zeolite balls* – for GIFT tilapia based RAS; development of an *inactivated vaccine* against *F. columnare* using local field isolate of *F. columnare* and a *dual vaccine* against *F. columnare* and *E. tarda (patent filed);* developed TaqManquantitative real-time PCR - based diagnosis of assays for WSSV *(patent granted)* and hepatopancreatic parvovirus (HPV) for shrimp viral diseases; captive broodstock development, breeding and seed production technology of *Anabas testudineus;* significant progress in undertaking the Indian magur genetics, selective breeding, genomics, and proteomics; and valuation and accounting of human capital in Indian fisheries higher education.

The quality of research efforts is evident from the publications in high impact journals. In 2021, the institute has published 182 research papers in reputed national and international journals, 25 book chapters, 37 popular articles, 14 training manuals and 18 extension materials. Two patents have been granted in 2021 for developing a portable FRP hatchery for carp seed production and formulation of fadrazole loaded nanoparticle feed for efficient masculization of *Poecilia reticulate*. The findings of laboratory research and the faculty expertise in various fields of fisheries has been disseminated through skill development programmes, CAFT and short-term training programmes.

The fast-developing fisheries sector is in dire need of skilled workforce. Being an academic institute, CIFE has always given utmost priority to impart training in various aspects of fisheries. Short-term Training Programmes (STP) and Skill Development Programmes (SDP) are regularly conducted at CIFE HQ as well as at its centers. During 2021, 41 SDPs were organized which benefitted 3500 farmers and youths from across the country. Under Tribal Sub Plan, 1468 tribal people were trained through 18 training programmes. Under the SCSP component, ICAR-CIFE has conducted a total of **12** training programmes in West Bengal, Andhra Pradesh and Jharkhand benefiting as many as 928 participants. We believe that the skill development trainings will empower the youth in terms of better employability and fulfil the needs of aquaculture and fish processing industries. The Institute actively pursues its endeavor to introduce youngsters into fisheries entrepreneurship through Agribusiness Incubation (ABI) center. This year the editorial team of the Annual Report 2021 has revised the presentation format. The research programs are categorised into 12 thematic areas and the research work by master's and doctoral students are presented under relevant themes. The other chapters have also been reorganised to give greater coherence.

In the pursuit of excellence, we sincerely acknowledge the support, guidance and continuous encouragement by Dr. Trilochan Mohapatra, Hon'ble Secretary (DARE) & Director General (ICAR) in all our endeavors. We are grateful to Dr. J. K. Jena, Deputy Director General (Fisheries Science) for his encouragement and support in all our activities. We thank Dr. Pravin Puthran, ADG (Marine Fisheries), Dr. B. P. Mohanty, ADG (Inland Fisheries) and other colleagues from the Fisheries Division for their co-operation and support. Our sincere thanks are due to the Members of Board of Management, Chairman and Members of Research Advisory Committee, Members of Academic Council, Institute Research Council, Extension Council, Board of Examiners and other institute-level committees for their cooperation and support. I especially acknowledge the support of Team CIFE and congratulate the publication team for bringing out this wonderful compilation of our activities.

(Ravishankar C. N.)
Director & Vice-Chancellor

Executive Summary

कार्यकारी सारांश

ICAR-CIFE is a distinguished academic institution known for its excellence in teaching and research in the field of fisheries science. In the last 6 decades, it has contributed remarkably to the development of fisheries sector since its inception in 1961, catering to the needs of industry and the academia alike. The institute has evolved from a training center to a Deemed-to-be University and today, the institute with its highly qualified scientific and technical manpower offers post-graduate programmes in 11 specialized disciplines of fisheries science. Recognising the concerted efforts and contribution of ICAR-CIFE, Education Division of ICAR has conferred CIFE with the 7th rank among 66 other Agricultural Universities of India. This year, about 171 post-graduate students (96 MFSc and 75 Ph.D) gained entry into the institute through national level entrance examinations. CIFE has the best research infrastructure and laboratory facilities at the headquarter and at its five centers that provide enormous opportunities for the scientists and students to realize their research ideas into workable solutions to the problems of fisheries sector. The institute continues its endeavor of providing trained human resources, who continue contributing to the development of fisheries sector in various capacities as entrepreneurs, scientists, educationists, consultants and trainers.

The second wave of COVID-19 which hit the World in March 2021 gave a severe jolt to the research progress and the academic activities. Nevertheless, like first wave, CIFE could quickly come in terms with the emergency with contingent plans to carry out research, extension, teaching, and training activities. The virtual mode was adopted immediately and in quick succession, all the activities of the institute were routed through the virtual mode. This rapid transformation helped the institute to accomplish its set goals without significant shortcomings. The curricular activities including teaching, examination, evaluation and the declaration of results were done through the virtual platform. The training programs were also conducted online as scheduled.

Spanning 6 specialized Departments and 5 Centers equipped with up-to-date laboratories and farm facilities, CIFE's academic breadth is extensive. CIFE has diverse and eminent faculty with over 90% of them holding Ph.D. They are drawn from the best universities across India and have been trained in leading universities all around the world. CIFE prides itself in being a progressive and truly multicultural institution with students and faculty drawn from all corners of India. International students enrich the already colorful cross-cultural experience on campus. CIFE alumni include over 2500 flag bearers who are driving aquaculture engine across the globe and are part of brilliant research teams. CIFE has an excellent faculty-student ratio with focus on one-to-one interaction and student accomplishments. While the full-time degree courses remain the flagship, other need-based customized programs are offered by CIFE. Professional Development Program (PDP), Entrepreneurial Development Program (EDP), and the short-term demand-driven and customized Skill Development Programs (SDPs) are organised by CIFE and its Centres creating a cadre of competent para-professionals and confident entrepreneurs. During 2021, **113 theses** were submitted; of which 29 are PhD & 84 are M.F.Sc theses. Besides, CIFE is recognized as the only Centre of Excellence for Advanced Faculty Training (CAFT) in Fisheries wherein more than 300 faculty/scientists from State Agricultural University and ICAR institutes have been trained.

The research activities of CIFE are oriented to serve the dual goal of scientific advancement and the welfare of the sector. In 2021, a total of **53 Projects** (18 are externally funded with a budget of about Rs.30 crores and 35 are institutional funded projects) were in operation. These research projects focus on the key areas of fisheries leading to impact making knowledge products, be it publications or technological packages. CIFE's technological package for shrimp aquaculture in inland salt-affected soils of north-west India is transforming the degraded ecosystem in parts of Haryana, Punjab, and Rajasthan creating wealth from waste and providing viable livelihoods. Recently, CIFE has made strides in areas such as developing bioflocs using multiple carbon sources for high-yielding and organic small-scale aquaculture systems; package of practices for application of Biochar in inland saline aquaculture system; cost-effective recirculatory aquaponic system (*Pangasius* grown with Spinach) for small-scale farmers/ households; Use of novel biofilter - *natural zeolite balls* – for GIFT tilapia based RAS; developed an *inactivated vaccine* against *F. columnare* using local field isolate of *F. columnare* and a *dual vaccine* against *F. columnare* and *E. tarda (patent filed);* developed TaqManquantitative real-time PCR - based diagnosis of assays for WSSV *(patent granted)* and hepatopancreatic parvovirus (HPV) for shrimp viral diseases, Captive broodstock development, breeding and seed production technology of *Anabas testudineus, s*ignificant research and development on Indian magur genetics, selective breeding, genomics, and proteomics. In addition, *CIFE's human capital* calculated using the TFP model, contributed to the fisheries economy to the tune of Rs. 299 crores during 2020-21, indicating a 6 times return on investment in fisheries higher education. Adding more accolades to the achievement basket, two patents were granted in 2021 for developing a portable FRP hatchery for carp seed production and formulation of Fadrazole loaded nanoparticle feed for efficient masculization of Poecilia reticulate.

In the year under report, ICAR-CIFE published **182 research articles, 130** in **international and 52** in **National** peer-reviewed journals with an average NAAS Score of 8 (NAAS>10= 48 papers). Further, 2 books, 25 book chapters, 37 popular articles, 14 training manuals, and 18 extension materials were also published from CIFE. The faculty of CIFE delivered 110 invited talks in national and international forums.

During 2021, CIFE and its centers conducted **41** skill development programs (SDPs) in which 3500 trainees participated from different parts of the country. The training programs covered diverse topics such as Value Added Fish Products Preparation, Basic and Advanced Computational tools for Molecular Genetics, Preparation of leaf meals-based feed, Statistics for Social Science Scholars, Molecular Taxonomy, Biofloc Technology in Fish Farming, In-plant training programme for college students, specialised training programs for Bihar fish farmers from Kolkata and Kakinada centers, online training programmes as per the advice of Ministry of Agriculture, Govt. of India.

Under the SCSP component, ICAR-CIFE has conducted several training programmes for the development of the SC community. During 2021 a total of **12** training programmes were conducted in West Bengal, Andhra Pradesh and Jharkhand benefiting as many as 928 participants. The training programmes covered topics such as Integrated Aquaculture, Freshwater Fish Culture, Modern methods of freshwater aquaculture, Demonstration of leaf meal based farm made aqua-feed preparation and on-farm feeding management, Preparation of value added fishery products, Livelihood improvement of fisherwomen through value addition and Basics in Aquaculture Practices. Under TSP during 2021 a total of 18 training programmes were conducted in Maharashtra, Tripura, Meghalaya, Jharkhand, Manipur and West Bengal including a launch workshop benefiting as many as 1468 participants. The areas covered were Aquaculture in Percolation Tank, Modern Methods of Freshwater Aquaculture, Ornamental Fish Culture for women fish farmers of Dimbhe and Jharkhand, Hygienic fish handling and value-added fish product, Aquaculture as a Potential Livelihood Option for Tribal Communities, Disease Management and Sustainable Aquaculture Practices with Good Post-Harvest Techniques, Value added fish products preparation from freshwater fish, enhancing fish productivity through farmers participatory research etc. Under NEH programme, ICAR-CIFE conducted **6** awareness cum demonstration and training programmes on modern methods for Sustainable Aquaculture, Value added fish products preparation from freshwater fish at Arunachal Pradesh, Tripura, Manipur and Assam including a launch workshop. A total of 376 participants were benefitted.

In addition to all these achievements, ICAR-CIFE strives to promotes eco-friendly activities e.g. conservation of water resources through rain water harvesting, open well, waste water utilization for aquaculture purpose ; optimisation of energy through solar street light, LED bulbs, adoption of green building concepts, operational mobile fish cooler; waste management and compositing, decentralised segregation of hazardous waste; maintaining the greenery and diversity of plants through plantation of indigenous species, no single use plastic inside the campus etc. Recognising these efforts, ICAR-CIFE was bestowed with the Green and Clean Campus award 2021 on the occasion of the Vice-Chancellors' Conference held on 28 September, 2021. The award was announced in the presence of the Honorable Prime Minister of India (online) at New Delhi.

In 2021, the institute conducted statutory meetings such as Research Advisory Committee (RAC), Institutional Research Committee (IRC), Academic council, Extension council and Board of Management. The institute celebrated the vigilance awareness week, Yoga day, Swachhta abhiyaan, Hindi pakhwada, Industry day, Farmers' day, Republic and Independence days. Due to the pandemic, most of these events were conducted virtually or with the involvement of limited faculty in the campus as per the guidelines prevailing at the time. Despite the phenomenal turnaround of events due to the outbreak of COVID-19 pandemic that severely crippled the normal functioning of the institutions, the dedicated staff of CIFE strived extremely hard in ensuring continuation of academic, research, training and extension activities. The positive outlook and dedication of all the faculty and the students was instrumental in weathering the impact of pandemic. This, together with the constant support from ICAR headquarters has immensely boosted our commitment to fisheries sector through education, research and welfare of farmers.

भाकृअनुप-सीआईएफई एक प्रतिष्ठित शैक्षणिक संस्थान है जो मात्स्यिकी विज्ञान के क्षेत्र में शिक्षण और अनुसंधान में उत्कृष्टता के लिए जाना जाता है। पिछले 6 दशकों में, 1961 में अपनी स्थापना के बाद से मत्स्य पालन क्षेत्र के विकास में उल्लेखनीय योगदान दिया है, तथा उद्योग और शिक्षाविदों की जरूरतों को समान रूप से पूरा किया है। संस्थान एक प्रशिक्षण केंद्र से एक समतुल्य विश्वविद्यालय के रूप में विकसित हुआ है और आज, संस्थान अपने उच्च योग्य वैज्ञानिक और तकनीकी जनशक्ति के साथ मत्स्य विज्ञान के 11 विशेष विषयों में स्नातकोत्तर कार्यक्रम प्रदान करता है। आईसीएआर-सीआईएफई के सम्मिलित प्रयासों और योगदानों से, आईसीएआर के शिक्षा प्रभाग ने सीआईएफई को भारत के 66 अन्य कृषि विश्वविद्यालयों में 7वां रैंक प्रदान किया है। इस वर्ष, लगभग 171 स्नातकोत्तर छात्रों (96 एमएफएससी और 75 पीएचडी) ने राष्ट्रीय स्तर की प्रवेश परीक्षाओं के माध्यम से संस्थान में प्रवेश प्राप्त किया। सीआईएफई के पास मुख्यालय और इसके पांच केंद्रों में सर्वोत्तम अनुसंधान अवसंरचना और प्रयोगशाला सुविधाएं उपलब्ध हैं जो वैज्ञानिकों और छात्रों को मात्स्यिकी क्षेत्र की समस्याओं के व्यावहारिक समाधान में अपने शोध विचारों को साकार करने के लिए सर्वोत्तम अवसर प्रदान करता है। संस्थान, निरन्तर प्रशिक्षित मानव संसाधन प्रदान कर रहा है, जो उद्यमियों, वैज्ञानिकों, शिक्षाविदों, सलाहकारों और प्रशिक्षकों के रूप में विभिन्न क्षमताओं में मत्स्य पालन क्षेत्र के विकास में अपना योगदान प्रदान करते है।

मार्च 2021 में, दुनिया में आई COVID-19 की दूसरी लहर ने अनुसंधान प्रगति और शैक्षणिक गतिविधियों को गंभीर रूप से प्रभावित किया। फिर भी, पहली लहर की तरह, सीआईएफई आपात स्थिति के संदर्भ में अनुसंधान, विस्तार, शिक्षण और प्रशिक्षण गतिविधियों को करने के लिए आकस्मिक योजनाओं के साथ जल्दी ही अपने पुर्नरूप में आ जाएगा । वर्चुअल मोड को तुरंत अपना कर और त्वरित उत्तराधिकार में, संस्थान की सभी गतिविधियों को वर्चुअल मोड के माध्यम से संचालित किया गया । इस विशेष परिवर्तन ने संस्थान को महत्वपूर्ण कमियों के बिना अपने निर्धारित लक्ष्यों को पूरा करने में मदद की। वर्चुअल प्लेटफॉर्म के माध्यम से शिक्षण, परीक्षा, मूल्यांकन और परिणामों की घोषणा सहित पाठ्यक्रम संबंधी गतिविधियां की गईं। प्रशिक्षण कार्यक्रम भी निर्धारित समयानुसार ऑनलाइन के माध्यम से आयोजित किए गए।

आधुनिक प्रयोगशालाओं और कृषि सुविधाओं से सुसज्जित 6 विशिष्ट विभागों और 5 केंद्रों में, सीआईएफई का शैक्षणिक विस्तार व्यापक है। सीआईएफई में विविध और प्रख्यात वैज्ञानिक हैं, जिसमें से 90% से अधिक ने भारत के सर्वश्रेष्ठ विश्वविद्यालयों से पी.एच.डी. की उपाधि प्राप्त की है, और उन्होंने दुनिया भर के अग्रणी विश्वविद्यालयों में प्रशिक्षण ग्रहण किया है। सीआईएफई एक प्रगतिशील और सही मायनों में बहुसांस्कृतिक संस्थान होने पर गर्व करता है जिसमें भारत के सभी कोनों से छात्र- छात्राएं और वैज्ञानिक है। अंतर्राष्ट्रीय छात्र परिसर में विविध-सांस्कृतिक अनुभव को समृद्ध करते हैं। सीआईएफई के पूर्व छात्रों में 2500 से अधिक नायक शामिल हैं जो दुनिया भर में जलकृषि क्षेत्र में अपना विशेष योगदान दे रहे हैं और प्रतिभाशाली शोध समूह का हिस्सा हैं। सीआईएफई में एक उत्कृष्ट छात्र-वैज्ञानिक अनुपात हैं जो कि परस्पर छात्र- छात्राएं के विचार-विमर्श और छात्र उपलब्धियों पर ध्यान रखता है। सीआईएफई में पूर्णकालिक डिग्री पाठ्यक्रम प्रमुख हैं, इसके साथ ही अन्य आवश्यकता-आधारित अनुकूलित कार्यक्रम भी प्रदान किए जाते हैं। व्यावसायिक विकास कार्यक्रम (पीडीपी), उद्यमिता विकास कार्यक्रम (ईडीपी), और अल्पकालिक मांग-संचालित और अनुकूलित कौशल विकास कार्यक्रम (एसडीपी) सीआईएफई और इसके केंद्रों द्वारा आयोजित किए जाते हैं, जो सक्षम पेशेवरों और आत्मविश्वास से भरे उद्यमियों का एक मंच प्रदान करता हैं। 2021 के दौरान, 113 शोध प्रबंध प्रस्तुत किए गए; जिनमें से 29 पीएचडी और 84 एम.एफ.एससी शोध हैं। इसके अलावा, सीआईएफई को मत्स्य पालन में उन्नत संकाय प्रशिक्षण (सीएएफटी) के लिए एकमात्र उत्कृष्टता केंद्र के रूप में मान्यता प्राप्त है, जिसमें राज्य कृषि विश्वविद्यालय और आईसीएआर संस्थानों के 300 से अधिक वैज्ञानिकों/ कर्मचारियों को प्रशिक्षित किया गया है।

सीआईएफई की अनुसंधान गतिविधियां वैज्ञानिक उन्नति और क्षेत्र के कल्याण के दोहरे लक्ष्य की पूर्ति के लिए उन्मुख हैं। 2021 में, कुल 53 परियोजनाएं (लगभग 30 करोड़ रुपये के बजट के साथ 18 बाहरी रूप से वित्त पोषित और 35 संस्थागत वित्त पोषित परियोजनाएं) प्रचालन में थीं। ये शोध परियोजनाएं, मत्स्य पालन के प्रमुख क्षेत्रों पर ध्यान केंद्रित करती हैं, जो कि मत्स्य पालन के ज्ञान को प्रभावित करता है, चाहे वह प्रकाशन हो या तकनीकी पैकेज। उत्तर-पश्चिम भारत की अंतर्देशीय लवण प्रभावित मिट्टी में सीआईएफई द्वारा विकसित झींगा पालन के तकनिकी पैकेज के द्वारा हरियाणा, पंजाब और राजस्थान के कुछ हिस्सों में प्रभावित पारिस्थितिकी तंत्र को बदलकर, किसानो को व्यवहार्य आजीविका प्रदान कर रहा है । हाल ही में, सीआईएफई ने उच्च-उपज और जैविक लघु-स्तरीय जलीय कृषि प्रणालियों के लिए कई कार्बन स्रोतों का उपयोग करके बायोफ्लोक्स विकसित करने जैसे क्षेत्रों में प्रगति की है; अंतर्देशीय लवणीय जलकृषि प्रणाली में बायोचार के उपयोग के लिए पद्धतियों का पैकेज; छोटे पैमाने के किसानों/परिवारों के लिए किफ़ायती रीसर्क्युलेटरी एक्वापोनिक सिस्टम (पैंगेसियस मछली के साथ पालक); गिफ्ट तिलापिया आधारित आरएएस के लिए नोवेल बायोफिल्टर - प्राकृतिक जिओलाइट बॉल्स का उपयोग; एफ. कॉलमरे के स्थानीय क्षेत्र आइसोलेट का उपयोग कर, एफ.

कॉलमरे के खिलाफ एक निष्क्रिय टीका और एफ. कॉलमरे और ई. टार्डा के खिलाफ एक दोहरी टीका (पेटेंट दायर) विकसित किया गया है; डब्ल्यूएसएसवी (पेटेंट प्रदान किया गया) और झींगा वायरल रोगों के लिए हेपेटोपैनक्रिएटिक परवोयरस (एचपीवी) के लिए टैकमैनाक्वांटिटेटिव रीयल-टाइम पीसीआर-आधारित निदान विकसित किया, कैप्टिव ब्रूडस्टॉक विकास, एनाबास टेस्टुडीनस की प्रजनन और बीज उत्पादन तकनीक, भारतीय मांगुर की आनुवंशिकी पर महत्वपूर्ण अनुसंधान और विकास, चयनात्मक प्रजनन, जीनोमिक्स और प्रोटिओमिक्स जैसे क्षेत्रों में शोध किया गया है । इसके अलावा, सीआईएफई की मानव पूंजी की गणना टीएफपी मॉडल का उपयोग करके की गई, मत्स्य पालन अर्थव्यवस्था में 2020-21 के दौरान 299 करोड़ रुपये का योगदान दिया, जो मत्स्य पालन उच्च शिक्षा में निवेश पर 6 गुना रिटर्न का संकेत देता है। उपलब्धि अंक में एक और कड़ी जोड़ते हुए, कार्प बीज उत्पादन के लिए पोर्टेबल एफआरपी हैचरी विकसित करने और पॉसिलिया रेटिकुलेट के कुशल मेल प्रोजनी के लिए फैड्राज़ोल लोडेड नैनोपार्टिकल फीड के निर्माण के लिए 2021 में दो पेटेंट प्रदान किए गए थे।

इस वर्ष में, आईसीएआर-सीआईएफई ने 182 शोध लेख, 130 अंतरराष्ट्रीय और 52 राष्ट्रीय सहकर्मी-समीक्षित पत्रिकाओं में प्रकाशित किए, जिनका औसत एनएएएस स्कोर 8 (एनएएएस> 10 = 48 प्रकाशन) था। इसके अलावा, सीआईएफई से 2 पुस्तकें, 25 पुस्तक अध्याय, 37 लोकप्रिय लेख, 14 प्रशिक्षण नियमावली और 18 विस्तार सामग्री भी प्रकाशित की गईं। सीआईएफई के वैज्ञानिकों ने राष्ट्रीय और अंतर्राष्ट्रीय मंचों पर 110 आमंत्रित वार्ताओं में भाग भी लिया ।

2021 के दौरान, सीआईएफई और उसके केंद्रों ने 41 कौशल विकास कार्यक्रम (एसडीपी) आयोजित किए, जिसमें देश के विभिन्न हिस्सों से 3500 प्रशिक्षुओं ने भाग लिया। प्रशिक्षण कार्यक्रमों में मूल्य वर्धित मछली उत्पाद तैयार करना, आणविक आनुवंशिकी के लिए बुनियादी और उन्नत कम्प्यूटेशनल उपकरण, पत्ती भोजन-आधारित आहार तैयार करना, सामाजिक विज्ञान के विद्वानों के लिए सांख्यिकी, आणविक वर्गीकरण, मछली पालन में बायोफ्लोक प्रौद्योगिकी, कॉलेज के छात्रों के लिए इन-प्लांट प्रशिक्षण, बिहार के मछली किसानों के लिए कोलकाता और काकीनाडा केंद्रों से विशेष प्रशिक्षण कार्यक्रम, कृषि मंत्रालय, भारत सरकार की सलाह के अनुसार ऑनलाइन प्रशिक्षण कार्यक्रम जैसे विविध विषयों को शामिल किया गया।

एससीएसपी घटक के तहत, आईसीएआर-सीआईएफई ने अनुसूचित जाति समुदाय के विकास के लिए कई प्रशिक्षण कार्यक्रम आयोजित किए हैं। 2021 के दौरान पश्चिम बंगाल, आंध्र प्रदेश और झारखंड में कुल 12 प्रशिक्षण कार्यक्रम आयोजित किए गए, जिसमें 928 प्रतिभागियों को लाभ हुआ। प्रशिक्षण कार्यक्रमों में एकीकृत जलकृषि, मीठे पानी में मछली पालन, आधुनिक तरीके से मीठे पानी की जलकृषि, पत्ती भोजन आधारित फार्म मेड जलीय-आहार तैयारी और ऑन-फार्म आहार प्रबंधन, मूल्य वर्धित मत्स्य उत्पादों की तैयारी के माध्यम से मछुआरों की आजीविका में सुधार जैसे विषयों को शामिल किया गया। टीएसपी के तहत 2021 के दौरान महाराष्ट्र, त्रिपुरा, मेघालय, झारखंड, मणिपुर और पश्चिम बंगाल में कुल 18 प्रशिक्षण कार्यक्रम आयोजित किए गए थे, जिसमें एक कार्यशाला भी शामिल थी, जिसमें 1468 प्रतिभागियों को लाभ हुआ। इसमें शामिल किए गए क्षेत्रों में परकोलेशन टैंक में जलकृषि, मीठे पानी के जलकृषि के आधुनिक तरीके, डिंभे और झारखंड के महिला मत्स्य किसानों के लिए सजावटी मछली पालन, मछली की स्वच्छ तरीके से प्रबंधन और मूल्य वर्धित मछली उत्पाद, जनजातीय समुदायों के लिए संभावित आजीविका विकल्प के रूप में जलीय कृषि, रोग प्रबंधन और अच्छी पोस्ट-हार्वेस्ट तकनीकों के साथ सतत जलीय कृषि अभ्यास, मीठे पानी की मछली से मूल्य वर्धित मछली उत्पाद तैयार करना, किसानों की अनुसंधान में भागीदारी आदि के माध्यम से मछली उत्पादकता बढ़ाना। एनईएच कार्यक्रम के तहत, आईसीएआर-सीआईएफई ने अरुणाचल प्रदेश, त्रिपुरा, मणिपुर और असम में सतत जलीय कृषि के लिए आधुनिक तरीकों पर 6 जागरूकता सह-प्रदर्शन, प्रशिक्षण कार्यक्रम और वर्कशॉप आयोजित किए गये, जिसमे कुल 376 प्रतिभागी मीठे पानी की मछली से मूल्य वर्धित उत्पाद तैयार करने के कार्यक्रम से लाभान्वित हुए ।

इन सभी उपलब्धियों के अलावा, आईसीएआर-सीआईएफई पर्यावरण के अनुकूल गतिविधियों को बढ़ावा देने का प्रयास करता है, जैसे कि वर्षा जल संचयन, खुले कुएं, जलकृषि प्रयोजन के लिए अपशिष्ट जल के उपयोग के माध्यम से जल संसाधनों का संरक्षण; सौर स्ट्रीट लाइट, एलईडी बल्ब, हरित भवन अवधारणाओं को अपनाने, परिचालन मोबाइल फिश कूलर के माध्यम से ऊर्जा का अनुकूलन; अपशिष्ट प्रबंधन और संयोजन, कचरे का विकेन्द्रीकृत पृथक्करण; स्वदेशी प्रजातियों के पौधा रोपण के माध्यम से हरियाली और विविधता को बनाए रखना, परिसर के अंदर प्लास्टिक का उपयोग नहीं करना आदि। इन प्रयासों आंकलन के हेतु, नई दिल्ली में भारत के माननीय प्रधान मंत्री (ऑनलाइन) की उपस्थिति में सीआईएफई को हरित और स्वच्छ परिसर पुरस्कार 2021 प्रदान करने की घोषणा की गई। यह पुरस्कार आईसीएआर-सीआईएफई को कुलपति सम्मेलन 28 सितंबर, 2021 के अवसर पर प्रदान किया गया ।

2021 में, संस्थान ने अनुसंधान सलाहकार समिति (आरएसी), संस्थागत अनुसंधान समिति (आईआरसी), अकादमिक परिषद, विस्तार परिषद और प्रबंधन बोर्ड जैसी वैधानिक बैठकें आयोजित कीं। संस्थान ने सतर्कता जागरूकता सप्ताह, योग दिवस, स्वच्छता अभियान, हिंदी पखवाड़ा, उद्योग दिवस, किसान दिवस, गणतंत्र और स्वतंत्रता दिवस मनाया। महामारी के कारण, इनमें से अधिकांश कार्यक्रम वर्चुअल मोड या परिसर में सीमित वैज्ञानिको की भागीदारी के साथ दिशानिर्देशों के अनुसार आयोजित किए गए। COVID-19 महामारी के प्रकोप के कारण कार्यक्रमों के अभूतपूर्व बदलाव के बावजूद, जिसने संस्थानों के सामान्य कामकाज को गंभीर रूप से प्रभावित किये, सीआईएफई के समर्पित कर्मचारियों ने शैक्षणिक, अनुसंधान, प्रशिक्षण और विस्तार गतिविधियों को जारी रखने के लिए बहुत कठिन प्रयास किए । सभी शिक्षकों और छात्रों के सकारात्मक दृष्टिकोण और समर्पण ने महामारी के प्रभाव को कम करने में महत्वपूर्ण भूमिका निभाई। इसने, आईसीएआर मुख्यालय के निरंतर समर्थन के साथ, शिक्षा, अनुसंधान और किसानों के कल्याण के माध्यम से मत्स्य पालन क्षेत्र के प्रति हमारी प्रतिबद्धता को काफी बढ़ावा दिया है।

01
Introduction

Educating Excellence

ICAR-Central Institute of Fisheries Education (ICAR-CIFE), Mumbai is the premier National Institution of Indian Council of Agricultural Research. An enviable brand name in the field of fisheries education and research over the last 60 years, CIFE continues to produce a rich pool of specialised professional human resources, outstanding research work and viable technological packages for the benefit of fishers, fish farmers and entrepreneurs. Located in a serene environ with state-of-the-art facilities at Mumbai, CIFE has five regional centres at Rohtak (Haryana), Kolkata (West Bengal), Powarkheda (Madhya Pradesh), Kakinada (Andhra Pradesh) and Motihari (Bihar) representing different aqua-climatic regions.

The Institute was established on 6th June 1961, under the Ministry of Agriculture, Govt. of India with assistance from FAO/UNDP to primarily strengthen the capacity of State Fisheries Departments and its staff. It became part of Indian Council of Agricultural Research (ICAR) in 1979 and subsequently transformed into a University in 1989 with mandate of education, research and extension. Having nurtured 2500+ illustrious scholars and built the professional competencies of 5000+ development professionals from within India and Afro-Asian region, the emphasis has always been on quality education.

The University offers post-graduation programs across 11 specialised disciplines in fisheries and aquaculture sciences with about 100 Masters and 75 doctoral seats every year. Demand driven Diploma programs, Certificate courses and customised short term training programmes are offered through the year. ICAR-CIFE has created an ecosystem of teaching and research excellence making it a preferred destination of students and scholars. The breadth of disciplines, state-of art facilities, research networks within and across the globe, and an enabling work environment give unparalleled opportunity to explore, excel and become the leaders shaping the future of fisheries sector.

Mission

To achieve academic and research excellence

Vision

To be a world-class organisation providing leadership in fisheries education and research

Mandate

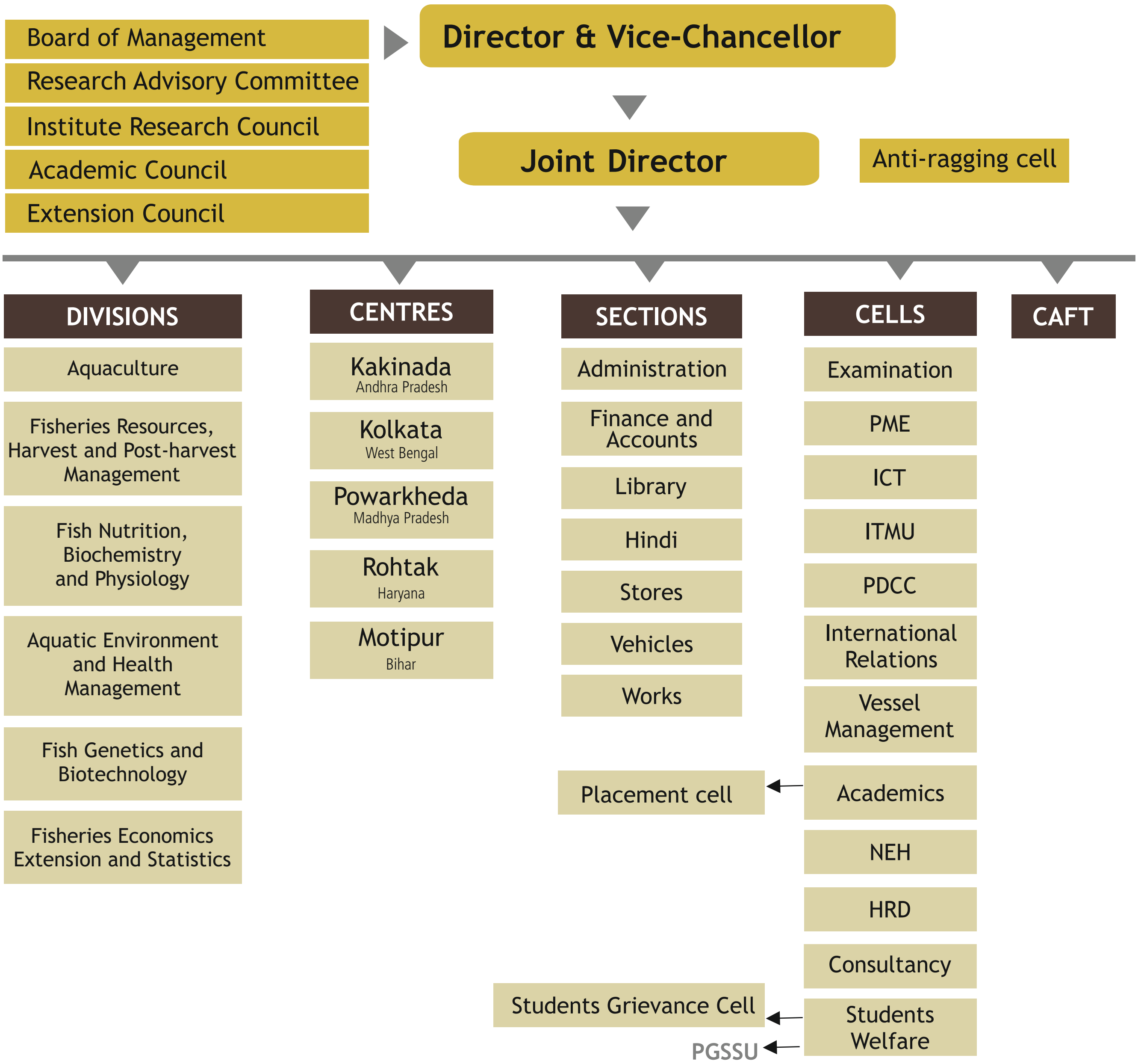
Conduct post-graduate programmes in fisheries science

Basic and strategic research in frontier areas of fisheries science

Human Resource Development, capacity building and skill development through training, education & extension

Organogram

ICAR-CIFE, Mumbai



Board of Management

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Dr. Gopal Krishna
(upto 3 November, 2021)

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Shri S.K.Singh
Dr. B.B. Nayak
Dr. Kishore Kumar Krishnani
Dr. Aparna Chaudhari
Dr. S. Jahageerdar
Dr. Subodh Gupta
Dr. B.K. Mahapatra
Dr. Parimal Sardar
Dr. K. Pani Prasad
Dr. Gayatri Tripathi
Dr. N.P. Sahu
Dr. K.V. Rajendran
Dr. S.N. Ojha
Dr. R.C. Srivastava
Dr. Ravishankar.C.N.
Dr. Basanta Kumar Das
Commissioner (Fisheries), Maharashtra
Dr. G. Gopikrishna
Dr. R.K. Singh, Former Director, IVRI
Shri R.K. Singh, DDF-III, ICAR, New Delhi

Member Secretary (upto 30 April 2021)
Mr. P.J. Davis

Extension Council

Chairman
Dr. Gopal Krishna (upto 03.11.2021)

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Dr. N. P. Sahu
Dr. K. V. Rajendran
Dr. N. K. Chadha
Dr. S. N. Ojha
Dr. B. B. Nayak
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Dr. Shivaji Argade
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Commissioner (Fisheries), Maharashtra

Member Secretary
Dr. Arpita Sharma

*RAC

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Dr. E. Vivekanandan
Dr. Ravishankar
Dr. Rina Chakrabarti
Dr. C.G. Joshi
Dr. K.M. Shankar
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Dr. K. Pani Prasad (Member Secretary)

*Research Advisory Committee

Academic Council

Chairman
Dr.Gopal Krishna
(upto 3 November, 2021)

Members
Dr. N.P. Sahu
Dr. B.B. Nayak
Dr. Kishore Kumar Krishnani
Dr. Aparna Chaudhari
Dr. K.V. Rajendran
Dr. S.N. Ojha
Dr. S. Jahageerdar
Dr. Subodh Gupta
Dr. B.K. Mahapatra
Dr. Arpita Sharma
Dr. A.K. Jaiswar
Dr. Subodh Gupta
Dr. S.P. Shukla
Dr. Mukunda Goswami
Dr. Subrata Dasgupta
Dr. Ashutosh D. Deo
Dr. Sanath Kumar H.
Dr. Shubendu Dutta
Dr. Ajit Kumar Verma
Dr. Asha T. Landge
Dr. Annam Pavan Kumar
Dr. Mujahidkhan Pathan
Dr. Sunil Kumar Naik
Dr. Md. Aklakur
Dr. R.C. Agrawal, DDG (Education), ICAR
Dr. Rameshwar Singh, VC, BASU, Patna
Dr. M.B. Chetti, VC, UAS, Dharwad
Prof. Ashish M. Paturkar, VC, MAFSU, Nagpur
Dr. Saroj Kumar Swain, Director (I/C), CIFA, Bhuvaneswar
Prof. Shalini Bharat, Director/VC, TISS, Mumbai
Dr. M.S. Chauhan, Director, ICAR-NDRI, Karnal
Mr. Sandeep Patnaik, President, PGSSU, ICAR-CIFE
Mr. Manas Kumar Maiti, Student Member, ICRA-CIFE

Member Secretary (upto 30 April 2021)
Shri. P.J. Davis

3.3. Staff Position (2021)

Category Wise

CIFE Staff	Sanctioned	In position	Vacant
RMP	02	01	01
Scientific	107	88	19
Technical	106	53	53
Administrative	80	38	42
Skilled Supporting	46	37	09
Non-Ministrial	01	01	00
Total	**342**	**218**	**124**

3.4. Budget (2021)

Rs. in lakh

S. No.	Head r	Sanctioned/ Balance C/f	Received	Expenditure r Incurred r
1.	Institute Expenditure	9078.36	8852.42	8,704.42 r
2.	CAFT r	6.26	-	6.85 r
3.	SDU r	22.86	71.26	83.96 r
4.	Library Strengthening (SDAE)	10.86	-	-
5.	Scheduled Caste Sub-Plan (SCSP)	-	100.00	84.78 r
6.	NAHEP	585.06	525.06	367.10 r
7.	Externally Funded Projects	230.93	90.88	74.08 r
	Total	**855.97**	**9765.56**	**9377.56** r

Revenue generation: Rs. 53.95 Lakhs r

Financial year	Institute budget	Revenue Generation
2020-21	90,78,36,000.00	53,94,880.00
2021-22 (Upto 24.02.22)	95,62,34,000.00	88,08,794.00

(Figure in Rupees)

02

Academic Achievements

Highlights

Number of Students Enrolled During the Year 2021 (1 January-31 December, 2021)

M.F.Sc. **96**

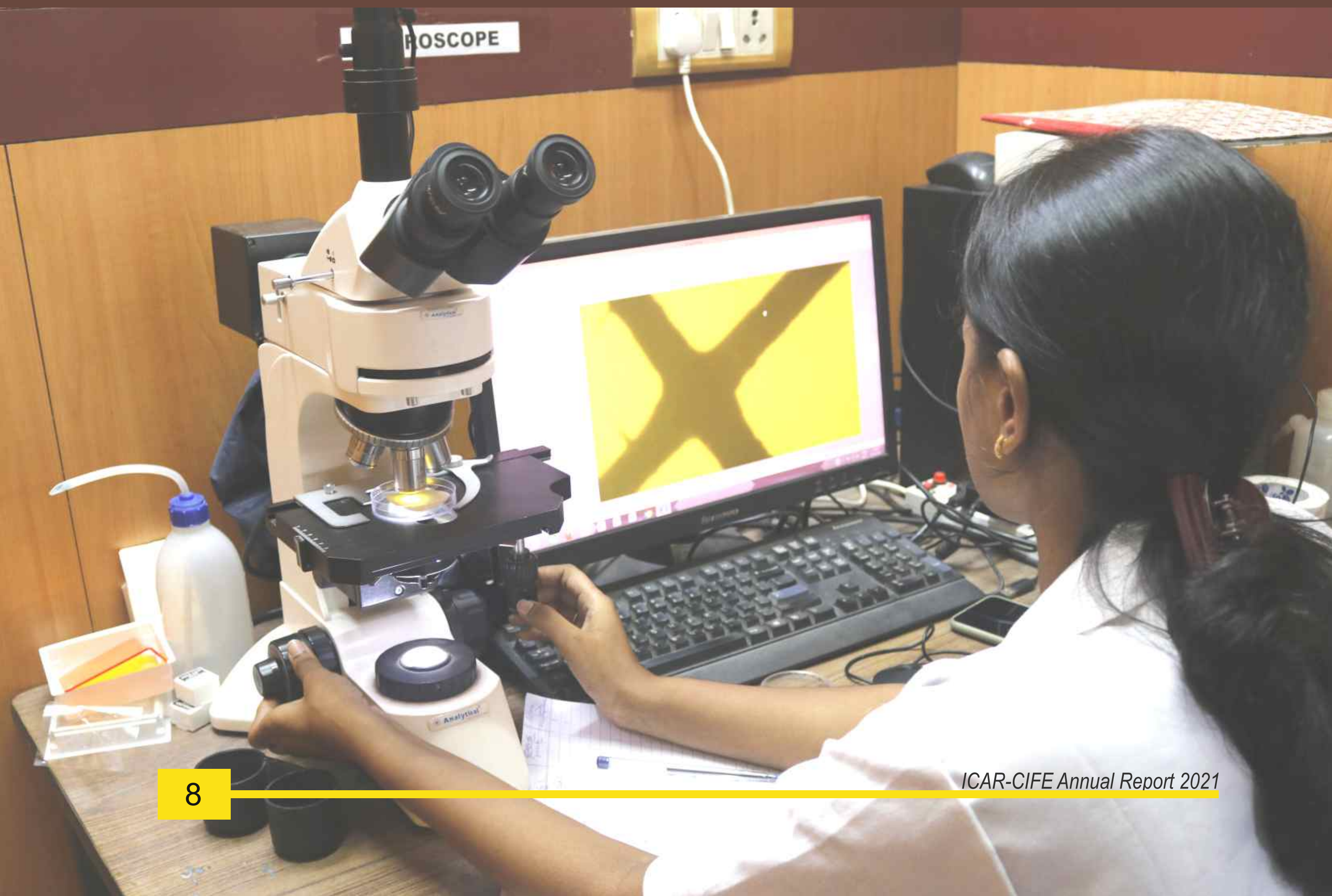
Ph.D. **67**

Number of Successful Students During the Year 2021 (1 January-31 December, 2021)

M.F.Sc. **90**

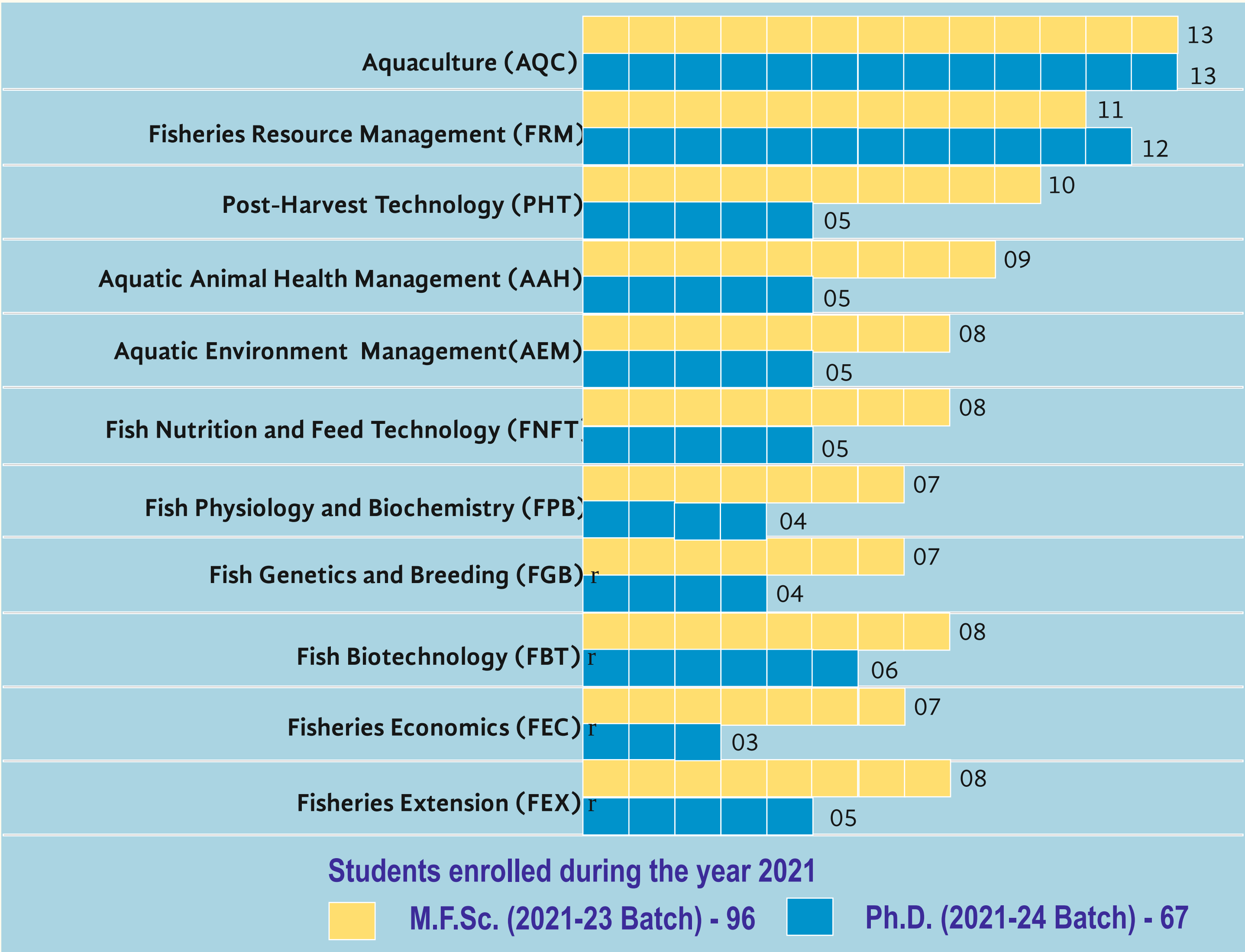
Ph.D. **29**

110	22	54	41
Guest Lectures	Awards Received by Students	Papers Presented by Students in Conferences/ Symposia etc.	Placement

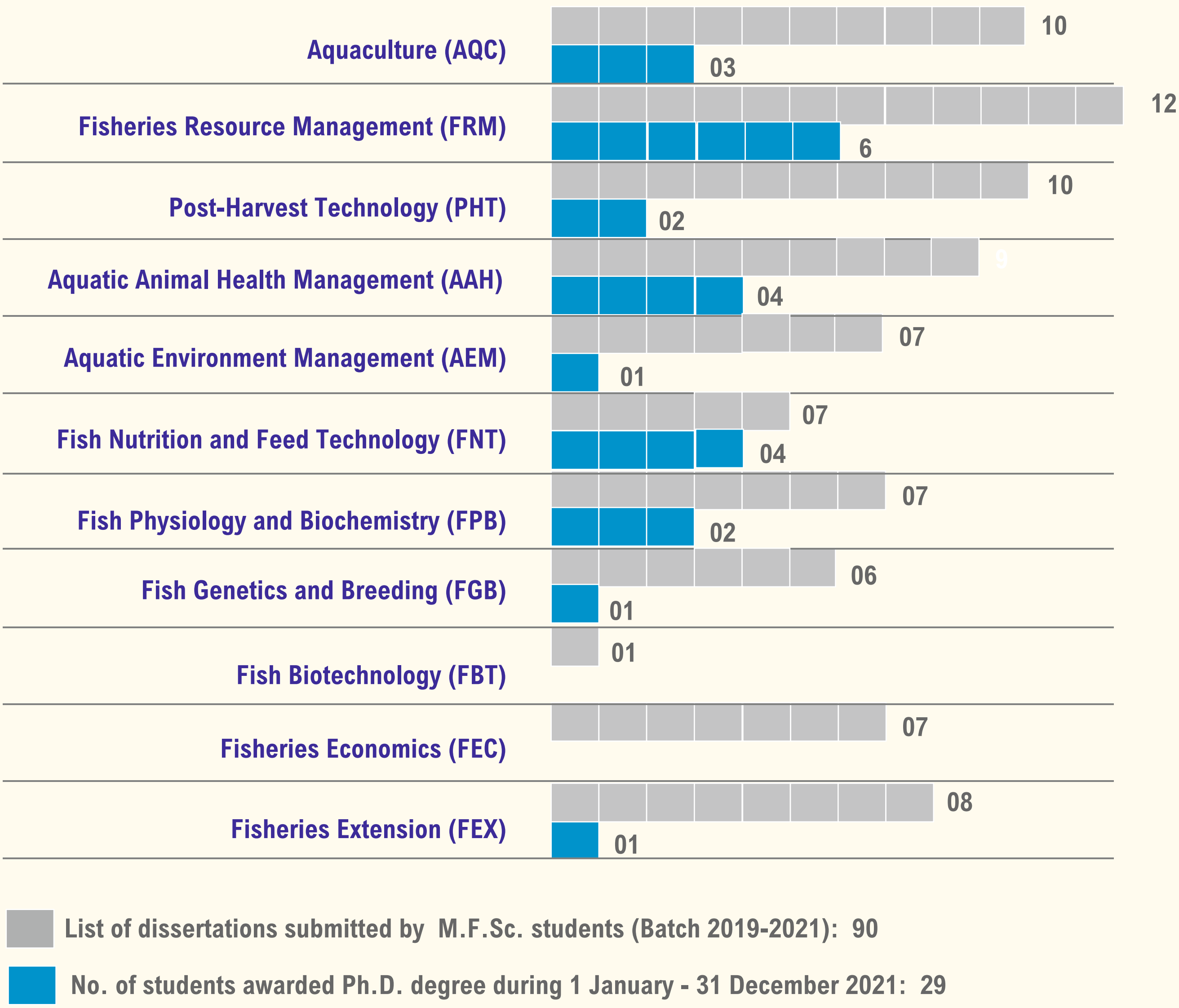


2.1 Enrollments

A total of 96 students have enrolled for the master's programme and 67 have enrolled for the doctoral programme during 2021.



2.2 Results



Aquaculture (AQC)
10
03
Fisheries Resource Management (FRM)
12
6
Post-Harvest Technology (PHT)
10
02
Aquatic Animal Health Management (AAH)
04
Aquatic Environment Management (AEM)
07
01
Fish Nutrition and Feed Technology (FNT)
07
04
Fish Physiology and Biochemistry (FPB)
07
02
Fish Genetics and Breeding (FGB)
06
01
Fish Biotechnology (FBT)
01
Fisheries Economics (FEC)
07
Fisheries Extension (FEX)
08
01
List of dissertations submitted by M.F.Sc. students (Batch 2019-2021): 90
No. of students awarded Ph.D. degree during 1 January - 31 December 2021: 29

2.3. Students awarded M.F.Sc. and Research Titles (2021)

1.	Ms. Anjali Kumari FRM-MA9-01	Study on the trophic wise bioaccumulation of metals in Panvel and Karanja creek	Dr. Shashi Bhushan
2.	Ms. Abisha C. FRM-MA9-02	Microplastic ingestion exposure in edible bivalves and gastropods from the south-west coast of India	Dr. Martin Xavier
3.	Ms. Bharathi Kollati FRM-MA9-03	Spatio-temporal and environmnetal drivers of fish community structure in the river Vasishtha Godavari, AP, India	Dr. Asha Landge
4.	Ms. Gagana T. J. FRM-MA9-04	Bioaccumulation of heavy metals in some bivalves and gastropods along Mumbai coast, Maharashtra	Dr. Shashi Bhushan
5.	Ms. Keisham Geenita FRM-MA9-05	A study on species diversity in family Sciaenidae from Mumbai waters	Dr. A. K. Jaiswar
6.	Mr. Komal Ratan N. FRM-MA9-06	Assessment of sedimentation and its impacts on fisheries in Navegaonbandh Reservoir using remote sensing	Dr. Karan Kumar Ramteke
7.	Mr. Muzammal Hoque FRM-MA9-07	Productivity susceptibility analysis (PSA) ecological framework for assessment of marine fishery	Dr. Z. J. Abidi
8.	Ms. Sneha Satheesh K. FRM-MA9-08	Assessment of elasmobranchs diversity along the Kerala coast	Dr. A. K. Jaiswar
9.	Ms. Sonam Angmo FRM-MA9-09	Spatial variability of *Sepia pharaonis* Ehrenberg, 1831 and its assemblage in relation to the environment variables along Maharashtra coast	Dr. Z. J. Abidi
10.	Ms. Swati FRM-MA9-10	Assessment of the impact of temperature and salinity on growth of brackishwater phytoplankton	Dr. Geetanjali Deshmukhe
11.	Ms. Tejaswini P. Karale FRM-MA9-11	Impact of inland saline water on growth of some aquatic plants	Dr. Geetanjali Deshmukhe
12.	Ms. Shamyung Ongh FRM-MA9-12	Spatio-temporal and environmental drivers of fish community structure of Dhansiri River, Nagaland, India	Dr. Asha Landge
Aquaculture			
13.	Ms. Adya Pande AQC-MA9-01	Performance evaluation of *Penaeus vannamei* (Boone, 1931) reared at varying stocking densities in inland saline water	Dr. Harikrishna V.
14.	Ms. Aalia Bashir AQC-MA9-02	Aquatic Weed Assisted Bioremediation of Priority Pollutants under Controlled Condition	Dr. K.K. Krishnani

16.	Mr. Arunkumar D. AQC-MA9-04	Characterization and evaluation of clinoptilolite for removal of cationic toxicants from water of fish pond	Dr. K. K. Krishnani
17.	Mr. Gajanan Uddhav Kate AQC-MA9-05	Plant assisted bioremediation of nitrogenous waste and bacterial contaminants	Dr. K.K. Krishnani
18.	Ms. Gitanjali Behra AQC-MA9-06	Role of miRNAs, their expression, profiling and identification in gonadal development of *Channa striata* (Bloch,1793)	Dr. J. Sundaray
19.	Mr. Hariharan M. AQC-MA9-07	Effect of phytoremediation and zooremediation on growth and water quality dynamics in *Labeo rohita* (Ham. 1822) grow-out culture system	Dr. Syamala K.
22.	Mr. Bhadade Pranay D. AQC-MA9-10	Studies on combined effects of temperature and salinity in common carp reared in inland saline water	Dr. Harikrishna
24.	Mr. Sowa O Lamare AQC-MA9-12	Synthesis, Characterization and bactericidal activity of silver nanoparticles using pig and sheep wastes for exploring potential application in aquaculture	Dr. Harikrishna V.
25.	Ms. Venisza Cathy John AQC-MA9-13	Effect of potassium supplementation on growth performance of *Pangasianodon hypophthalmus* (Sauvage, 1878) and *Spinacia oleracea L.* in aquaponic system	Dr. A. K. Verma
Post-Harvest Technology			
26.	Ms. Angela Brighty R. J. PHT-MA9-01	Effect of alginate oligosaccharides on quality preservation of fish	Dr. Layana P.
27.	Ms. Ashmita Pandey PHT-MA9-02	Controlled bacterial degradation of fish scales	Dr. Sanath Kumar
28.	Ms. Dharani M. PHT-MA9-03	Meat quality assessment of common carp (*Cyprinus carpio*) reared in inland saline water	Dr. A. K. Balange
29.	Mr. Dhanush C. K. PHT-MA9-04	Phylogenetic evaluation of quinolone and colistin resistant *Escherichia coli*.	Dr. Sanath Kumar
30.	Ms. Fathima Salam PHT-MA9-05	Physiological and virulence characteristics of seafood-borne Salmonella enterica	Dr. L. Manjusha
31.	Mr. Lokesh S. PHT-MA9-06	Preparation and characterization of colloidal chitin	Dr. Martin Xavier
32.	Mr. Nikesh N. Hajare PHT-MA9-07	Use of microbes in different stages for chitin extraction	Dr.B.B. Nayak
33.	Mr. Rakesh R. PHT-MA9-08	Microplastic contamination in cured fishery products	Dr. Martin Xavier

34.	Ms. Vasanthi Kalli PHT-MA9-10	Comparison of growth and histamine production abilities of prolific histamine formers in different culture media	Dr. B.B. Nayak
35.	Ms. Akshaya Mayekar FGB-MA9-01	Analysis of genetic combining abilities of various populations of Rohu (*Labeo Rohita*, Hamilton 1822) for growth traits	Dr. S. Jahageerdar
36.	Ms. Harshvarthini M. FGB-MA9-02	Evaluation of teratogenicity and genotoxicity of Mithi River water in zebrafish (*Danio rerio*)	Dr. N. S. Nagpure
37.	Mr. Lalramnusanga FGB-MA9-03	Assessment of genetic diversity in selected geographical population of *Cyprinus carpio* (Linnaeus, 1758) using morphometry and mitochondrial D-Loop Marker	Dr. Mujahid Pathan
38.	Mr. Nagaraja P. S. FGB-MA9-04	Genetic characterization of Moina species from different geographical locations of India	Dr. Sunil Kumar Naik
39.	Ms. Nikita N. Gurphale FGB-MA9-05	Toxicity and biodistribution of polyethylene glycol (peg) functionalised multi-walled carbon nanotubes in zebrafish	Dr. Rupam Sharma
40.	Mr. Yadvesh Ranvir Singh FGB-MA9-07	Toxicity of chitosan nanoparticle conjugated conspecific kisspeptin in *Labeo catla* (hamilton, 1822)	Dr. Rupam Sharma
Fish Biotechnology			
41.	Biswaranjan Mahapatra FBT-MA9-03	Mining and characterization of SSRs from Lamellidens marginalis (Lamarck, 1819) Genome	Dr.Pavan Kumar
42.	Ms. Dhivyakumari S. FBT-MA9-04	Development and characterization of muscle cell culture system from *Clarias magur*	Dr. Mukunda Goswami
43.	Mr. Diganta Dey FBT-MA9-05	Expression profiling of selected reproductive genes of *Clarias magur* (Hamilton,1822)	Dr. Aparna Chaudhari
44.	Mr. Omkar N. Ingale FBT-MA9-06	Studies on gut microbiome of *Cyprinus carpio* (Linnaeus, 1758) Reared in different salinities	Dr. Gopal Krishna
45.	Ms. Subashini V FBT-MA9-07	Mining of antimicrobial peptides from *Clarias magur* (Hamilton, 1822) transcriptome	Dr. Aparna Chaudhari
46.	Ms. Shasti Risha K. FBT-MA9-08	Experimental Validation of MicroRNAs (miRNAs) in Clarias magur (Hamilton,1822)	Dr. Dhalongsaih Reang
48.	Mr. Avijit S. Pramanik AAH-MA9-02	Study on antiparasitic effect of Nootkatone against Argulus infection in goldfish (*Carassius auratus*)	Dr. R.P. Raman

50.	Mr. Ashish P. M. AAH-MA9-04	Study on pharmacokinetics of florfenicol in Common carp, *Cyprinus carpio*	Dr. K. Paniprasad
51.	Mr. Khakchang Debbarma AAH-MA9-05	Screening of integrons in selected Gram negative bacteria isolated from shrimp farms	Dr. Jeena K.
52.	Mr. Mohiadeen Shajia Banu S. AAH-MA9-06	Study on effect of emulsion based adjuvant on protection and immune response of Labeo rohita immunized by formalin-killed cells of *Edwardsiella tarda*	Dr. Megha K. Bedekar
53.	Mr. Sanjaykumar K. Rathod AAH-MA9-07	Assessment of protective immune response induced by inactivated *Aeromonas spp*. in Tilapia (*Oreochromis niloticus*, Linnaeus 1757)	Dr. Megha Bedekar
54.	Mr. Shirsak Mondal AAH-MA9-08	Studies on the host-range of Enterocytozoon hepatopenaei (EHP)	Dr. K. V. Rajendran
55.	Ms. Sunanda Allakonda AAH-MA9-09	Study on tissue depletion and withdrawal period of florfenicol in Common carp (*Cyprinus carpio*)	Dr. K. Pani Prasad
56.	Mr. Devkate Dhiraj S. FEC-MA9-01	Dynamics of seafood export, trend and competitiveness of Maharashtra	Dr. Rama Sharma
57.	Mr. Kavin S. FEC-MA9-02	Value chain analysis of *penaeus vannamei* hatcheries in Tamil Nadu	Dr. Swadesh Prakash
58.	Mr. Mandeep Saikia FEC-MA9-03	Assessing vulnerability and effect of climatic variables on inland fisheries In selected reservoirs of Madhya Pradesh	Dr. Vinod Kumar Yadav
59.	Mr. Sathya G. FEC-MA9-04	Socio-economic vulnerability and fisheries development: transformation pathways for an aspirational district in Andhra Pradesh	Dr. Neha Qureshi
60.	Mr. Seenivasan P. FEC-MA9-05	Socio-economic vulnerability and fisheries development: transformation pathways for an aspirational district in Maharashtra	Dr. P. S. Ananthan
61.	Mr. Talib Mohammad FEC-MA9-06	Socio-economic vulnerability and fisheries development: transformation pathways for an aspirational district in Madhya Pradesh	Dr. P. S. Ananthan
63.	Ms. Deepa Chettri FEX-MA9-02	Fish farmers livelihood and fisheries extension in Sikkim	Dr. S. N. Ojha
64.	Mr. Ganeshkumar K. FEX-MA9-03	Gender dynamics in marine fisheries based livelihood of Tamil Nadu	Dr. Shivaji Argade
65.	Mr. Martina Meinam FEX-MA9-04	Students' aspirations and attitudes to entrepreneurship in Manipur	Dr. S. N. Ojha

66.	Mr. Shubham Soni FEX-MA9-05	Utilization of fish waste as a resource strategy of circular economy to develop novel fish skin leather	Dr. Arpita Sharma
67.	Mr. Sourav Debnath FEX-MA9-06	Gender dynamics in culture fisheries based livelihood of Tripura	Dr. Shivaji Argade
68.	Ms. Suvetha V. FEX-MA9-07	Socio-economic vulnerability and fisheries development: transformation pathways for an aspirational district in Tamil Nadu	Dr. P. S. Ananthan
69.	Ms. Krishnaveni K. N. FEX-MA9-08	Community-based fisheries management and fishers' vulnerability in Pulicat Lake, Tamil Nadu	Dr. Swadesh Prakash
70.	Mr. Amal C.T. AEM-MA9-01	Impact of biochar on soil microbial activity and growth of *Penaeus vannamei* (Boone, 1931) in inland saline aquaculture system	Dr. Vidhya Shree Bharati
71.	Mr. Bhautik D. Savaliya AEM-MA9-02	Assessment of selected azo dye bioremediation potential of *Chlorella vulgaris*	Dr. Rathi Bhubneswari
72.	Mr. Jateen AEM-MA9-04	A study on the effect of biochar amended sediment on growth and physiological response of *Penaeus vannamei* (Boone, 1931) reared in inland saline water	Dr. Saurav Kumar
73.	Ms. Monisha Boruah AEM-MA9-05	Development of biodegradable plastic using selected industrial byproduct and waste material	Dr. S. P. Shukla
74.	Ms. Sakshi Patil AEM-MA9-06	Isolation and characterization of triclosan – degrading bacteria from Versova creek	Dr. Kundan Kumar
75.	Ms. Suchismita Jana AEM-MA9-07	Algae Mediated Biogenic Metal Nanoparticles Production for Application as Anti-Algal and Antimicrobial Agents	Dr. S. P. Shukla
76.	Mr. Tao Kara AEM-MA9-08	Impact of biochar on sediment quality and growth of GIFT tilapia	Dr. Vidyashree Bharati
77.	Mr. Adarsh K. C. FNT-MA9-01	Effect of Microcystis Rich Dietary Cyanobacteria on Physio-Metabolic Responses of *Catla Catla*	Dr. Md Aklakur
78.	Ms. Anusha Edla Patel FNT-MA9-02	Evaluation of dietary nitrogen and phosphorus release in recirculating aquaculture system of GIFT tilapia, *Oreochromis niloticus*	Dr. Sikendra Kumar
79.	Ms. Bhavatharaniya U. FNT-MA9-03	Evaluation of the low protein and high energy diet supplemented with taurine on growth and immunity of *Peneaus vannamei* (Boone,1931) juveniles reared in inland saline water	Dr. N.P. Sahu

80.	Mr. Raghuvaran N. FNT-MA9-05	Evaluation of the low protein and high energy diet supplemented with *L-carnitine* on growth and immunity of *Peneaus vannamei* (Boone,1931) juveniles reared in inland saline water	Dr. Parimal Sardar
81.	Ms. Revathi A. FNT-MA9-06	Effect of dietary crude onion peel extract (COPE) on feed intake and growth in Rohu (*Labeo rohita*) fingerlings reared at low Ttmperature	Dr. Manish Jayant
82.	Mr. Saiprasad P. Bhusare FNT-MA9-07	Evaluation of the low protein and high energy diet supplemented with bile acids on growth and immunity of GIFT juveniles reared in inland saline water	Dr. Parimal Sardar
83.	Ms. Tejaswini K. FNT-MA9-08	Effect of dietary crude lemon peel extract (COPE) on feed intake and growth in Rohu (*Labeo rohita*) fingerlings reared at low temperature	Dr. Ashutosh D Deo
84.	Ms. Arunashri A. FPB-MA9-01	Effects of alfalfa (*Medicago sativa*) meal based phytoestrogens on gonadal development and sex steroids in female *Cyprinus carpio* (Linnaeus, 1758)	Dr. P.P. Shrivastava
85.	Ms. Gari Hymavathi K. FPB-MA9-02	Nano-selenium and L-methionine supplementation on growth performance and biochemical responses in *Labeo rohita* (Hamilton, 1822) fingerlings	Dr. Subodh Gupta
86.	Ms. Mathumitha S. P. FPB-MA9-03	Effect of dietary supplementation of Sugar beet forage on Sex Steroid and Gonadal Development of Female *Cyprinus carpio* (Linnaeus, 1758)	Dr. P.P. Shrivastava
87.	Mr. Paul Nathaniel FPB-MA9-04	Cross-protection of *Penaeus vannamei* (Boone, 1931) against potassium deficient low saline water due to Non-lethal heat shock	Dr. Das Gupta
88.	Ms. Samikshya Mishra FPB-MA9-05	Combitorial effects of dietary genistein and daidzein on sex steroid profile in female *Cyprinus carpio* (Linnaeus, 1758)	Dr. Subodh Gupta
89.	Ms. Shivangi Bhatt FPB-MA9-06	Effect of sulphate on physio-biochemical responses of GIFT reared in potassium-deficient low saline waters	Dr. Tincy Verghecy
90.	Mr. Siddharth S. Sahoo FPB-MA9-07	Biochemical and hematological profiling of *Catla catla* (Hamilton, 1822) in different culture systems	Dr. Sujata Sahoo

2.4. Students awarded Ph.D. and their Research Titles (2021)

Sr. No.	Name of the student	Thesis title	Major Advisor	Date of *viva voce*
2.	Ms. Remya L. AEM-PA3-01 2013-2016	Studies on biology and stock assessment of leiognathids and relationship of the fishery with selected environmental parameters in Mandapam waters	Dr. P.U.Zacharia	28 January2021
4.	Mr. Karankumar R. FRM-PA6-10 2016-2019	Integrated approach to studies on trawl fisheries using sea-truth and remote sensing information off Mumbai coast	Dr. Latha Shenoy	06 March 2021
6.	Mr. Abdul Azeez P. FRM-PA4-03 2014-2017	Application of remote sensing and GIS to Trichiurus leptutus fishery in the North-West coast of India: A management approach	Dr. Latha Shenoy	12 March 2021
8.	Mr. Simanku Borah FRM-PA3-06 2013-2016	Fishery, biology and stock characterization of *Tenualosa ilisha* (Hamilton, 1822) in Brahmaputra River, Assam, India	Dr. B.K.Das	24 March 2021
9.	Mr. Parmanand Prabhakar PHT-PA4-05 2014-2017	Molecular characterization of seafood-borne non-typhoidal in *Salmonella enterica*	Dr. Sanath Kumar	27 March 2021
10.	Mr. Dilip Kumar Chowdhury FNFT-PA6-05 2016-2019	Evaluation of dietary herbal stimulants on nutrients digestibility, growth and immune responses in *Labeo rohita*	Dr. N.P. Sahu	03 May 2021
12.	Ms. Dhanya M.Lal FRM-PA6-02 2016-2019	A study on the trophic structure of Ulhas River Estuary, Maharashtra	Dr. Zeba Jaffer Abidi	16 July 2021
14.	Mr. Tasok Leya AAH-PA5-03 2015-2018	Mucosal immune response studies following PLGA conjugated DNA vaccine construct delivery through immersion method in *Labeo rohita* against *Edwardsiella tarda*	Dr. Megha K. Bedekar	13 August 2021

15.	Mr. Tandel Ritesh Kumar Shantilal AQC-PA6-13 2016-2019	Evaluation of antifungal potential of selected Himalayan herbs and peptide in mitigating oomyeetes infection in Rainbow trout, *Oncorhynchus mykiss* (Walbaum, 1792)	Dr. N.K.Chadha	16 August 2021
16.	Mr. Kiran Dashrath Rasal FBT-PA7-04 2017-2020	Identification and functional characterization of MicroRNAs associated with carbohydrates metabolism in Rohu, *Labeo rohita* (Hamilton, 1822)	Dr. Jitendra Kumar Sundaray	17 August 2021
17.	Mr. Sri Hari M. FRM-PA7-05 2017-2020	Stock characterization of *Nemipterus randalli* Russel, 1986 and *Saurida tumbil* (Bloch, 1795) along the Indian coast	Dr. Zeba Jaffer Abidi	24 August 2021
18.	Mr. Rameez Roshan P.M. FGB-PA5-03 2015-2018	Evaluating alternate models to estimate genetic parameters of economic traits in *Clarias magur*	Dr. S. Jahageerdar	30 August 2021
19.	Mr. Naresh Raj Keer AQC-PA6-07 2016-2019	Effect of selected medicinal herbs on growth immunity and metabolic response of *Labeo rajasthanicus* (Datta and Majumdar, 1970)	Dr. N.K.Chadha	01 September 2021
20.	Mr. Raja Aadil Hussain Bhat AAH-PA4-01 2014-2017	Assessment of antimicrobial potential of novel synthetic de-novo designed peptides against fish pathogens	Dr. Gayatri Tripathi	20 September 2021
21.	Mr. Vinod Kumar Paswan AQC-PA5-07 2015-2018	Studies on the optimization of stocking density and feeding ration for rearing of stunted *Labeo rohita* (Hamilton, 1822) fingerlings reared in cages	Dr. Kiran Dube Rawat	25 September 2021
22.	Ms. Nuzaiba P.M. FPB-PA6-02 2016-2019	Transcriptomic study of genes responsible for reproductive function in *Cyprinus carpio* L. exposed to phytoestrogen	Dr. Subodh Gupta	25 September 2021
23.	Mr. Avinash Talukdar FNFT-PA6-02 2016-2019	Nutritional evaluation of leaf meal based feed with variable protein levels in shrimp and finfish under polyculture system reared in inland saline water	Dr. Ashutosh D. Deo	29 September 2021
24.	Ms. Jess Maria Wilson AQC-PA6-01 2016-2019	Intensive culture technique for a tropical Calanoid copepod of *Acartia* species as a live feed for aquaculture	Dr. Boby Ignatius	13 October 2021
25.	Ms. Sangeeta Kumari AQC-PA5-05 2015-2018	Evaluation of growth, physiological response, and carcass quality of red tilapia in biofloc system in inland saline groundwater	Dr. Babita Rani A.M.	29 October 2021
26.	Mr. Himanshu Sekhar Swain AQC-PA4-10 2014-2017	Studies on growth and immunological responses of *Labeo rohita* (Ham.1822) and *Pangasianodon hypophthalmus* (Sau.1878) in cage based polyculture	Dr. B.K.Das	05 November 2021
27.	Mr. Dharmendra Kumar Meena FNFT-PA6-042016-2019	Evaluation of Herbal Extracts of *Arjuna*, *Terminalia arjuna*, on growth, immune responses and disease resistance in *Labeo rohita* (Ham, 1822)	Dr. B.K.Das	05 November 2021
28.	Mr. Anirban Paul AAH-PA4-02 2014-2017	Dactylogyrosis In Indian majoer carps : Understanding host-pathogen interaction towards designing prevention strategy	Dr. P.K.Sahoo	23 November
29.	Mr. Munish Kumar FPB-PA7-02 2017-2020	Development of super-paramagnetic iron oxide nanoparticles (SPIONs) for removal of selected bacteria from aquatic system and their bio-toxicity in fish	Dr. Subodh Gupta	22 December 2022

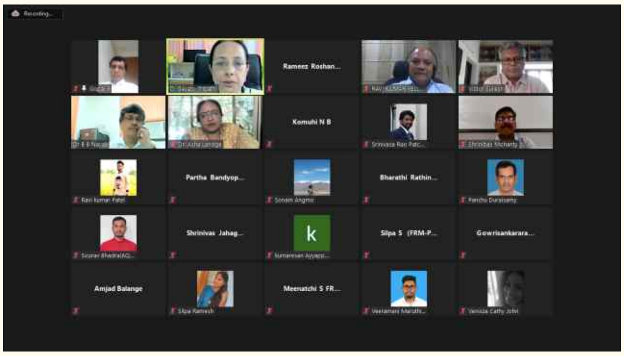
2.5. Guest Lectures

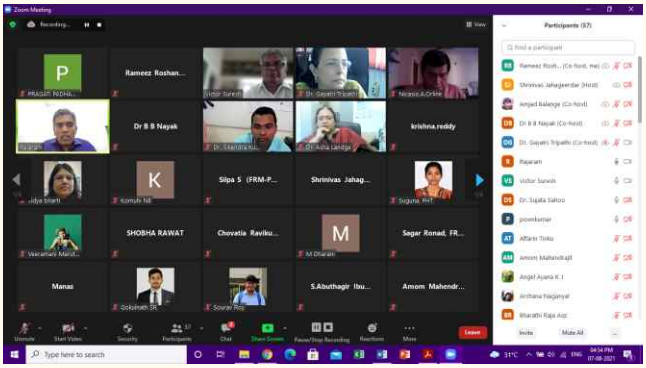
Pro-Aqua 2021: Professional Practice in Aquaculture Lecture Series by SAP to University Students

Coordinators: Dr. B. B Nayak, Dr. Gayatri Tripathi & Dr. A. K. Balange

The ICAR-Central Institute of Fisheries Education, Mumbai, in association with the Society of Aquaculture Professionals (SAP) under the aegis of the National Agricultural Higher Education Project (NAHEP), organized an online lecture series on "Pro-Aqua 2021: Professional Practice in Aquaculture Lecture Series by SAP to University Students". The lecture series was conducted every Saturday (02.30 pm to 05.00 pm IST) from 17 July, 2021 to 28 August, 2021. The program was aimed to offer relevant and practical aquaculture education to the students of aquaculture. A total of 523 participants attended the five-week lecture series.

The inaugural session was held on 17 July, 2021, to which four industry experts were invited to deliver the lecture. Dr. Gayatri Tripathi, Principal Scientist and Nodal Officer (CIFE-NAHEP), conducted the program. Dr. Gopal Krishna, Director and Vice-Chancellor, PI-CIFE-NAHEP, ICAR-CIFE, Mumbai, inaugurated the program and gave the welcome address. In his address, Dr. Gopal Krishna stressed the importance of a strong industry-academia interface for the collateral progression of both academia and industry. After the welcome address, Mr. Shrinibas Mohanty, VP (Education), SAP, introduced the SAP and its mission for the audience. Dr. B.B. Nayak, Head, FRHPHM Division and industry component leader NAHEP, ICAR-CIFE, gave the context and relevance of the programme. The second lecture from the series were themed up on "Practices in Production System" while third was on the "Practices in Aquatic Animal Health Management", fourth one emphasized on "Practices in Aquatic Animal Nutrition and Feed Technology" and the fifth and final lecture on "Practices in Farm Management". The lecture series received much positive feedback for the initiative on bringing industry experts onto the academic platform. Dr. Victor Suresh, Technical Director, Growel Feeds, gave his remarks on behalf of SAP.





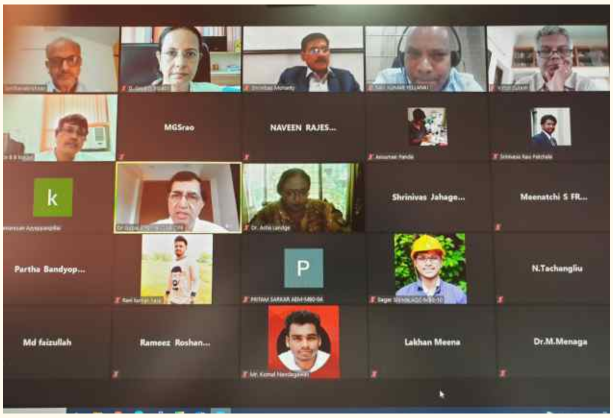


Table: Pro-Aqua 2021: Professional Practice in Aquaculture Lecture Series by SAP to University Students

Guest Name /Designation/Place	Title of lecture/Event	Date & Place	No. of participants
Mr. S. Santhanakrishnan Founder President, SAP & CEO, Maritech	The educated aquaculturist: Role of aquaculture education in India's aquaculture development in the last 30 years	17 July, 2021	115
Mr. Ravi Kumar Yellanki Former President SAP & Managing Director, Vaisakhi Bio Resources	Status of shrimp farming in India and potential areas of improvement that calls for the involvement of professionals		
Dr. Manoj Sharma Managing Director, Mayank Aqua Farms	My journey from Zhinga (shrimp) to Zhingalala (entrepreneur)		
Dr. Victor Suresh Technical Director, Growel Feeds	Professional education in aquaculture from a practitioner's viewpoint		
Mr. Shrinibas Mohanty Vice President (Education), SAP	Shrimp Farming in India Today	24 July, 2021	93
Dr. Patchala Srinivasa Rao Senior Technical Manager Avanti Feeds Ltd	Dissolved Oxygen Management in Ponds		
Dr Amerneni Ravikumar Founder, Ravi Aqua Academy	Running a diagnostic lab	31 July, 2021	104
Dr Akshaya Panigrahi Principal Scientist, ICAR-Central Institute of Brackishwater Aquaculture)	Practical Issues in Field Diagnostics and Suggestive Remedial measures		
Dr. Victor Suresh Technical Director, Growel Feeds)	Designing and Formulating Feeds	7 August, 2021	91
Dr V. Rajaram Senior Manager -Formulations Grobest Feeds Corporation India (P) Ltd)	Feed Manufacturing Technology		
Mr. Sreeram Raavi Managing Director, Eruvaka Technologies	Advanced Technologies in Pond Management	21 August, 2021	65
Mr A. Kumaresan Senior DGM and Marketing Head, Shenglong Biotech India Pvt Ltd	Feed Management Challenges and Solutions		
Ms. Suchitra Upare (FAO consultant, CAFI-SSF Network, New York Area, USA)	Blue finance to support small-scale fisheries (NAHEP)	26 February, 2021	94
Dr. Thomas Gitterle Breeding and Genetics Director, Regal Springs, Florida	Role and contribution of industry in the growth of aquaculture (NAHEP)	28 May, 2021	100
Dr. Ronald W. Hardy Professor Emeritus, University of Idaho, USA	Towards New Feeds for Sustainable Aquaculture (NAHEP)	15 July, 2021	262

2.6. Students Placement

Assistant Professor

Ms. Abisha Juliet Mary has been selected as Assistant Professor in Tamil Nadu J Jayalalitha Fisheries University, Nagapatinam

The following students has been selected as Assistant Professor on contractual basis **Ms. Dhenuvakonda Kiranmayi** in School of Agri. Science, Hyderabad, **Ms. Suchismita Prusty** iand **Mr. Subhash Kumar Banjare** in Gopal Narayan University, Bihar, **Mr. Vignesh D** in Tamil Nadu J Jayalalitha Fisheries University, Nagapatinam

Subject Matter Specialist

Mr. Syam K.R.	KVK, Dept. of Agriculture & Welfare, Tripura

Fisheries Officer

Ms. Napiner Kaur	Dept. of Fisheries, Punjab

State Fisheries Officer

Fisheries Extension Officer in Government of West Bengal

Mr. Suman Dey, Mr. Ramjanul Haque, Mr. Sambit Kishore Das , Mr. Udipto Roy, Mr. Prasanta Jana, Mr. Utsa Roy, Mr. Somnath Saha, Mr. Tanmoy Mondal, Mr. Chandan Halder, Mr. Sourav Bhadra, Ms. Oishi Das, Ms. Sanchita Naskar, Mr. Kuntal Krishna Bera, Ms. Susmita Mukherjee, Mr. Sandip Pal

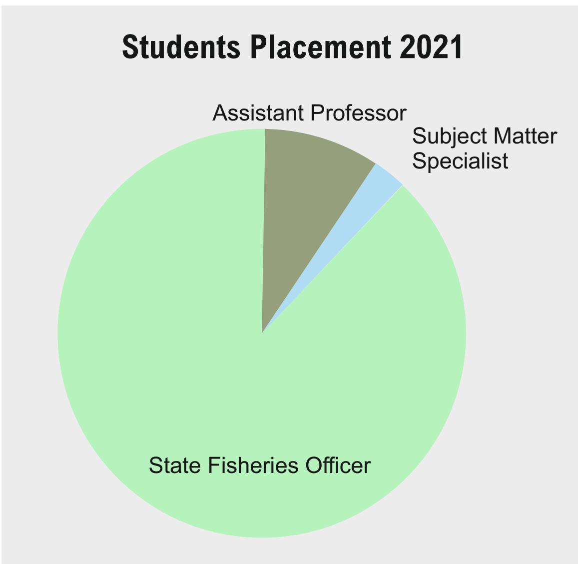
Assistant Fisheries Officer in Government of Odisha

Mr. Suraj Kumar Pradhan, Mr. Sambit Priyadarshi , Mr.Rajan Kumar Behera , Ms. Sanskruti Padra, Ms. Mitali M.Sahoo, Mr. Shobhan Samal, Mr. Pabani Prasad Acharya, Mr. Laxminarayan Hembram ,Mr. Chittaranjan Raul , Mr. Sandeep Shankar Pattanaik, Mr. Alok Kumar Jena , Mr. Alok Kumar Sethy, Ms. Pravati Kishan , Mr. Manabesh Mahapatra , Mr. Rajesh Kumar Dash, Ms. Banani Mohanta ,Mr. Debashish Jena , Mr. Bhubanendra Prasad Acharya , Ms. Swarnaprava Mohapatra

Other State Governments

Mr. Subhash Kumar Banjare has been selected as fisheries inspector in Department of Fisheries, **Chattisgarh**

Ms.Napiner Kaur has been selected as fisheries officer in Dept. of Fisheries, **Punjab**



2.7. Honours and Awards received by Students

Endowment Awards -2021

Dr. C.V. Kulkarni Best M.F.Sc. Student Research Award	:	**Ms. Nisha Chaph**al, FNT
Dr. C.V. Kulkarni Best Ph.D. Student Research Award	:	**Dr. Sandesh Patil**, FEX
Prof. K.H Alikunhi Gold Medal Award for Overall Best Ph.D. Student	:	**Dr. Oishi Das**, PHT
Prof. Ravindranath Krothapalli Best Ph.D. Thesis Award	:	**Dr. Ngairangbam Sushila**, AAH
Smt. Nirmala C. Kulkarni Best Girl Student Research Award	:	**Ms. Nidhi Katare**, FEX

Best Paper / Poster Award

Mr. Sudhan C., M.F.Sc., FRHPHM Division, won Second Best Poster Award for his poster presentation on "Biodiversity of Gorai Creek", organized by United Way of Mumbai, Wetland Day 2021 held on 2 February, 2021.(Online).

Mr. Suman Dey, Ph.D. Scholar, FEES Division won the Second Best Oral Presentation Award in 6th National Youth convention on "Innovation and Agricultural Reforms towards Farmers' Prosperity" for the paper entitled "Fish farmers and fish marketing agents prosperity models- A step towards market-led fisheries prosperity" held during 20-21 February at PJTSAU, Hyderabad, Telangana.(Online)

Mr. Vijay Mannur, M.F.Sc. Scholar, FNFB won the Best Paper Award for his paper entitled, Dietary lipid requirement of GIFT tilapia juveniles reared in inland saline water in SMARTP3BLUEECO-21 held during 12-13 March, 2021, at Thiruvanathapuram, Kerala. (Online)

Dr. Sandesh Patil, Ph.D. scholar of FEES Division, won Young Scientist Award 2021 in Fisheries Science from Vigyan Varta- An International Magazine for Science Enthusiasts.(Online)

Ms. Treasa Merin Pious,M.F.Sc., Aquaculture Division, Won first prize in oral competition on the topic "Aligning Fisheries Education with the New Higher Education Policy 2020" organised by ICAR-CIFE. (In person)

Mr. Sagar Vitthal Shinde,M.F.Sc., Aquaculture Division, Won second prize in oral competition on the topic "Aligning Fisheries Education with the New Higher Education Policy 2020" organised by ICAR-CIFE.(In person)

Mr. Ramjanul Haque, Ph.D. Scholar., Aquaculture Division, Won Best student award, 2021 on the occasion of 2 nd International conference on aquaculture and marine biology, during 21-22 September, 2021.(Online)

Mr. Ramjanul Haque, Ph.D. Scholar., Aquaculture Division, Won Student Academic excellence award, 2021 on the occasion of 3 rd International conference on Global initiative in agriculture forestry and applied sciences for food security environmental safety and sustainable development(GIAFIS 2021) held at Shri Guru Ram Rai University, Dehradun, during 17-18 October, 2021.(Online)

Mr. Sowa O Lamare, M.F.Sc., Aquaculture Division won Best Rapid Presentation and Poster Award for the topic " Pig waste derived green synthesis and characterization of silver nanoparticles and their bactericidal activity against fish pathogens" on XVIII Convention of BRSI - International Conference on Biotechnology for Resource Efficiency, Energy, Environment, Chemicals and Health (BRE3CH2021) held online during 1-4 December, 2021.(Online)

Mr. Udai Ram Gurjar, Ph.D. Scholar, FRHPHM Division won best Oral Presentation Award for the topic "Challenges associated with microplastics in different trophic levels of coastal ecosystem off Mumbai coast, India" on International web Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS-2021) held online between 13-15 December, 2021.(Online)

Quiz competition

Mr. Ramjanul Haque, Ph.D. Scholar., Aquaculture Division, won price in online quiz Competition on Fish as you next pet held on 21 November 2021 by Department of Fisheries, GOI, New delhi.

Grant

Ms. Shamika S. Sawant, M.F.Sc., AEHM Division received Dr. E. G. Silas Small Grant Programme 2021 from Marine Biological Association of India (MBAI), Kochi.

Mr. Suman Dey, Ph.D. Scholar, FEES Division received Minderoo Foundation Grant to attend World Fisheries Congress 2021 (WFC2021) in virtual mode held from Adelaite, Australia.

NAIF-ITMU and ABI Innovative Local Business Idea award 2021 organized by ICAR-CIFE, Mumbai

Winner : **Mr. Chanikya Naidu, Mr. Shiva Krishna Avadootha, Mr. Ramakrishna Reddy,** *FRHPHM Divison*

Runner 1 : **Ms. Jane Jacob, Ms. Abinaya,** *Aquaculture Division*

Runner 2 : **Ms. Aatira Farooq,** *Aquaculture Division*

Consolation : **Ms. Sahana M.D., Mr. Chanikya Naidu, Mr. Ramakrishna Redd**y, *FRHPHM Division*

Fellowship

Junior Research Fellowship

Ms. Subashini V., Fisheries Biotechnology received JRF with fellowship of Rs. 35000 per month from Department of Biotechnology for pursuing Ph.D. programme in Fish Biotechnology, ICAR-CIFE, Mumbai.

Senior Research Fellowship

The following M.F.Sc students of ICAR-CIFE,Mumbai qualified ICAR All India Competitive Examination for admission to Doctoral Degree Programme (SRF 202) conducted by ICAR and became eligible for the fellowship of rupees Rs. 31000 per month for pursuing their Ph.D.

S.No	Name of the Student	Department
1	Ms. Gagana TJ	Fisheries Resource Management
2	Ms. Keisham Geenita	Fisheries Resource Management
3	Ms. Venisza Cathy John	Aquaculture
4	Ms. Ashmita Pandey	Post Harvest Technology
5	Mr. Mukkeri Kranthirekha	Fish genetics & Breeding
6	Ms. Shasti Risha K	Fish Biotechnology
7	Mr. Abhinav Prakash	Aquatic Animal Health Management
8	Mr. Rathod Sanjaykumar Karsanbhai	Aquatic Animal Health Management
9	Mr. Amal C.T	Aquatic Environment Management
10	Ms. Tejaswini K	Fish Nutrition and Feed technology
11	Ms. Sivangi Bhatt	Fish Physiology and Biochemistry

Other Awards

Mr. Sagar Vitthal Shinde, M.F.Sc., Aquaculture Division

- Won 1 st prize Aquafin Youth Icon 2021, organised by Aquaculture Technology & Research Foundation India, Chennai
- Won 2 nd prize for Innovative Idea 2021, organised by Institute's Innovation Council, College of Fisheries, Tripura

2.8. Training / Webinar/ Seminar Attended by Students

The students of ICAR-CIFE,Mumbai in spite of Covid-19 pandemic participated in many training programmes, webinars, seminars, workshops etc through online mode and utilised the online learning platforms for knowledge and skill development.

Name of the training	Date	Organizer
Regression Models	11 January- 11 February,2021	Johns Hopkins University, Baltimore, Maryland
Online Training on Management of Soil and Water Quality Parameters	13 January, 2021	ICAR-Central Institute of Fisheries Education, Kolkata Center
Short-term Course on Bycatch Reduction Fisheries: Recent Advances	17-25 January, 2021	ICAR-Central Institute of Fishery in Technology, Kochi
Hands-on training on fish cell culture	18-23 January, 2021	C. Abdul Hakeem College Melvisharam, Tamilnadu
Law of Sea & Maritime Security	20 January, 2021	Department of Zoology-Oceanography, Ratnagiri Sub-Campus, University of Mumbai, Ratnagiri in Collaboration with Indian Coast Guard, Ratnagiri
Feed and Feeding Methods in Aquaculture	22 January, 2021	ICAR- Central Institute of Fisheries Education, Kolkata Center
International Training Workshop on Ichthyo Taxonomy 2021	23-27, January, 2021	Department of Aquatic Biology, University of Kerala along with Kerala University of Fisheries and Ocean Studies (KUFOS)
Inland Fisheries Connectivity, Irrigation and Water Management	28 January, 2021	APFIC Secretariat in partnership with INFOFISH
Fish Culture and Management by Biofloc Technology	4 February, 2021	ICAR- Central Institute of Fisheries Education, Regional Centre, Motipur, Bihar
Ten-day Online Workshop in Research Methodology for MPhil, PhD and Postdoctoral Scholars in Social Sciences	15-26 February, 2021	Madras Institute of Development Studies, Chennai, Tamil Nadu
6th National Youth Convention on Innovation & Agricultural Reforms Prosperity	20- 21 February, 2021	ICAR, All India Agricultural Students Association (AIASA), Professor Jayashankar Telangana State Agricultural University
Statistics for Social Science Scholars	23 February- 22 March , 2021	ICAR-Indian Agricultural Statistics Research Institute , New Delhi
Statistics and Information in Experimental Management & Analysis	23 February- 04 March, 2021	ICAR-Indian Agricultural Data Statistics Research Institute , New Delhi
Visionary Innovations in Statistical and Applications (VISTA-2021)	24-28 February, 2021	ICAR - National Academy of Theory Agricultural Research Management Hyderabad
Webinar on Location Based Innovative Business Ideas	28 February, 2021	National Agriculture Innovation Fund (NAIF) - Institute Technology Management Unit (ITMU) &

Agri - Business Incubation (ABI) Center Tuna Industry and Sustainability: Mare Aperto Case study	31 March, 2021	World Sustainability Organization Washington, D.C
Aquaculture: Avenue for Assuring FISH (Food security, Income Growth, Social Upliftment and Healthy life)	16 April, 2021	Indian Council of Agricultural Research (ICAR) , New Delhi
Indian Ornamental Fisheries-Forward	22-24 April, 2021	ICAR-Central Institute of The Way Freshwater Aquaculture, Odisha
Indian Ornamental Fisheries 2.0 – Forward	22 - 24 April, 2021	ICAR-Central Institute of The way Brackishwater Aquaculture, Chennai
ArcGIS Training Programme	17-23 May, 2021	Geo Vigyan,Indian Space Research Organization, Banglore
Webinar on Nutraceuticals & Immunity Booster Foods for Combating COVID -19	17 May, 2021	Department of food science & Nutrition, ASPEE College of Home Science & Nutrition, S.D Agricultural University
Biodiversity and Health	22 May, 2021	Center for Innovation in Science and Social Action (CISSA), Navdanya and University of Kerala
Quiz Program on Environment	28 May, 2021	Earth Climate and Ocean research Foundation (ECOR), Kerala
Nanotechnology: a beginner guide to nanomakers	6 -14 June, 2021	Duke University,North Carolina, United States
Webinar on Promoting Food Safety Human Health	07 June, 2021	Department of Fish Quality and Assurance & Management, Dr.M.G.R. Fisheries College and Research Institute, TNJFU, Thoothukudi, Professional Fisheries Graduates Forum (PFGF), Mumbai
Nanotechnology and Nanosensors	15 June -15 July,2021	Technion Israel Institute of Technology
Covid-19 Epidemiological and Scientific Perspectives	19 June, 2021	PG and Research Department of Zoology, Pachaiyappa's College, Chennai
Spectrum of TNJFUans in Embellishing fisheries	19 June, 2021	Tamil Nadu Dr.J.Jayalalithaa Global Fisheries University, Nagapattinam
Morphometric Analysis for Geo-Hydrological and Active Tectonic Studies by Using ArcGIS and Excel	19-20 June, 2021	Geo Vigyan,Indian Space Research Organization, Banglore
Casting into the Future of Fisheries and Aquaculture	22-24 June, 2021	School of Fisheries , Centurion University of Technology and Management (CUTM), Odisha
Webinar on Casting into the Future of Fisheries & Aquaculture	22-23 June, 2021	School of Fisheries, Centurion University of Technology and Management (CUTM), Odisha
Online Training on Pre-processing Drying of Fishes	23 June, 2021	College of Fisheries Science , and Jabalpur

Webinar on Entrepreneurship Opportunities from Fish Processing Waste	29 June, .2021	Department of Fish Processing Technology, Dr.M.G.R. Fisheries College and Research Institute, Ponneri, Tamil Nadu Dr.J.Jayalalitha Fisheries University
Lecture on Recent Advances in Harvest and Post-harvest Technologies	30 June, 2021	NABARD Chair unit, ICAR-Central Marine Fisheries Research Institute, Mumbai Regional Station
MOOC on Theoretical Foundations of Educational Technology	1-30 July, 2021	ICAR- National Academy of Agricultural Research Management, Hyderabad
National Webinar on Perspective Fish Taxonomy	5 July, 2021	Tamil Nadu Dr.J. Jayalalithaa on Fisheries University, Nagapattinam
Introduction to Phylogenetics	7 July, 2021	Rajiv Gandhi Center for Biotechnology (RGCB), Thiruvananthapuram
Internship on Spatial Analysis using Geospatial and Image Processing Techniques.	9 July-19 August, 2021.	GeoVigyan, Indian Space Research Organisation, Banglore
Pro-Aqua 2021 SAP (The Society of Aquaculture Professionals) Lecture Series	17 July-21 August, 2021	ICAR- Central Institute of Fisheries Education, Mumbai under National Agricultural Higher Education Project (NAHEP)
Training programme on Entrepreneurship Development in Fisheries Sector	17 July, 2021	ICAR- National Academy of Agricultural Research Management, Hyderabad & ICAR- Central Institute of Fisheries Education, Mumbai
NGS Data Analysis with Galaxy	27- 30 July, 2021	GeneSpectrum Life science, Pune, Maharashtra
Agricultural Extension: An Exciting Profession for Future	28-30 July, 2021	National Institute of Agricultural Extension Management (MANAGE), Hyderabad
Knock on Effects of Climate Change in Increasing Incidence of Seafood Borne Pathogens and Toxins	4 August, 2021	Dr.M.G.R. Fisheries College and Research Institute, Thalainayeru, Tamil Nadu Dr. J Jayalalitha Fisheries University
International Conference & Exhibition "SEAWEED INDIA 2021"	26-27 August, 2021.	SMART Agri-Post, New Delhi
The India Smart Protein Innovation Challenge (ISPIC) 2021	17 September -14 October, 2021	The Good Food Institute India (GFI India)
Webinar on Utilization of Fishery Wastes for Reducing Post-Harvest Loss With a Focus on the Scope of Entrepreneurship	29 September,.2021	College of Fisheries, Central Agricultural University, IMPHAL
NFDB-PMMSY Sponsered One day Webinar on Implementaion of HACCP in Fish Processing Plants	30 September, 2021	Department of Fish Quality Assurance & Management, Dr.M.G.R. Fisheries College and Research Institute, Thoothukudi, Tamil Nadu Dr.J.Jayalalitha Fisheries University

2.9. Papers presented by Students

Name of the student	Title	Name of conference/ symposia Place and Date
Mr. Suman Dey	Fish Farmers and Fish Marketing Agents Prosperity Models- A step Towards Market-led Fisheries Prosperity	PJTSAU, Hyderabad (Virtual mode) 20-21 February, 2021
Mr. Rajpal Yadav	Opinion Leaders and Their Role in Co-management of Fisheries Resources	4th International Conference on "Global Approaches in Natural Resource Management for Climate Smart Agriculture (GNRSA-2020) During Pandemic Era of Covid-19" Shobhit Deemed University, Meerut 26-28 February, 2021
Ms.Jane Jacob	Plant Based Products for Bioremediation of Ammonia in Aquaculture	International Conference on Biotechnology for Sustainable Agriculture, Environment and Health 4-8 April, 2021
Mr. Bandela Dayakar	Sustainable Methods for Utilizing the Vannamei Shell Waste for Carotene Protein Recovery Using Biotechnological Interventions	International Conference on Sustainable Approaches in Food Engineering and Technology (SAFETY-2021) 24-25 June, 2021
Mr. Suman Dey	Articulating and Computing the Contribution of Fisheries Towards Food Security: A Mixed-Method Approach	World Fisheries Congress 2021 (WFC), Adelaide, Australia (Online) 20-24 September, 2021
Mr. D Arunkumar	Natural and Chemically Modified Clinoptilolite for Removal of Cationic Toxicants from Water of Fish Culture	XVIII Convention of BRSI - International Conference on Biotechnology for Resource Efficiency, Energy, Environment, Chemicals and Health (BRE3CH2021) 1-4 December, 2021
Mr. Gajanan U Kate	Medicinal Plant Derived Product for Mitigation of Priority Abiotic and Biotic Stress Under Controlled Condition	XVIII Convention of BRSI - International Conference on Biotechnology for Resource Efficiency, Energy, Environment, Chemicals and Health (BRE3CH2021) 1-4 December, 2021
Ms. R Abisha	Combined Strategy of Cation Exchanger and Bioaugmentation for Alleviation of Multiple Stresses in Aquaculture	International Conference on Biotechnology for Sustainable Agriculture, Environment and Health 4-8 April, 2021
Ms.Puja Chakraborty	Biogenic Synthesis and Characterisation of Nanosilver Using Livestock and Fish Viscera for Application in Aquaculture	International Conference on Biotechnology for Sustainable Agriculture, Environment and Health 4-8 April, 2021
Ms. Lalramnunsanga	Image Network Analysis Deciphers Genetic Variation and Sexual Dimorphism Among *Cyprinus Carpio* (Linnaeus, 1758) Populations of India	XV ISAGB National Conference on "Animal Breeding Strategies in the Era of Genomics and Phenomics" at ICAR-National Bureau of Animal Genetic Resources, Karnal 17-18 December, 2021

2.10. Students Activities

ICAR-CIFE fosters a dynamic and diverse environment and disporting Unity in Diversity; our students participate in various extracurricular activities. Besides sports and cultural activities that are part of regular annual activities, students enthusiastically and voluntarily contribute to social and environmental activities, like beach clean-up drives and citizen awareness programmes on marine biodiversity conservation. They conduct rallies and discussions with the stakeholders and the common public. During the unprecedented Covid-19 lockdown, which jolted the whole country, our students wholeheartedly led food donation drives across various places in India. They reached out to more than 200 underprivileged families who were affected.

2.11 Programs for Students, Faculty, Farmers and Entrepreneurs

Distinguished Lectures and Programs

An online lecture on "Filing a Patent Application, Prosecution and Grant of Patent in India" was delivered on 23 January, 2021 by the invited speaker, Mr. Samprati Basant, Patent Attorney, KAN AND KRISHME, West Delhi, Delhi, India. The lecturer Mr. Basant started the lecture by mentioning that the patenting activities of an organisation portrays the strength of an institution. He also explained the steps involved in patent filing in India. An interactive session was held at the end of the lecture. The lecture was attended by 85 participants with 22 females and 60 students.

An invited speaker, Ms. Suchitra Upare, FAO consultant, CAFI-SSF Network, New York Area, USA, also an alumnus of ICAR-CIFE, has delivered a live lecture titled "Blue finance to support small-scale fisheries" on 26 February 2021 through Zoom Meet. Ms. Upare mentioned that microfinance is key to the financial empowerment of small-scale fishing communities since it provides them access to the credits. This was the first lecture based on fisheries Economics under NAHEP- Lecture series. Ninety -four participants including 44% females and 59 students attended the lecture.

ICAR-CIFE), organised a lecture on the, "Role and contribution of industry in the growth of aquaculture" on 28 May 2021 in Zoom platform. A total of 100 participants, including faculties and students, attended the lecture. The class was also broadcasted live on social media to benefit a more significant number of participants.

ICAR-CIFE has organised an invited lecture titled "Towards New Feeds for Sustainable Aquaculture" by Prof. Ronald W. Hardy, Professor Emeritus, University of Idaho, USA and also author of the renowned book, Fish Nutrition. Dr. Hardy gave a glance on trends in aquaculture, feeds and nutritional consideration with alternate protein sources and novel protein sources. A Q&A session was held to clear the attendees' queries at the end of the lecture. The online lecture allowed participation of 262 including students and faculties from the institute, participants from other universities across the country as well as outside the country.

A webinar was organised on "Valuing Water: Conservation and Management" on the occasion of the World Water Day Celebration on 22 March 2021. The major objective of the webinar was to improve water management through nature-based solutions for the existing water resources for tackling the existing water crisis. The programme was held in virtual mode along with live streaming on YouTube, where more than 100 participants including students and faculties of CIFE attended the webinar.

A Virtual Alumni Meet, **"VaariSmriti'21: *Safalatha ki parampara*"** was organised on 24 and 25 July 2021 at 6.00 P.M. using Zoom online platform. The Alumni Meet linked the alumni with current students and provided a platform for students to interact with their seniors and get motivated. The Meet was attended by 306 and 267 participants on the first and second days.

2.12. Academia-Industry Interface

Collaborative work successfully initiated with Erfinden Technologies Pvt. Ltd. for developing a proof of concept (POC) for the identification of fish species using Artificial Intelligence (AI). To enable academic and research infrastructure at full potential, facilitative units were established. Under success stories, the technology for value-added shrimp products was popularised and disseminated to Fisherman Cooperative Society and women SHG's at Datiware, Lanja, and Rajapur. About 154 participants have benefited and they are imparting training to other SHGs. ICAR–CIFE, was recently bestowed with the "Green and Clean Campus Award- 3rd Position". The award was announced in the presence of the Honourable Prime Minister of India (online) on the occasion of the Vice-Chancellors' Conference held on 28th September 2021, at New Delhi. The following programs was organised.

The ICAR-CIFE industry day: PMMSY and Entrepreneurship Development

A one-day virtual industry day program under the theme Pradhan Mantri Matsya Sampada Yojana (PMMSY) and Entrepreneurship Development was organised. Dr. B.B. Nayak, Head, FRHPHM Division and industry component leader, NAHEP, gave the introductory note. Dr. S.N. Ojha delivered the talk on PMMSY and entrepreneurship development. He mentioned the importance of organizing the supply chain to reduce the wastage and increase farmers' income. After discussing the broad objectives of PMMSY, the projected fish production and productivity, economic value addition, enhanced income and employment generation upon the implementation of PMMSY were noted by the speaker. Further, he proceeded with the comprehensive list of 13 different stakeholders who can participate in the PMMSY scheme and the different support schemes through which the support could be available. Finally, the lecture was concluded with the description of how to prepare and submit a detailed project report to avail the PMSSY scheme. A total of 88 participants including students, faculty and entrepreneurs were present in the program.

Lecture on Commercial Cage Culture of Tilapia & Pond Culture of African Catfish in Nigeria

A lecture on the topic "Commercial Cage culture of Tilapia & Pond Culture of African Catfish in Nigeria" was organised on 17-02-2021. Dr. Suryaprakash Rao Voodi, Aquaculture Specialist, Premium Aquaculture Limited, Abeyokuta, Oyan Dam, Ogun State, Nigeria gave the lecture. Beginning with an overview of aquaculture production in Africa. He discussed about various aspects of the commercial cage culture of tilapia, such as identification of water bodies, broodstock development, hatchery development, production optimization, fabrication and installation of the cage, harvest and post-harvest technologies. The second half of the lecture discussed different aspects of African catfish culture in well-designed ponds, catfish farm design and feeding, major diseases in catfish, catfish hatchery, and harvest and post-harvest technologies. The lecture was highly engaging and enriching, emphasizing the industrial-scale production of tilapia and catfish. A total of 55 participants, including students and faculty, attended the lecture.

2.13. Gender Advancement for Transforming Institutions (GATI)

The Department of Science and Technology, GoI is conducting a monitoring and evaluation study under the GATI initiative. As part of the study, ICAR-CIFE is designated as a control group. The British Council is conducting a baseline study through Think Through Consultancy (TTC) agency which will help us benchmark and identify the baseline of Indian STEMM higher education institutions in the context of gender equality. Responses from randomly selected staff and students (each) from ICAR CIFE including scientist, finance, administration and students have been filled online as per the structured questionnaire and submitted for further analysis.

03

Research Achievements

Inland Saline Aquaculture

NATIONAL AGRICULTURAL HIGHER EDUCATION PROJECT

Development of Energy Efficient and Envionment Protective - Aquaculture Technologies for Degraded Soils -

Centres for Advanced Agricultural Science and Technology (CAAST)

Funded by: **World Bank & Govt.of India** Supported by: **ICAR-Education Division**

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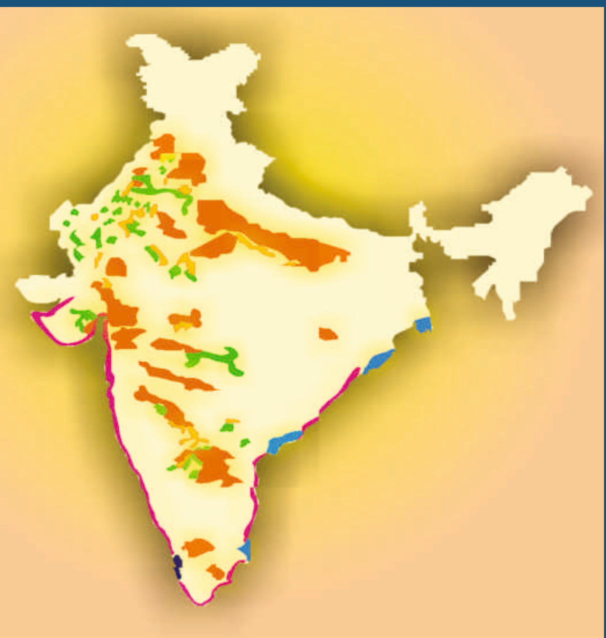
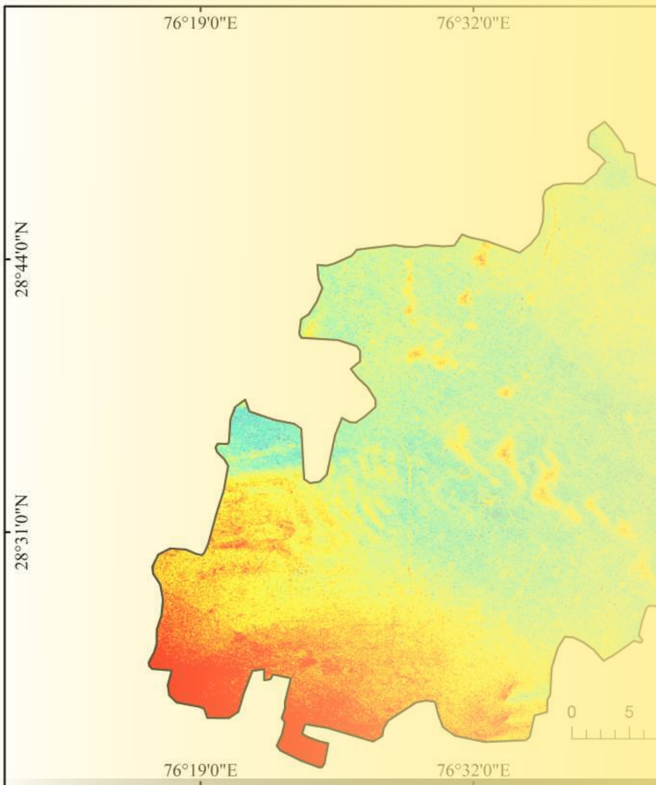
Dr. Shamna N.
Dr. Neha Wajahat Qureshi
Dr. Pankaj Kumar
Ms. Husne Banu
Mr. Satya Prakash
Dr. K. Sreedharan
Mr. Abuthagir Iburahim
Mr. Ram Singh
Mr. Dasari Bhoomaiah

Budget: Rs. **19.97** crore **Project duration**: **2017-2022**



The NAHEP-CAAST Project consists of four major Components with distinct objectives and activities. The First Component has eight sub-components focusing on different research areas in inland saline aquaculture from an interdisciplinary perspective with the unifying underlying theme of energy efficient and environment friendly aquaculture technologies. The second and third Components are development oriented with major emphasis on pedagogy, capacity development, and strengthening collaborations between academia and the industry. The fourth Component has a mix of development and research activities built around leveraging ICT for technology diffusion. Keeping with the theme-wise presentation of this Annual Report, the progress made under the Components 1 and 4 are presented here (Research Achievements), while that of Components 2 and 3 are presented in Academic Achievements.

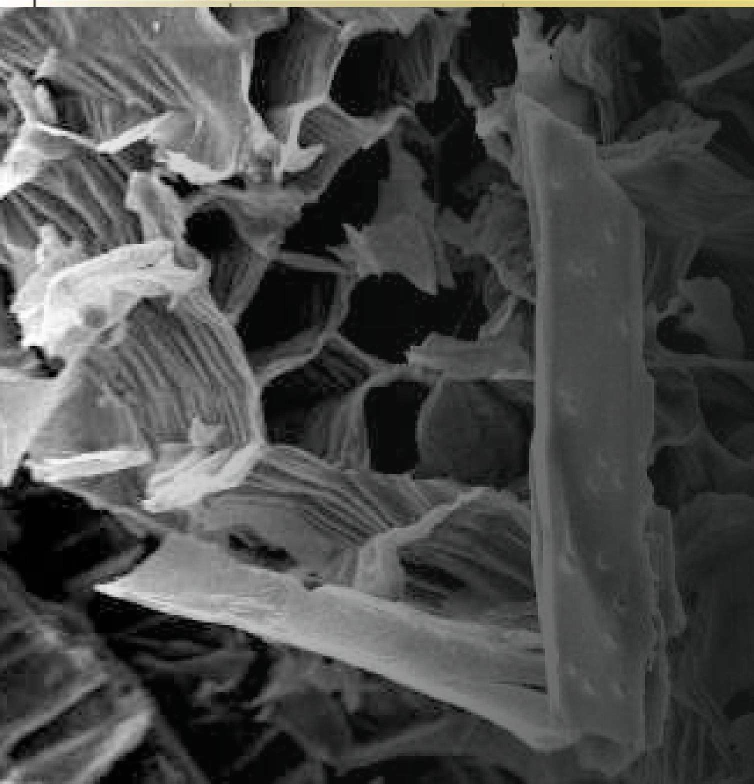
Component 1:
Development of Energy Efficient and Eco-friendly Technologies



Component 1a.

Resource Availability, Characteristics and Potential of Inland Saline Soil and Water

Under the resource availability, characteristics and potential of inland saline soil and water were evaluated. Spatial distribution maps were prepared for the various physico-chemical parameter of soil (pH, EC, Soil texture, Organic carbon, Chloride, CO_3, HCO_3, Na, K, Ca, Mg) for Rohtak, Jhajjar, Fazilka and Mathura districts of Haryana, Punjab and Uttar Pradesh respectively. The knowledge mapping of farmers in Haryana and Punjab was done. Vegetation indices models (SAVI, NDMI, NDVI) have been prepared to delineate saline soil and bare soil. Spatial distribution maps of groundwater depth have been prepared.



Component 1b.

Enriching Elemental Deficiency, Carbon Storage and Enhancing Productivity of the Soil

Biochar usage enriches elemental deficiency, carbon storage and enhances the productivity of the soil. Experiments revealed that biochar removes 80-85% ammonia from the water and improves water quality. Biochar enhances organic carbon, potassium, CEC (Cation Exchange Capacity), and water holding capacity of soil sediment.

A Study on the Effect of Biochar Amended Sediment on Growth and Physiological Response of *Penaeus vannamei* (Boone, 1931) Reared in Inland Saline Water

(CIFE/2019/AEM904/SR)

Jateen

Major Advisor: Dr. Saurav Kumar

There is growing interest in culturing *Penaeus vannamei* in inland saline water owing to the availability of enormous resources of inland saline water. However, these water bodies are facing serious problems of seepage and nutrient variability and deficiency, particularly potassium. In this context, the present study aimed to evaluate the effect of sugarcane bagasse biochar (SBB) and activated sugarcane bagasse biochar (A-SBB) amended sediment on water and sediment quality along with its effects on growth, survival and physiological response on *P. vannamei* reared in inland saline water. The whole experiment was divided in two distinct groups based on stocking density of shrimp in tanks *viz.* Group 1: C1 (without biochar), T1 (with BSS + sediment) and T2 (A-BSS + sediment); @ 60 juveniles/m^2 and Group 2: C2 (without biochar), T3 (BSS + sediment) and T4 (A-BSS + sediment); @ 90 Juveniles/m^2 in triplicates for 49 days. Water quality analysis was performed at a 14 days interval, whereas sediment samples were collected on the initial and final day. Further, shrimp organs (hepatopancreas, gills and muscles) and serum were collected for tissue enzymes (digestive, metabolic and oxidative) and serum profiles respectively at the end of experiment.

The results of water quality parameters showed a significant increase in K^+, Mg^{++} with reduction in ammonia-N value in biochar amendment treatments in both the experimental groups. Among the sediment properties, there was substantially higher water holding capacity, sediment organic carbon, pH and cation exchange capacity in biochar added treatments when compared with controls of both the trial groups. Further, a significant increase in final body weight, weight gain percent, specific growth rate, protein efficiency ratio with reduced feed conversion ratio was observed in biochar treated groups. Furthermore, the mean values of digestive enzyme (protease and amylase), metabolic enzymes (AST, and ALT in hepatopancreas) and oxidative enzymes (SOD in gills and hepatopancreas; CAT in gills) were found to be significantly higher in biochar amended treatment groups as compared to control. Serum parameters showed a differential pattern with higher haemocyanin and total protein level in SBB and A-SBB treated groups, whereas, glucose and sodium to potassium ratio was found to be highest in control groups.

Finally, an increased survival percentage of *P. vannamei* juveniles was recorded in only high stocking density groups in both biochar treated groups in comparison to control. Amendment of biochar (SBB) into the sediment showed overall enhancement in water (reduced ammonia, availability of K^+ and Mg^{++}) and sediment (increased CEC, WHC, pH) quality. Although, application of biochar increases the serum K^+, AST & ALT, protease activity which directly improves the growth performance and survivability of reared *P. vannamei* by lowering the FCR yet this finding needs to be verified with more sample size and pond condition.

Impact of Biochar on Sediment Quality and Growth of GIFT Tilapia

(CIFE/2019/AEM908/SR)

Tao kara

Major Advisor: Dr. Vidya Shree Bharti

The problems of global warming, soil degradation, and increasing water pollution are the most important issues in the present scenario and most importantly we need to shift from capture fisheries to culture fisheries. India has a vast area of Inland saline soil, it can be used for aquaculture, as it is not suitable for the agriculture purpose due to lack

Table: Specific growth rate (%), weight gain (%), feed efficiency ratio and feed conversion ratio of GIFT tilapia in different treatments after 45 days of experiment. Data are represented in mean ± SE.

Treatments	SGR	WG	FER	FCR
Control	2.10 ± 0.026^{a}	157.27 ± 2.29a	0.76 ± 0.018^{a}	1.31 ± 0.01^{c}
T1	2.18 ± 0.025^{a}	167.59 ± 1.37^{b}	0.78 ± 0.023^{a}	1.25 ± 0.00^{b}
T2	2.26 ± 0.013^{b}	177.31 ± 3.04^{c}	0.82 ± 0.008^{b}	1.21 ± 0.01^{b}
T3	2.61 ±0.023^{d}	223.69 ± 2.01^{e}	0.95 ± 0.005^{c}	1.05 ± 0.00^{a}
T4	2.55 ± 0.015^{c}	212.45 ± 2.05^{d}	0.92 ± 0.005^{a}	1.08 ± 0.00^{a}

Where, control= Sediment+GIFT tilapia; T1= Sediment+GIFT tilapia+SBB@9 t/ha, T2= Sediment+GIFT tilapia+PSB@9 t/ha, T3= Sediment+GIFT tilapia+SBB in feed @0.5%, T4= Sediment+GIFT tilapia+PSB in feed@0.05%, SBB=Sugarcane Bagasse biochar, PSB= Paddy straw biochar

of some important nutrients. These problems can be reduced to great extent by amendment of sediment with biochar. Sediment amendment with Biochar improves the sediment quality and water quality in the Aquaculture system. Biochar incorporated feed improves the growth performance of the animals. In this context a 45 days experiment was conducted in ICAR - CIFE Rohtak Centre, (Haryana) to study the impact of biochar on sediment quality and growth of GIFT Tilapia (*Oreochromis niloticus).* Sugarcane bagasse and paddy straw biochar was used in this study. Characterization of biochar was done for different physical and chemical properties like bulk density, water holding capacity, pH, EC, total & available potassium, total Calcium and functional groups by FTIR analysis. Biochar was applied in sediment @ 9 t/ha and incorporated in commercial feed containing 35% protein @ 0.5% on w/w basis.

In this study it was found that sediment and water quality was improved. Water holding capacity (%) was increased from 34.14±1.33 to 54.7±3.73, CEC and Organic carbon (%) were also increased. In water, available potassium was increased and Nitrite was decreased. SGR, FER, WG (%) were increased and FCR was decreased in GIFT Tilapia. Overall, the study provides substantial data for the validation of the hypothesis that biochar improves the survival and growth of Gift Tilapia, physico-chemical properties of inland saline pond sediment, and water when used as an amendment in the sediment as well as incorporated in feed. The findings of the study will serve as baseline information for developing a standard protocol for the application of biochar in the Inland saline aquaculture system.

Impact of biochar on soil microbial activity and growth of *P. vannamei* (Boone, 1931) in inland saline aquaculture system

(CIFE/2019/AEM901/SR)

Amal C. T

Dr. Vidya Shree Bharti

A 45-day experiment was conducted to assess the impact of biochar produced from pyrolysis of paddy straw (PSB) and sugarcane bagasse (SSB) on soil microbial activity, physicochemical properties of ISW, pond sediment, and growth of *P. vannamei* at CIFE, Rohtak centre, Haryana. The 100 g biochar was applied to 25 kg of sediment (9 t/ ha) in 300L capacity FRP tank, and the experimental animal (*P. vannamei*) was stocked at 90 juveniles/m^2. Hence, T1, indicates PSB application in sediment; T2, K^+ activated PSB; T3, SBB and T4, activated SBB. There was significant increase in sediment OC (2.17 times), WHC (2.66 times), available K^+ (176%) in the treatment T2. The highest increase in TN (2.84 times), EC (2.4 units), CEC (64.11%), available P (51.41%) was observed in T4. The pH was increased 1.03 times in T1, Ca^{++} increased highest in T3 (2.33 times), and BD was significantly decreased in T4 (35.36%) from initial (day 1) to final (45th day) sediment sample. Soil microbial activity measured in terms of soil enzyme dehydrogenase was significantly high in control sediment sample, and lowest in T1 treatment on 45th day of observation. Alkaline phosphatase activity was significantly high in T3. In water, the concentration of NH_3-N was increased highest in control and declined in T2. The K^+ and TSS in water increased, and highest value was observed in T2.

The total hardness, Mg, Ca:Mg ratio increased and Ca^{++} decreased significantly in T4. Among growth parameters of *P. vannamei*, weight gain (%) in T2, survival (%) in T3, FCR in control, and SGR in T2 were found to be higher during the experiment. Overall, the study provides a substantial data for the validation of the hypothesis that biochar improves the survival and growth of *P. vannamei*, physicochemical properties of inland saline pond sediment and water when used as an amendment in the sediment.

Compont 1c.
Biofloc Technology for Sustainable Effluent Management in Aquafarms

The biofloc meal production in the biofloc reactor was optimized using full factorial design and response surface methodology with three factors and 2 levels and the process was validated. The biochemical quality of the biofloc was analyzed to evaluate the biofloc as a possible quality dietary ingredient. Optimized different ratios of concentration of chitosan and cationic starch for effective development of biofloc in inland saline water. Optimum floc volume and flocculation activity was obtained at 1: 1 ratio of chitosan : cationic starch compared to other ratios i.e. 2 : 1, 1 : 2 and 1 : 3. Supplementation of vitamin-mineral mixture at $4 gL^{-1}$ into the biofloc inoculum with a C/N ratio of 15 significantly enhances the fish growth in BFT. Bioflocculating agents incorporated media for biofloc production is suitable for inland saline aquaculture which enables suitable floc quality and volume than conventional method.

Evaluation of Growth, Physiological Response and Carcass Quality of Red Tilapia in Biofloc System in Inland Saline Groundwater

(CIFE/20159/AQC505/SR)

Sangeeta Kumari

Major Advisor: Dr. Babita Rani

A biofloc-based intensive system is best suited to the culture of red tilapia, *Oreochromis mossambicus* × *Oreochromis niloticus*. Thus, an experiment of 90 days was conducted to evaluate the optimal stocking density of red tilapia fingerlings of average body weight 10.54 ± 0.43 g which 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 triplicates in inland saline ground water of 20 ppt. The Percentage body weight gain (570.02 ± 21.86), Specific growth rate (2.10 ± 0.04) and Protein efficiency ratio (1.90 ± 0.07) was found to be significantly higher in the biofloc treatment groups SD1 whereas the lowest Feed conversion ratio (1.04 ± 0.02), was noted in SD1. Growth and survival (95.57 ± 0.53) were obtained was the highest in SD1. Digestive enzymatic activities (units mg $protein^{-1}$) of protease (0.66 ± 0.05), amylase (1.28 ± 0.04) and lipase (1.25 ± 0.02) were the highest in SD1 and lowest was in control. The 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}) in the SD1 of the present study was within the safety limits for red tilapia. The highest volume of floc was recorded in SD4 (35.09 ± 0.20 ml L^{-1}) and the lowest was in SD1 (32.74 ± 0.37 ml L^{-1}). Therefore, this study indicated that at stocking density 150 m^{-3} in salinity of 20 ppt is optimum for the rearing of red tilapia in inland saline based biofloc ground water.

(CIFE/2019/AAH901/SR)

The Effect of Probiotic on Different Health Aspects of Pacific White Shrimp, *Penaeus vannamei* Farmed in Inland Saline Water

Amulya S. G.

Major Advisor: Dr. Gayatri Tripathi

The present study was conducted to evaluate the effect of commercial probiotics (MOS Mannan oligosaccharides, *Pediococcus acidilactici* MA18/5M and *Saccharomyces cerevisiae boulardii*) on different health aspects of *Litopenaeus vannamei* (initial body weight 3.32 ±0.04 g) reared in inland saline water (ISW). Four diets *viz.*, control (0% probiotic), T1 (0.25% probiotic), T2 (0.5% probiotic) and T3 (0.75% probiotic) were formulated using commercially available shrimp feed (nutriva, 36% crude protein) and fed to the respective groups for 45 days. Different parameters such as the growth performance, microbial load (total heterotrophic bacterial count (THBC) and total *Vibrio* count (TVC)), serum parameters, digestive, antioxidant and metabolic enzyme activities were determined. The disease resistance of control and probiotic-fed animals were evaluated by challenging them with the pathogenic strain of *Vibrio parahaemolyticus* through immersion method.

At the end of the feeding trial, probiotic-administered shrimp displayed better growth and survival rate than control. Optimum performance in growth parameters including average weight gain, (%) weight gain, specific growth rate, and protein efficiency rate were significantly higher ($P<0.05$) in T2 groups than other experimental groups. Moreover, THBC and TVC of T2 groups were comparatively less (both in pre- and post-challenged conditions) than other groups at the same conditions. The activities of digestive enzymes (protease, amylase, lipase), antioxidant enzymes (superoxide dismutase, catalase), metabolic enzymes (aspartate aminotransferase and alanine aminotransferase) and serum parameters (total serum protein, serum glucose and serum *malondialdehyde)* in T2 group were found to be significantly different ($p<0.05$) from other treatments, indicating that T2 group had an optimum performance. Histopathological analysis revealed that the animals in the T2 group retained the typical architecture of the hepatopancreas even after the challenge test. The results of the present study indicated that the administration of probiotic incorporated diet significantly improves growth, survival and the resistance of *L. vannamei* to infection.

1.

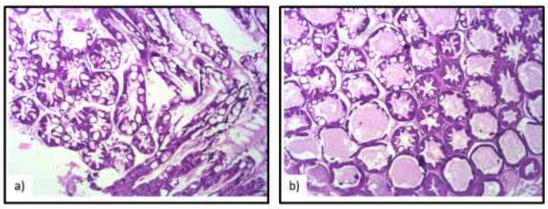


Fig 1 a and b represents the section of HP tissue fed with control diet (45 days)

2.

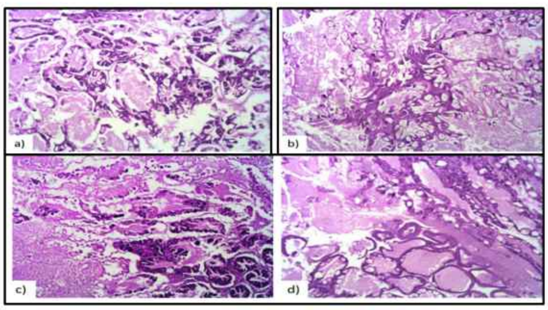


Fig 2 a b c d represents section of HP tissue from shrimp fed with control diet (45 days) and challenged with *Vibrio parahaemolyticus*

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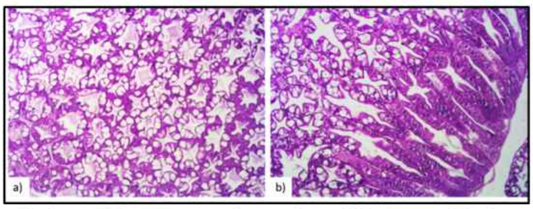


Fig 3 a and b represents the section of HP tissue of Shrimp fed with probiotic T2 diet (optimum dose)

4.

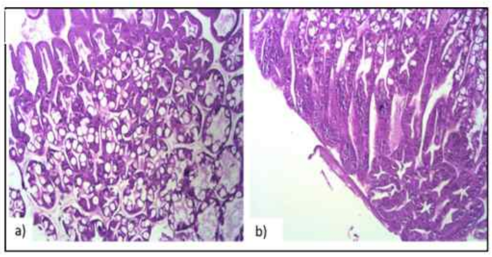


Fig 4 a and b represents Shrimp fed with T2 diet and challenged with *V. parahaemolyticus*

Histopathological observations of Hepatopancreas of experimental shrimp

Component 1d:
Nutraceuticals for stress mitigation and growth enhancement

Aim1: To study the cross-protective effect of non-lethal heat shock in *Penaeus vannamei* (boone, 1931) against potassium deficient low saline water

Effects of one-hour Non-lethal heat shock (1 h NLHS) mediated cross-protection in conferring stress tolerance in *Penaeus vannamei* against potassium (K^+) deficient Inland low saline water (ISW).

1. **Experiment 1:** *P. vannamei* juveniles incubated at 28 °C were heat-shocked for 1 h at 1 °C intervals from 34 °C to 41 °C in triplicates, with mortalities determined 8 h after returning them back to 28 °C by counting dead animals. The temperature which caused zero mortality after 8 h following 1 h heat shock was chosen as the 1 h NLHS. The 1 h NLHS for *P. vannamei* juveniles reared in 100% K^+ fortified 10 ppt ISW was found to be 36 °C

2. **Experiment 2:** To determine the cross-protection conferred by 1 h NLHS against different 25%, 50% and 75% K^+ fortified, 10 ppt ISW. Acute stress responses and growth performance after 45 days rearing were evaluated for control (without NLHS) and Treatment (with NLHS) groups.

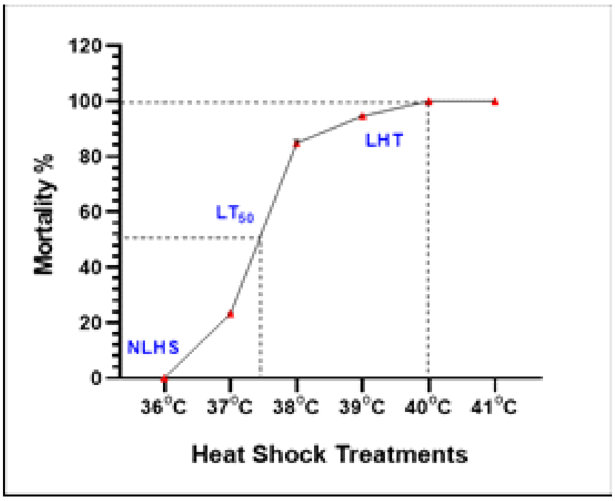


Figure: 1 The 1 h NLHS, LT50 and LHT of *P. vannamei* in 10 ppt, 100% K^+ ISW

NLHS, non lethal heat shock; LT50, Median lethal temperature, temperature that reduced animal survival by 50%; LHT, Lethal High Temperature, temperature that killed all animals.

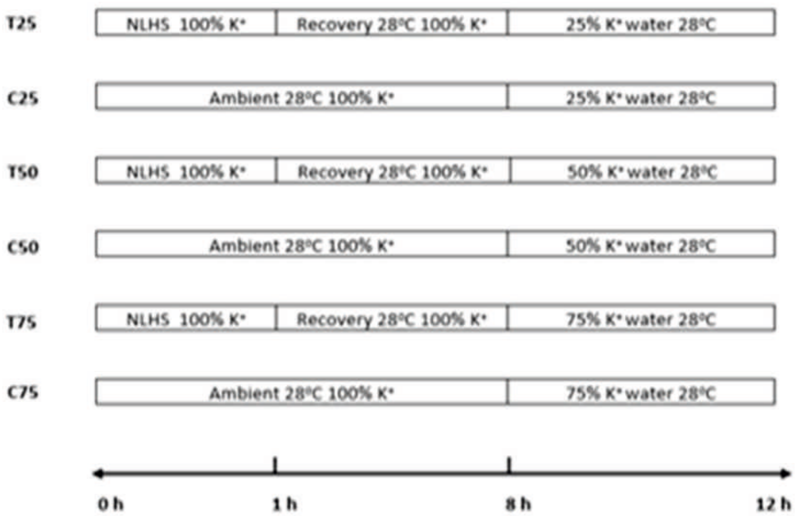


Fig. 2: Experimental protocol for the second experiment for estimating the cross tolerance shown as time series

Table 1: Design of the second experiment

Treatment annotations		Description	R1	R2	R3
C25	25% K+	ISW fortified with 25% of K+ compared to seawater of same salinity (10 ppt)	C25R1	C25R2	C25R3
T25	NLHS + 25% K+	NLHS followed by ISW fortified with 25% of K+ compared to seawater of same salinity (10 ppt)	T25R1	T25R2	T25R3
C50	50% K+	ISW fortified with 50% of K+ compared to seawater of same salinity (10 ppt)	C50R1	C50R2	C50R3
T50	NLHS + 50% K+	ISW fortified with 50% of K+ compared to seawater of same salinity (10 ppt)	T50R1	T50R2	T50R3
C75	75% K+	ISW fortified with 75% of K+ compared to seawater of same salinity (10 ppt)	C75R1	C75R2	C75R3
T75	NLHS + 75% K+	ISW fortified with 75% of K+ compared to seawater of same salinity (10 ppt)	T75R1	T75R2	T75R3

In treatments (T25, T50, T75), shrimps were subjected to NLHS for 1 h followed by 8 h recovery and transferred to the next stress K^+ deficient ISW of 25%, 50% and 75%. In control (C25, C50, C75), shrimps were transferred directly to K^+ deficient ISW of 25%, 50% and 75% without NLHS.

A. B.

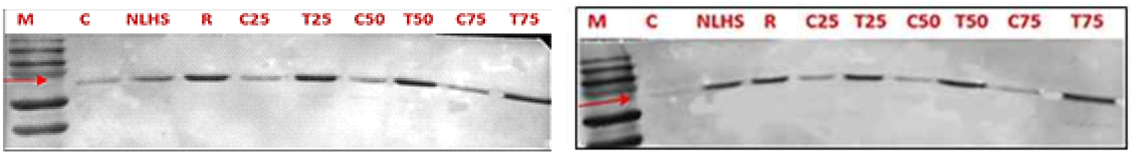


Fig. 3: Western blots of *P. vannamei* juveniles showing the abundance of Hsp70 following 1 h NLHS, recovery and exposed to different potassium levels of ISW with and without NLHS after 12 hours of exposure; The red arrow corresponds to 70 KDa protein. The lanes are labeled as follows: M, protein molecular weight marker; C, control at ambient 28°C; NLHS, Non-lethal heat shock; R, recovery in 100% K^+ fortified ISW Fig.3 (A)- Muscle tissue blot; Fig.3 (B)-Gill tissue blot.

Table 2: SOD and CAT activities before NLHS (0 h Control), 1 h after NLHS and 8 h recovery in 100% K^+ fortified water

[1]Treatments	[2]SOD		[3]CAT		Hemocyanin (mmol/l)	Serum Glucose (g/dl)
	HP	G	HP	G		
0 h (Control)	45.03^{b}±3.57	23.63^{c}±0.01	23.01^{b}± 0.84	17.03±2.24^{b}	1.48a ± 0.05	36.15^{c}±0.21
1 h NLHS	61.62^{a} ± 3.49	38.17^{b}±4.59	59.76^{a}±3.32	33.88±0.65^{b}	1.11^{b} ± 0.09	57.74^{a}±0.29
8 h Recovery	54.33^{ab}±1.67	59.62^{a}±2.73	22.62^{b} ±3.07	53.12±8.19^{a}	0.88^{c} ± 0.02	39.38^{b}±0.17
p value	0.023	0.001	0.000	0.006	0.000	0.000

All values in the table are expressed as Mean± SE (n=3). The mean values in the same columns with different superscripts differ significantly (p< 0.05);[1]Control (No heat shock) and recovery tanks were maintained at 28°C, NLHS-Non-lethal heat shock.

Table 3: SOD, Catalase, Glucose and Haemocyanin values of *P. vannamei* exposed to different potassium levels with and without NLHS after 12 hours of exposure

[1]Treatments	[2]SOD		[3]CAT (Catalase)		Glucose (g/dl)	Haemocyanin (mmol/l)
	HP	G	HP	G		
Effect of Potassium						
25%	51.279	61.806^{a}	31.903^{a}	37.015^{a}	36.77^{c}	1.03^{c}
50%	51.762	44.457^{b}	32.023^{a}	23.829^{b}	42.74^{a}	1.06^{b}
75%	55.011	37.401^{b}	27.96^{b}	41.41^{a}	40.95^{b}	1.45^{a}
SEM	1.473	2.594	1.201	2.601	0.28	0.01
p value	0.192	0.000	0.056	0.001	0.000	0.000
Effect of Heat Shock						
Control	61.13^{a}	37.846^{b}	24.31^{b}	30.722^{b}	34.93^{b}	0.82^{b}
NLHS	44.238^{b}	57.93^{a}	36.947^{a}	37.448^{a}	45.38^{a}	1.54^{a}
SEM	1.203	2.118	0.981	2.124	0.23	0.01
p value	0.000	0.000	0.000	0.045	0.000	0.000
Effect of Potassium × Heat Shock						
p value	0.664	0.033	0.010	0.940	0.000	0.000

All values in the table are expressed as Mean± SE (n=3). The values are expressed as two way means with standard error. Different superscripts in the same column differ significantly ($p < 0.05$). Control-without heat shock; NLHS-1-hour heat shock at 36°C; HP- Hepatopancreas; G-Gill. [2]SOD (Superoxide Dismutase) activity is expressed as 50% inhibition of epinephrine autoxidation/mg protein/min. [3]CAT (Catalase) activity is expressed as Nano moles H_2O_2 decomposed/min/mg protein. SEM-standard error of mean.

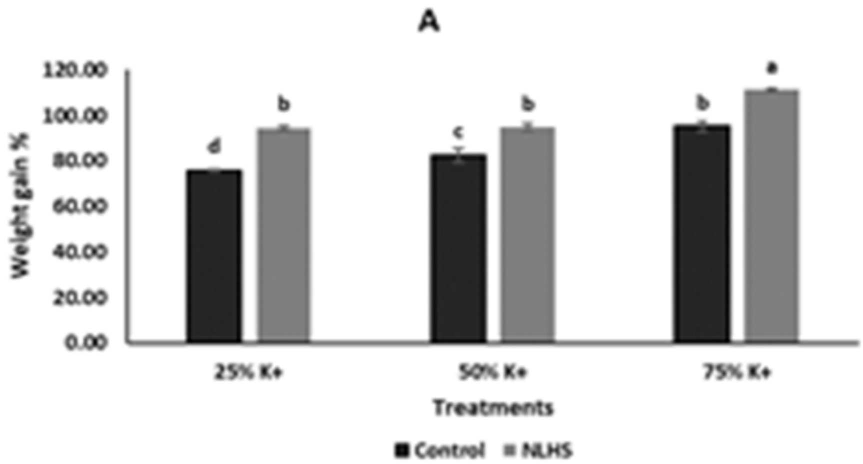


Fig. 3: Growth and survival of *P. vannamei* juveniles reared in different levels of K^+ fortified ISW of 25% K^+, 50% K^+ and 75% K^+ with and without NLHS, fed with commercial feed for 45 days. Control-without heat shock; NLHS-1-hour heat shock at 36°C. Values are expressed as mean ± SE (n = 3); bars with different superscripts differ significantly ($p<0.05$). Fig.3 (A)-Weight gain (%); Fig.3(B)- Survival (%)

The results indicated that NLHS provides cross-protection through Hsp 70 protein abundance in potassium deficient ISW up to 50% K^+ fortification, but not at the lower K^+ concentration. However, NLHS promoted the weight gain % in all the treatment groups compared to control in different K^+ fortified ISW. Thus, 50% aqueous K^+ requirement can be compensated with NLHS for the survival of *P. vannamei* in potassium deficient ISW.

Aim2: To study the effect of Low Protein High Energy (LPHE) diet supplemented with various nutraceuticals in inland saline reared GIFT tilapia and *P. vannamei* juveniles

- A practical diet containing 33% protein and 8% lipid supplemented with 0.05% L-carnitine is ideal for higher production of white-leg shrimp, *P. vannamei* in inland ground saline water of 10 ppt salinity
- Feeding of 33% crude protein, 8% lipid and 0.5% taurine resulted in maximum growth performance, nutrient utilisation, physio-metabolic status and immune responses in white leg shrimp, *P. vannamei* reared in inland saline water at 10 ppt ambient salinity
- Diet with 35% crude protein, 11% lipid and 0.05% bile acid can result in better growth, nutrient utilization, physio-metabolic status and immune responses of GIFT tilapia reared in inland saline water of 10 ppt salinity
- LPHE diet (35% protein and 11% lipid) supplemented with 0.05% bile acid showed better growth performance for tilapia culture in inland ground saline water of 15 ppt salinity
- LPHE diet (36% protein and 8% lipid) supplemented with nutraceuticals (0.025% L-carnitine and 0.25% taurine) is ideal for *L. vannamei* culture in inland ground saline water of 15 ppt salinity

Table 4: Effect of L-carnitine supplemented high protein low energy and low protein high energy diets on growth of white leg shrimp, *P.vannamei* reared in inland saline water of 10 ppt salinity for the period of 60 days

One-way ANOVA			**Parameters**		
Treatments[1]	**WG[2](g)**	**WG[3]%**	**SGR[4](%/day)**	**TGC[5] (%/day/°C)**	
P36L5C0	9.84^{c}±0.16	244.94^{c}±2.67	2.06^{c}±0.02	0.45^{c}±0.01	
P36L5C0.05	11.18^{e}±0.09	277.91^{e}±1.71	2.21^{e}±0.02	0.49^{e}±0.02	
P36L5C0.1	10.60^{d}±0.12	262.51^{d}±2.67	2.15^{d}±0.01	0.47^{d}±0.01	
P33L8C0	9.18^{b}±0.04	228.52^{b}±1.66	1.98^{b}±0.01	0.43^{b}±0.04	
P33L8C0.05	13.21^{f}±0.10	329.57^{f}±4.14	2.43^{f}±0.03	0.55^{f}±0.03	
P33L8C0.1	11.01^{e}±0.15	274.72^{e}±2.65	2.20^{e}±0.01	0.49^{e}±0.04	
P30L11C0	8.56^{a}±0.12	213.12^{a}±3.15	1.90^{a}±0.02	0.41^{a}±0.03	
P30L11C0.05	9.28^{b}±0.09	230.70^{b}±3.35	1.99^{b}±0.02	0.43^{b}±0.02	
P30L11C0.1	9.10^{b}±0.09	227.36^{b}±1.65	1.98^{b}±0.01	0.43^{b}±0.01	
p-value	<0.001	<0.001	<0.001	<0.001	
Effect of dietary protein – lipid levels				**Two way ANOVA**	
P36L5	10.54^{b}	261.78^{b}		2.14^{b}	0.47^{b}
P33L8	11.13^{c}	277.60^{c}		2.21^{c}	0.48^{c}
P30L11	8.98^{a}	223.73^{a}		1.96^{a}	0.42^{a}
SEM	0.065	1.586	0.007	0.002	
p-value	<0.001	<0.001	<0.001	<0.001	
Effect of L-carnitine levels					
0	9.19^{a}	228.86^{a}	1.98^{a}	0.42^{a}	
0.05	11.22^{c}	279.39^{c}	2.21^{c}	0.49^{c}	
0.1	10.24^{b}	254.86^{b}	2.11^{b}	0.46^{b}	
SEM	0.065	1.586	0.007	0.002	
p-value	<0.001	<0.001		<0.001	<0.001
Effect of dietary protein – lipid levels * L-carnitine levels					
p-value	<0.001	<0.001	<0.001	<0.001	

[1]P36L5To, optimum dietary protein and lipid level (36 % CP , 5% lipid) and no supplementation of L-carnitine; P36L5To.05 , P36L5To diet supplemented with 0.05% L-carnitine; P36L5To.1 , P36L5To diet supplemented with 0.1% L-carnitine; P33L8To, (33% CP , 8 % lipid and no supplementation L-carnitine); P33L8To.05 , P33L8To diet supplemented with 0.05% L-carnitine; P33L8To.1, ; P33L8To diet supplemented with 0.1% L-carnitine; P30L11To (30 % CP ,11 % lipid and no supplementation L- carnitine); P30L11To.05 , P30L11To with 0.05% L-carnitine ; P30L11To.1, , P30L11To diet supplemented with 0.1% L-carnitine [2]WG (g), gram weight gain, [3]WG%, weight gain percentage; [4]SGR (%/day), specific growth rate, [5]TGC-thermal growth coefficient.

Table 5: Effects of feed (low protein high energy), level of taurine and interaction between feed and taurine on growth performance, nutrient utilization, and body indices of white-leg shrimp, *Penaeus vannamei* reared in inland ground saline water of 10 ppt salinity

One-way ANOVA		**Parameters**				
[1]**Diets**	[2]**WG(g)**	[3]**WG%**	[4]**SGR**	[5]**FCR**	[6]**PER**	[8]**HPSI**
P36L5To	10.20^{e}±0.06	253.83^{e}±2.72	2.11^{e}±0.01	1.28^{c}±0.02	2.17^{c}±0.03	1.54^{c}±0.02
P36L5To.5	12.25^{g}±0.09	304.42^{g}±1.69	2.33^{g}±0.05	1.14^{b}±0.01	2.45^{d}±0.05	1.36^{a}±0.03
P36L5T1	9.60^{d}±0.08	237.79^{d}±3.66	2.03^{d}±0.02	1.41^{d}±0.02	1.97^{b}±0.04	1.45b±0.02
P33L8To	9.14^{c}±0.05	227.44^{c}±2.05	1.98^{c}±0.01	1.39^{d}±0.01	2.19^{c}±0.02	1.64^{d}±0.02
P33L8To.5	13.92^{h}±0.06	347.30^{h}±3.17	2.49^{h}±0.06	1.08^{a}±0.03	2.80^{e}±0.06	1.47^{b}±0.02
P33L8T1	11.01^{f}±0.15	274.72^{f}±2.65	2.20^{f}±0.03	1.26^{c}±0.01	2.40^{d}±0.05	1.55^{c}±0.02
P30L11To	7.27^{a}±0.12	181.06^{a}±4.12	1.72^{a}±0.04	1.69^{f}±0.04	1.98^{b}±0.05	1.79^{f}±0.02
P30L11To.5	8.37^{b}±0.11	208.07^{b}±3.70	1.88^{b}±0.02	1.54^{e}±0.03	2.16^{c}±0.04	1.63^{d}±0.02
P30L11T1	7.10^{a}±0.05	177.40^{a}±3.31	1.70^{a}±0.04	1.80^{g}±0.04	1.85^{a}±0.03	1.71^{e}±0.02
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Two-way ANOVA						
Effect of feed						
P36L5	10.68^{b}	265.39^{b}	2.15^{b}	1.28^{b}	2.19^{b}	1.45^{a}
P33L8	11.36^{c}	283.15^{c}	2.22^{c}	1.24^{a}	2.46^{c}	1.56^{b}
P30L11	7.58^{a}	188.84^{a}	1.76^{a}	1.67^{c}	1.99^{a}	1.71^{c}
SEM	0.053	1.654	0.008	0.010	0.015	0.012
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Effect of taurine level						
0	8.87^{a}	220.77^{a}	1.94^{a}	1.45b	2.10^{a}	1.66c
0.5	11.51c	286.59c	2.23c	1.25^{a}	2.47^{b}	1.49^{a}
1.5	9.24^{b}	229.97^{b}	1.98^{b}	1.49c	2.07^{a}	1.57b
SEM	0.053	1.654	0.008	0.010	0.015	0.012
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Effect of feed * taurine						
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	0.996

[1] P36L5To, optimum dietary protein and lipid level (360 g CP/kg + 50 g lipid/kg) supplemented with 0% taurine; P36L5To.5, P36L5To diet supplemented with 0.5% taurine; P36L5T1, P36L5To diet supplemented with 1.0% taurine; P33L8To, 330 g CP/kg + 80 g lipid/kg supplemented with 0% taurine; P33L8To.5, P33L8To diet supplemented with 0.5% taurine; P33L8T1, P33L8To diet supplemented with 1.0% taurine; P30L11To, 300 g CP/kg + 110 g lipid/kg; P30L11To.5, P30L11To diet supplemented with 0.5% taurine; P30L11T1, P30L11To diet supplemented with 1.0% taurine; Abbreviations: [2]WG (g), gram weight gain , 3%WG, percentage weight gain; [4]SGR (%/day), specific growth rate; [5]FCR, feed conversion ratio; [6]PER, protein efficiency ratio; [7]LER, lipid efficiency ratio; [8]HPSI, hepatopancreatic somatic index.

Table 6: Effects of bile acid supplemented low protein high energy on growth, nutrient utilization and survival of GIFT tilapia reared in inland ground saline water of 10 ppt salinity

One Way ANOVA					
Treatments	**WG2 (g)**	**WG%[3]**	**SGR[4] (%/day)**	**FCR[5]**	**PER[6]**
P38L8B0	$8.04^{bcd}\pm0.11$	$320.16^{bc}\pm5.31$	$2.39^{bc}\pm0.02$	$1.32^{a}\pm0.03$	$1.88^{a}\pm0.01$
P38L8B0.05	$8.98^{e}\pm0.14$	$354.70^{d}\pm5.77$	$2.53^{d}\pm0.02$	$1.21^{a}\pm0.03$	$2.05^{abc}\pm0.01$
P38L8B0.1	$8.74^{de}\pm0.22$	$351.37^{d}\pm5.82$	$2.51^{d}\pm0.02$	$1.25^{a}\pm0.02$	$2.05^{abc}\pm0.14$
P35L11B0	$7.89^{bc}\pm0.26$	$316.97^{bc}\pm8.25$	$2.38^{bc}\pm0.03$	$1.34^{a}\pm0.03$	$1.99^{ab}\pm0.04$
P35L11B0.05	$8.94^{e}\pm0.11$	355.99d±4.79	2.52d±0.02	$1.21^{a}\pm0.02$	$2.16^{bcd}\pm0.06$
P35L11B0.1	$8.62^{cde}\pm0.39$	$340.28^{cd}\pm15.53$	$2.47^{cd}\pm0.06$	$1.27^{a}\pm0.04$	$2.09^{bc}\pm0.04$
P32L14B0	$6.96^{a}\pm0.08$	$274.96^{a}\pm3.14$	$2.20^{a}\pm0.01$	$1.65^{c}\pm0.01$	$2.14^{bc}\pm0.05$
P32L14B0.05	$7.62^{ab}\pm0.06$	$303.47^{ab}\pm3.73$	$2.33^{ab}\pm0.02$	$1.51^{b}\pm0.01$	$2.35^{d}\pm0.04$
P32L14B0.1	$7.49^{ab}\pm0.55$	$297.96^{ab}\pm19.59$	$2.30^{ab}\pm0.08$	$1.52^{b}\pm0.11$	$2.24^{cd}\pm0.07$
p-value	<0.001	<0.001	<0.001	<0.001	<0.001
Two Way ANOVA					
Effect of dietary protein-lipid levels					
P38L8	8.59^{b}	342.08^{b}	2.47^{b}	1.26^{a}	1.99^{a}
P35L11	8.48^{b}	337.75^{b}	2.45^{b}	1.27^{a}	2.08^{a}
P32L14	7.36^{a}	292.13^{a}	2.27^{a}	1.56b	2.24^{b}
SEM	0.152	5.561	0.022	0.240	0.035
p-value	<0.001	<0.001	<0.001	<0.001	<0.001
Effect of bile acid levels					
0	7.63^{a}	304.03^{a}	2.32^{a}	1.43^{b}	2.00^{a}
0.05	8.51^{b}	338.06^{b}	2.46^{b}	1.31^{a}	2.19^{b}
0.1	8.29^{b}	329.87^{b}	2.43^{b}	1.35^{a}	2.13^{b}
SEM	0.152	5.561	0.022	0.024	0.035
p-value	<0.001	<0.001	<0.001	0.001	<0.001
Effect of dietary protein-lipid levels * bile acid levels					
p-value	0.960	0.952	0.972	0.938	0.906

[1]$P_{38}L_8B_0$, optimum dietary protein and lipid level (38% CP, 8% Lipid &0% bile acid); $P_{38}L_8B_{0.05}$, $P_{38}L_8B_0$diet supplemented with 0.05% bile acid; $P_{38}L_8B_{0.1}$, $P_{38}L_8B_0$diet supplemented with 0.1% bile acid; $P_{35}L_{11}B_0$, low protein and high lipid (35% CP,11% Lipid&0% bile acid); $P_{35}L_{11}B_{0.05}$,$P_{35}L_{11}B_0$diet supplemented with 0.05% bile acid ; $P_{35}L_{11}B_{0.1}$, $P_{35}L_{11}B_0$diet supplemented with 0.1% bile acid; $P_{32}L_{14}B_0$, low protein and high lipid (32% CP, 14% Lipid&0% bile acid); $P_{32}L_{14}B_{0.05}$, $P_{32}L_{14}B_0$, diet supplemented with 0.05% bile acid; $P_{32}L_{14}B_{0.1}$, $P_{32}L_{14}B_0$ diet supplemented with 0.1% bile acid. [2]WG, weight gain, [3]%WG, weight gain percentage; [4]SGR, specific growth rate; [5]FCR, feed conversion ratio; [6] PER, protein efficiency ratio.

Conclusion

The crude protein inclusion in GIFT diets can be reduced from 37 to 35% with inclusion of 11% lipid and 0.05% bile acid in ISW. Meanwhile, crude protein inclusion in *P. vannamei* diets can be reduced from 36 to 33% with inclusion of 8% lipid and 0.5% taurine or 0.5% carnitine in ISW.

Cross-protection of *Penaeus vannamei* (Boone, 1931) Against Potassium Deficient Low Saline Water due to Non-lethal Heat Shock

(CIFE/2019/FPB904/SR)

Paul Nathaniel T

Major Advisor: Dr. Das Gupta

Inland saline waters (ISW) are highly deficient in potassium ion (K^+) compared to seawater of the same salinity. This deficiency hinders the usage of ISW for shrimps. K^+ is usually supplemented to maintain the aqueous K^+ concentration in ISW. The present study was conducted to evaluate the effect of non-lethal heat shock (NLHS) on the cross protection of *P. vannamei* juveniles against potassium deficient ISW. The initial experiment determined the NLHS for *P. vannamei* juveniles (3.52 ± 0.23g) reared at 10 ppt, 100% K^+ fortified ISW. The 1 hour (h) NLHS was found to be 36°C, followed by 8 h recovery at 10 ppt, 100% K^+ fortified ISW. The 1 h NLHS has significantly increased the heat shock protein 70 (Hsp 70) protein abundance in the gill and muscle; which almost doubled after 8 hour recovery. The second experiment was conducted to determine the effect of NLHS on cross-protection of *P. vannamei* juveniles (4.64 ± 0.01g) against different K^+ fortified (25%, 50% and 75%) ISW. After subjecting 1 h NLHS and 8 h recovery, ten shrimps were exposed to different K^+ ion fortified water in triplicates. A group that did not receive NLHS served as a control in triplicates.

The NLHS significantly induced the serum glucose, catalase and SOD in the gill and hepatopancreas compared to control. Haemocyanin concentration increased with increase in K^+ concentration after 12 h exposure in NLHS groups compared to control. Hsp 70 protein abundance in muscle and gill was upregulated even after 12-hour exposure in different K^+ fortified ISW thereby conferring cross-protection against K^+ deficient water. The gill Hsp 70 abundance increased with decrease in K^+ concentration in ISW in control groups. The 45-day growth trial showed significant increase in weight gain (%), SGR, FER, PER and Survival (%) in groups subjected to NLHS compared to treatments without NLHS irrespective of the K^+ level while FCR was lowest in the NLHS groups. This growth enhancing effect of NLHS treatment was evident even in the most potassium deficient groups. Thus, the study indicates that NLHS provides cross-protection through Hsp 70 protein abundance and antioxidant enzyme activation in potassium poor low saline water, thereby promoting improved growth and survival of shrimp with minimum aqueous potassium fortification.

Effect of Sulphate on Physio-biochemical Responses of GIFT Reared in Potassium-Deficient Low Saline Waters

(CIFE/2019/FPB906/SR)

Shivangi Bhatt

Major Advisor: Dr. Tincy Varghese

Two experiments were conducted to assess the effect of sulphate on physio-biochemical responses of GIFT reared in potassium-deficient low saline waters. A LC_{50} trial was performed in GIFT (Genetically improved farmed tilapia) fry (0.5 ± 0.02g) to determine the acute sulphate toxicity. The median lethal concentration (96h LC_{50}) of sulphate ion in the GIFT was found to be 5.30 gL^{-1}. The second experiment was conducted for 21 days exposing fish to a sub-lethal level of sulphate ion (SO_4^{2-}) concentration (1000 mgL^{-1}, 1/5th of LC_{50}) with different types of waters (FW, Freshwater; ASW, Artificial seawater, 10 gL^{-1}; LPSW, Low potassium saline water, 10 gL^{-1}) with and without sulphate inclusion to constitute the treatments as follows, (FW, FW + SO_4, ASW, ASW + SO_4, LPSW, LPSW + SO_4). The effect of sulphate on GIFT reared in sulphate-rich potassium deficient low saline water was evaluated by focusing on the haematological adjustments, stress-induced changes, oxidative damage and osmoregulatory imbalances. The survival was not altered due to the sulphate concentration and K^+ deficiency; however, there were significant changes in the osmolality and branchial Na^+/K^+- ATPase (NKA) activity.

The increase in NKA was highest in LPSW treatment, suggesting that internal ionic imbalance was triggered due to an interactive effect of sulphate and K^+ deficiency. The cortisol levels showed a pronounced increase due to sulphate inclusion irrespective of K^+ deficiency. The antioxidant enzymes, i.e. SOD, Catalase, GST, GPX, reflected a similar pattern of increment in the liver and gills of the LPSW + SO_4 groups, suggesting a poor antioxidant status of the exposed group. The hepatic peroxidation status, i.e. TBARS, and the peroxide values were enhanced due to both K^+ deficiency and sulphate inclusion, suggesting a possible lipid peroxidation in the liver due to handling of the excess concentration of sulphate anion. The haematological parameters, including haemoglobin, total erythrocyte count and haematocrit level, reduced significantly in the LPSW + SO_4 group when compared to other groups indicating a reduced blood oxygen capacity due to the sulphate exposure and water potassium deficiency. Thus, it is concluded that sulphate induced physiological imbalances are more manifested in potassium deficient water, indicating that environmental sulphate is more detrimental to inland saline water than freshwater or brackish water of the same salinity.

(CIFE/2019/FNT907/SR)

Evaluation of the Low Protein and High Energy Diets Supplemented With Bile Acid on Growth and Immunity of GIFT Juveniles Reared In Inland Saline Water

Saipraad Bhusare

Major Advisor: Dr. Parimal Sardar

A-60 day's feeding trials was conducted to find out the effect of bile acid supplemented low protein and high energy diet on growth, nutrient utilization, physio-metabolic changes and immune responses of *Oreochromis niloticus* juveniles reared in 10 ppt inland saline water. Three heteronitrogenous (32, 35, 38% CP), heterolipidic (8, 11, 14% lipid) and heterocaloric (409.54-439.60 Kcal DE/100g) within the range of practical diets with three different levels of bile acid (0, 0.05 and 0.1%) were prepared. Four hundred and five (405) acclimated GIFT juveniles (2.5±0.01g) with stocking density of 15 fishes per tank were randomly distributed in nine treatment groups viz. P38L8B0, P38L8B0.05, P38L8B0.1, P35L11B0, P35L11B0.05, P35L11B0.1, P32L14B0, P32L14B0.05 and P32L14B0.1 in triplicates. Results indicated that the whole body crude protein was not significantly (p>0.05) affected by different levels of protein-lipid diet with bile acid supplementation. Whereas, whole body lipid content increased with increase in dietary lipid and decreasing dietary protein levels. The fishes fed with 35% protein, 11% lipid and 0.05% supplemented bile acid (P35L11B0.05) showed higher WG (g), WG%, SGR, activities of AST and ALT while lower FCR, PER and activities of SOD and CAT activities. There was no mortality during the entire experimental period.

The body indices (HSI, VSI) and IPF were found to be significantly increased with increase in lipid and decreasing protein content in diet. The malondialdehyde (MDA) and respiratory burst activity increased significantly (p<0.05) with increase in the dietary lipid levels in the diet. All the hematological parameters such as

Hb, TEC, HCT and TLC exhibited increasing trend with decreasing protein and increasing lipid content in diet and highest value found in 0.05% bile acid fed group. Serum glucose levels were observed to be the highest in 32% protein and 14% lipid fed groups. The serum cholesterol, triglyceride and LDL cholesterol levels were found to be in an increasing trend with increase in lipid and decreasing protein content in diet, while HDL cholesterol showed reverse trend. From the present study it is concluded that the feeding of 35% crude protein, 11% lipid and 0.05% bile acid can cause better growth, nutrient utilization, physio-metabolic status and immune responses of for GIFT tilapia reared in inland saline water of 10 ppt salinity.

(CIFE/2019/FNT903/SR)

Evaluation of the Low Protein and High Energy Diets Supplemented with Taurine on Growth and Immunity of *Penaeus vannamei* (boone, 1931) Juveniles Reared in Inland Saline Water

Bhavatharaniya U

Major Advisor: Dr. N.P Sahu

The present study evaluated the effect of taurine supplemented low protein and high energy diets on growth performance and physio-immunological response of *Penaeus vannamei* (Boone, 1931) juveniles reared in inland saline water of 10 ppt. The experimental diets were formulated with three levels of protein-lipid (36% protein & 5% lipid, 33% protein & 8% lipid and 30% protein & 11% lipid) with three levels of taurine (0 ,0.5 and 1%). Six hundred and seventy five acclimatized *P. vannamei* juveniles (avg.b.wt 4.03 ± 0.05 g) were randomly distributed into nine experimental groups ($P_{36}L_5T_0$, $P_{36}L_5T_{0.5}$, $P_{36}L_5T_1$, $P_{33}L_8T_0$, $P_{33}L_8T_{0.5}$, $P_{33}L_8T_1$, $P_{30}L_{11}T_0$, $P_{30}L_{11}T_{0.5}$ and $P_{30}L_{11}T_1$) in triplicates with the stocking density of 25 shrimps per tank. The results showed that the whole body crude protein and ash content were not significantly (p>0.05) affected by dietary protein-lipid combination irrespective of taurine supplementation. However, the whole body lipid level was higher in $P_{30}L_{11}$ group, while optimum level was observed in $P_{33}L_8$ group. Similarly, $P_{33}L_8$ group fed with 0.5% taurine showed higher WG (g), WG (%), SGR, TGC, FER, PER, LER and lower FCR while the hepatopancreatic somatic index (HPSI) was significantly lower in $P_{36}L_5T_{0.5}$ group.

The total protein in serum decreased with decrease in protein and increase in lipid in the diet and the serum glucose, cholesterol and triglyceride levels increased significantly (p<0.05) in $P_{30}L_{11}$ group. The hepatopancreatic malondialdehyde (MDA) content increased significantly (p<0.05) with increase in the dietary lipid level. The protease and lipase activities were significantly higher in $P_{33}L_8T_{0.5}$ and $P_{30}L_{11}T_{0.5}$ groups respectively, whereas, amylase activity was lower in $P_{36}L_5T_0$ group. The AST activities in the hepatopancreas was similar (p>0.05) in $P_{33}L_8T_{0.5}$ and $P_{36}L_5T_{0.5}$ groups. The activities of muscle AST and hepatopancreatic ALT were significantly (p<0.05) higher in $P_{33}L_8T_{0.5}$ group. The SOD and catalase activities in gill and hepatopancreas were significantly lower in $P_{33}L_8T_{0.5}$ group. Hemocyanin (Hc) was lower in the P30L11T1 group. From the result, it can be concluded that feeding of 33% crude protein, 8% lipid and 0.5% taurine resulted in maximum growth performance, nutrient utilisation, physio-metabolic status and immune responses in white leg shrimp, *P. vannamei* reared in inland saline water at 10 ppt ambient salinity.

(CIFE/2019/FNT905/SR)

Evaluation of the Low Protein and High Energy Diets Supplemented with L-Carnitine on Growth and Immunity of *Penaeus Vannamei* (Boone, 1931) Juveniles Reared in Inland Saline Water

Raghuvaran N

Major Advisor: Dr. Parimal Sardar

A 60-day feeding trial was conducted to evaluate the effect of L-carnitine supplemented high protein low energy and low protein high energy diets on the growth, nutrient utilization, physio-metabolic status and immune responses of *Penaeus vannamei* juveniles reared in inland saline water (ISW) of 10 ppt salinity. Nine heteronitrogenous (30-36% Crude protein), heterolipidic (5-11%) and heterocaloric (378-411 Kcal DE/100g) practical diets with three different supplemental levels of L-carnitine (0, 0.05 and 0.1%) were used in the study. Six hundred and seventy-five acclimated *P. vannamei* juveniles (average body weight 4.02 ± 0.01 g) were randomly distributed to nine treatment groups with different levels of dietary protein-lipid and L-carnitine *viz.* $P_{36}L_5C_0$, $P_{36}L_5C_{0.05}$, $P_{36}L_5C_{0.1}$, $P_{33}L_8C_0$, $P_{33}L_8C_{0.05}$, $P_{33}L_8C_{0.1}$, $P_{30}L_{11}C_0$, $P_{30}L_{11}C_{0.05}$ and $P_{30}L_{11}C_{0.1}$ in triplicate following a 3x3 factorial design with the stocking density of 25 shrimp/400 L and fed their respective experimental diet thrice daily to satiation level.

The whole body lipid content increased with increase in dietary lipid levels and the $P_{30}L_{11}$ group exhibited significantly ($p<0.05$) higher lipid content compared to other groups. The $P_{33}L_8C_{0.05}$ group exhibited significantly ($p<0.05$) the highest WG (g), WG (%), SGR, TGC, FER, PER, THC and activities of proPO, AST, ALT, protease, amylase and lipase and lower FCR, activities of SOD and CAT and hepatopancreatic MDA compared to other groups. Significantly ($p<0.05$) lower LER and higher HPSI were found in higher lipid and lower protein consuming group but 0.05% dietary L-carnitine caused increased LER and decreased HPSI significantly. The varying levels of protein-lipid and L-carnitine did not have a significant effect on the survival, serum osmolality and osmoregulatory capacity of the cultured shrimps. Significantly ($p<0.05$) reduced serum glucose, cholesterol and triglyceride was also found in $P_{33}L_8C_{0.05}$ group. Thus, based on the results, it can be concluded that the diet with 33% crude protein, 8% lipid and 0.05% L-carnitine is ideal for rearing of *P. vannamei* in inland saline water of 10 ppt salinity for achieving maximum growth and wellbeing of shrimp. Revalidation of results through field trials is suggested.

(CIFE/2016/FNT602/SR)

Nutritional Evaluation of Leaf Meal Based Feed with Variable Protein Levels in Shrimp and Finfish under Polyculture System Reared in Inland Saline Water

Avinash Talukdar

Major Advisor: Dr. Ashutosh Deo

Five experiments were conducted to develop a cost-effective feed for the polyculture system of *Litopenaeus vannamei*, *Mugil cephalus* and *Anabas testudineus* reared in inland saline water (ISW) at 8 g/l salinity. The first three experiments were conducted separately to illustrate the effect of graded protein levels on the growth and physio-metabolic status, whereas the fourth and fifth experiments were conducted to assess the economic feasibility of the diets for polyculture systems. Six isoenergetic (367-372 Kcal/100 g) and isolipidic (6% lipid) diets containing 24% (T24), 26% (T26), 28% (T28), 30% (T30), 32% (T32), and 34% (T34) crude protein were formulated and fed in triplicate groups for first three experiments. After 60 days of feeding, significantly higher ($p<0.05$) weight gain (%), specific growth rate, RNA/DNA ratio and lower feed conversion ratio were found in T32, T30 and T34 groups for *L. vannamei, M. cephalus* and *A. testudineus,* respectively. The protein utilizing efficiency and whole-body protein content was significantly higher ($p<0.05$) in the T30 group for *M. cephalus* and T32 group for *L. vannamei* and *A. testudineus*. Significantly higher ($p<0.05$) whole-body lipid content, hepatosomatic index, and liver glycogen content of *M. cephalus* were found in the T24 group. A significantly lower ($p<0.05$) value of hepatosomatic index and glycogen was found in T24 and T26 groups for *L. vannamei* and *A. testudineus*. Protease or trypsin activity increased with the increasing dietary CP level up to T32 group, whereas; amylase activity was significantly higher ($p<0.05$) in the lower protein fed groups (T24 and T26 groups). The haemolymph protein and hemocyanin contents were elevated in T32 and T34 groups in *L. vannamei* with a significantly lower ($p<0.05$) value of haemolymph glucose and antioxidant enzymes activities than the other groups.

Significantly higher ($p<0.05$) transaminase enzyme activities were found in higher protein fed groups (T30-T34 groups) for *L. vannamei, M. cephalus* and *A. testudineus*. No significant ($p>0.05$) variations were observed for lactate dehydrogenase, antioxidant enzymes, blood parameters, and serum osmolality for *M. cephalus* among the treatment groups. Whereas, significantly higher ($p<0.05$) antioxidant enzymes, lactate dehydrogenase, and malate dehydrogenase enzymes were found in T24 and T26 groups for *L. vannamei* and *A. testudineus*. The erythrocyte count and serum total protein were significantly lower ($p<0.05$) in T24 and T26 groups in *A. testudineus*. Based on the results, feeding dietary CP level of 32%, 30%, and 34% is optimum for supporting maximum growth and health status of *L. vannamei M. cephalus* and *A. testudineus* reared in ISW at 8 g/l salinity. The fourth and fifth polyculture system experiments were carried out for 60 days and 45 days in indoor tanks and pond, respectively, with 32% (T32) and 34% (T34) dietary CP. The stocking density was 15/m^3 (*L. vannamei*), 12/m^3 (*M. cephalus*) and 12/m^3 (*A. testudineus*). The final biomass (g), biomass gain (%), daily weight gain (g/day), overall feed conversion ratio, and overall protein efficiency ratio were similar ($p>0.05$) in T32 and T34 groups.

The combined nitrogen recovery ranged from 25.68 to 30.15 and was similar ($p>0.05$) in T32 and T34 groups. In the fifth trial, the economic analysis revealed that the net return was higher with the T32 fed group; however, the benefit-cost ratio remained similar ($p>0.05$) in T32 and T34 groups. Based on the production performance and economic analysis, the SLMBD (*Sesbania* leaf meal-based diet) with 32% dietary CP (T32) is better than the 34% dietary CP (T34) for the polyculture of *L. vannamei, M. cephalus,* and *A. testudineus* in ISW at 8 g/l salinity. Further, this integrated model of the polyculture system is technically and economically feasible in ISW. This study will help develop a cost-effective feed and generate extra income for the farmers of salt-affected regions.

Component 1e. Sustainable Fish and Shellfish Production Systems through Stocking, Harvesting and Bioremediation Strategies

Impact of Inland Saline Water on Growth of Some Aquatic Plants

(CIFE/2019/FRM911/SR)

Tejaswini P. Karale

Major Advisor: Dr. Geetanjali Deshmukhe

Two economically and medicinally important aquatic/semi aquatic plant species used to study the impact of inland saline water on their growth rate were: a) *Centella asiatica* (L.) Urb, commonly known as mandukaparni, or Jalbrahmi in India, is among the top 10 drugs in the category of anti-aging and central nervous system (CNS) drugs used

worldwide; and b) *Trapa bispinosa* Rox (water chestnut) is an annual, floating leaved aquatic plant. It contains a significant quantity of antioxidants, such as flavonoids, flavones, and total phenol, and is used as food for humans. The present study has been designed to investigate the growth of the Jalbrahmi and Trapa plant cultured in different salinities by using inland saline water. The maximum growth rate observed in the Jalbrahmi plant is grown in 0 ppt water followed by 2 ppt water, waste waste-pond water, 4 ppt water. Reduced growth of Jalbrahmi found in 6 ppt. The maximum length gain of Jalbrahmi found in control is 9.76cm, followed by 2 ppt water is 7.79 cm, waste pond water is 6.71cm, and 4 ppt water is 4.14 cm. The percentage gain in the number of leaves of Jalbrahmi in 0 ppt water is 66.40 %, in 2 ppt water is 60.85%, in waste pond water is 50.40%, and in 4 ppt water is 32.91%.

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 plants 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. There was no survival of the Trapa plant more than 1 ppt after 30 days. In the study, the concentration of chlorides in soil decreased from 1.5 mg/L to 1 mg/L, and calcium concentration decreased from 216 mg/L to 160 mg/L, magnesium concentration decreased from 135mg/L to 116 mg/L, sodium in soil reduced from 542 mg/L to 368 mg/L in 0 ppt water for Jalbrahmi experiment. Chlorides in soil decreased from 2mg/L to 1.3 mg/L, calcium concentration decreased from 256 mg/L to 196 mg/L, magnesium concentration decreased from 155mg/L to 131mg/L, sodium in soil reduced from 660 mg/L to 496 mg/L in 2 ppt water for Jalbrahmi experiment. Chloride, calcium, magnesium, sodium concentration of soil decreased in control and 1ppt water in *Trapa* plant culture trial.

(CIFE/2019/FRM910/SR)

Assessment of the Impact of Temperature and Salinity on Growth of Brackishwater Phytoplankton

Swati

Major Advisor: Dr. Geetanjali Deshmukhe

Brackishwater biota has received significantly less attention due to their limited distribution and the intricacy of their biocoenoses, which comprise species from freshwater, brackishwater, and marine ecosystems. The smaller size of the species present adds to the complications, which is especially obvious in algal communities where nano-phytoplankters predominate. Since dynamic changes in the estuarine environment occur often, a comprehensive approach to ecosystem research is essential. Hence, it is imperative to acknowledge the current status of biodiversity in the Manori estuarine ecosystem. Monthly sampling was conducted along six stations of Manori creek which is a tidal channel located in the state of Maharashtra. Due to covid restrictions, sampling could not be done regularly after March and for experiments on growth, some samples were collected from two stations of Manori and five stations of Thane creek. A total of 28 genera of phytoplankton were identified from Manori creek. Out of these, maximum diversity was formed by diatoms with 17 genera, followed by green algae with 7 genera,

blue green algae with 3 genera and dinoflagellates with only 1 genus. The collected samples were inoculated into f/2 medium of varying salinities and incubated at different temperatures for 10 days. The initial and final number of cells of each genera was enumerated to calculate the growth. *Chaetoceros* sp. showed the maximum growth out of all genera. It could survive in most of the temperature-salinity combinations. The growth was analyzed statistically by one way ANOVA which revealed the temperature-salinity conditions best suited for each genera of cultured brackishwater phytoplankton.

Component 1f.
Microbial Composition of ISW and Interaction with Host and Environment

Post-larval samples were collected before stocking in the ponds and preserved in absolute alcohol for metagenomic analysis, and in Davidson's fixative for histopathological study. Shrimp tissues (gut and hepatopancreas; n=3) were collected from ponds stocked in three different densities (30 no./m^2, 45 no./m^2 and 60 no./m^2) every month till harvest. Tissues were preserved in absolute alcohol for metagenomic analysis and in Davidson's fixative for histopathological study.

During the period of study, water samples were also collected in duplicates (10 days interval) from *L. vannamei* ponds stocked at three different stocking densities (duplicates) and analysed for various chemical parameters such as the pH, salinity, total alkalinity, total hardness, calcium, magnesium and potassium. The water samples were also analyzed for the total heterotrophic bacterial (using nutrient agar) and total *Vibrio* counts (using TCBS agar).

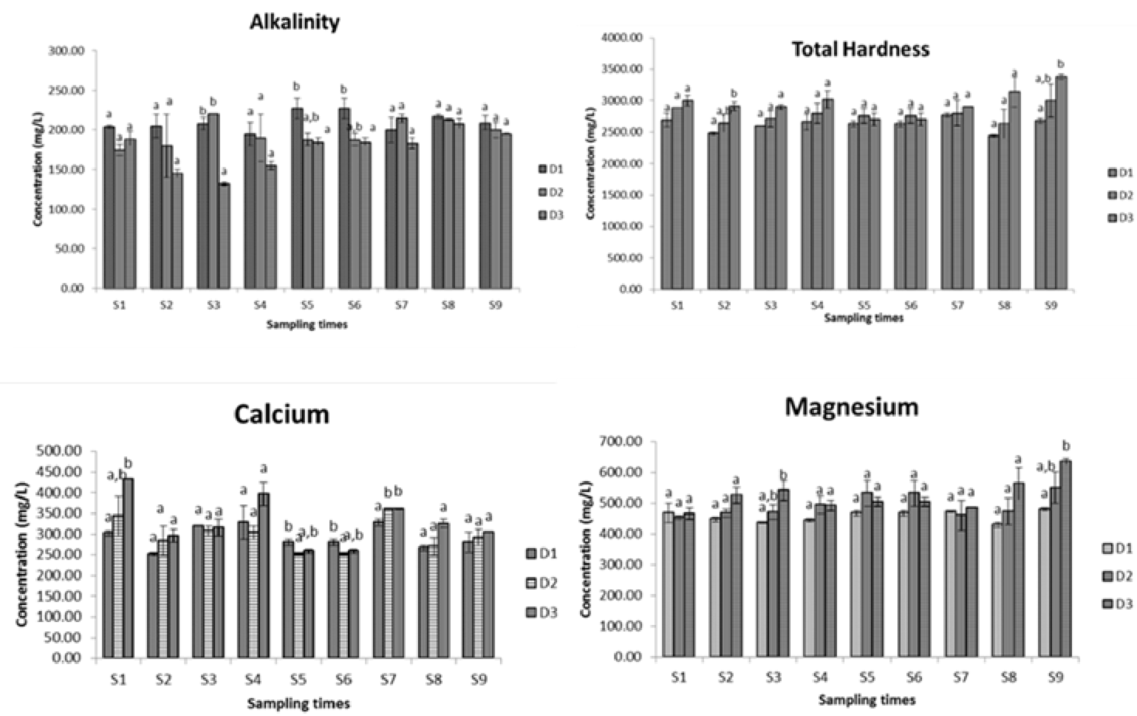


Figure 1: Analaysis of water quality parameters in ponds D1 (60 no./ m^2), D2 (45 no/m^2) and D3 (30 no,/m^2). S1-S9 indicates different sampling points. Different alphabets indicate significant ($p<0.05$) differences between the mean values.

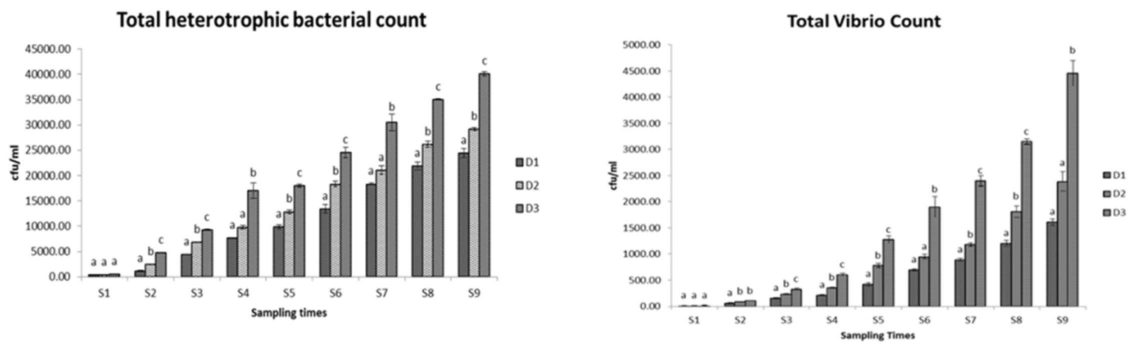


Figure 2: Total *Vibrio* count in different ponds (cfu/mL). D1, D2 and D3 indicates ponds with different stocking densities (D1: Stocking density 60 No/ m^2; D2; Stocking density 45 No/m^2; D3; Stocking density 30 No/m^2; S1-S9 indicates different sampling times. Alphabets indicate significant differences (p<0.05) among different ponds during different sampling times.

No particular pattern in the water quality parameters could be noticed among samples collected from different ponds. Ponds stocked in lower densities (30 no./m^2) showed higher total heterotrophic bacterial and *Vibrio* counts in comparison to ponds with higher densities (45 No/m^2 and 60 no./m^2) .

After trimming			
Sample Name	% Dups	% GC	M Seqs
BSP5HP2_S5_R1_001	5.80%	33%	138
BSP5HP2_S5_R2_001	5.80%	33%	135
BSP_10HP1_S15_R1_001	6.40%	33%	139
BSP_10HP1_S15_R2_001	6.70%	33%	136
BSP_10HP2_S16_R1_001	6.60%	34%	141
BSP_10HP2_S16_R2_001	6.70%	34%	138
BSP_10HP3_S17_R1_001	6.70%	33%	140
BSP_10HP3_S17_R2_001	6.90%	33%	138
BSP_8HP2_S13_R1_001	5.90%	31%	141
BSP_8HP2_S13_R2_001	6.10%	31%	137
BSP_8HP3_S14_R1_001	6.90%	32%	140
BSP_8HP3_S14_R2_001	7.00%	32%	138
PanchamPL1_S1_R1_001	6.10%	33%	140
PanchamPL1_S1_R2_001	6.40%	33%	138

Figure 3. Details of the samples subjected to metagenomic sequencing and the sequences derived

Metagenomic analysis

Metagenome sequence data was derived from 7 samples. Of these, 6 samples were of ISW- reared L*. vannamei* and one was a post-larval sample of *L. vannamei* from brackishwater. The latter sample was included to understand the differences between the gut microbiomes of shrimp reared in two distinct environments. Sequencing was done by Illumina Nextseq 500 PE sequencing method at Bioserve/Reporcell Hyderabad. FastQC quality check was done to eliminate low quality reads. De-novo sequence assembly was done using MEGAHIT genome assembler.

The analysis of metagenome sequences is in progress. Preliminary analysis of BSP_10HP1 revealed that about 50% of 60646 bacterial sequences were Proteobacteria and 20% were Firmicutes. Gamma Proteobacteria, which constituted 30% of the Proteobacteria group, comprised of *Enterobacteriaceae* members such as *Klebsiella*, *Escherichia, Yersinia, Enterobacter, Citrobacter*, *Pantoea*, etc. Other important genera identified include *Pseudomonas*, *Xytella*, *Shewanella*, *Xanthomonas*, *Alteromonas* etc. About 35% of *Vibrio* sequences belonged to *V. parahaemolyticus*. Other species identified were *V. harveyi*, *V. vulnificus*, *V. alginolyticus*, *V. furnissi* etc.

Sequences belonging to diverse virus families were detected in the metagenome. Herpesviridae was predominant. Nimaviridae, a group of viruses to which WSSV belongs, was identified. Phage sequences belonging to myoviridae, siphoviridae etc were also predominantly found. Since phages of several bacterial groups, particularly *Vibrio* spp. belong to these groups, the significance of the simultaneous presence of *Vibrio* spp. and the phages is of particular interest.

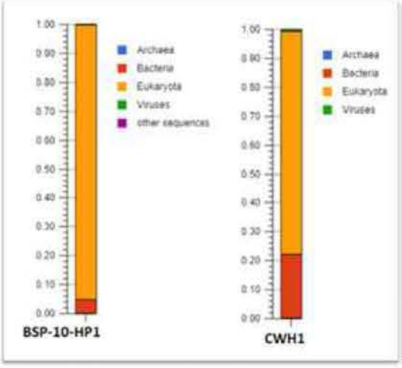


Figure 4 Domain level analysis: Comparison of metagenome sequences generated from shrimp reared in inland saline (IS) and brackishwater (BW): BSP- ISW; CWH-BW

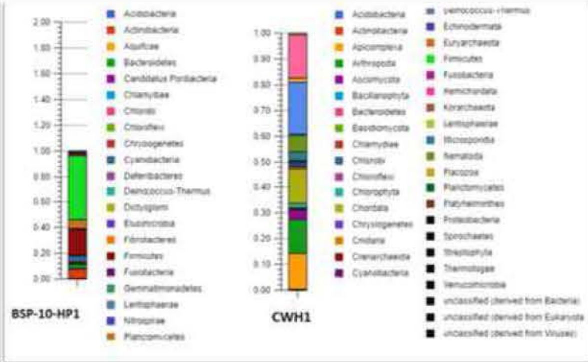


Figure 5 Phylum level analysis: Comparison of metagenome sequences generated from shrimp reared in inland saline (IS) and brackishwater (BW): BSP- ISW; CWH-BW

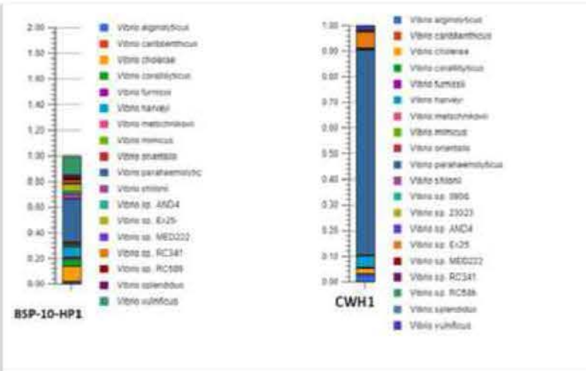


Figure 6 Vibrio diversity: Comparison of metagenome sequences generated from shrimp reared in inland saline (IS) and brackishwater (BW): BSP- ISW; CWH-BW

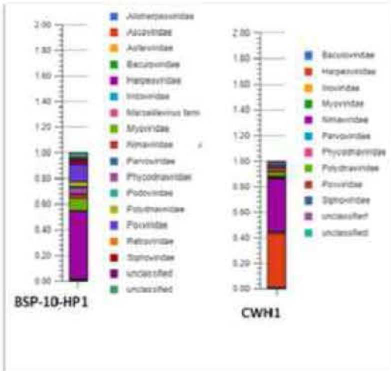
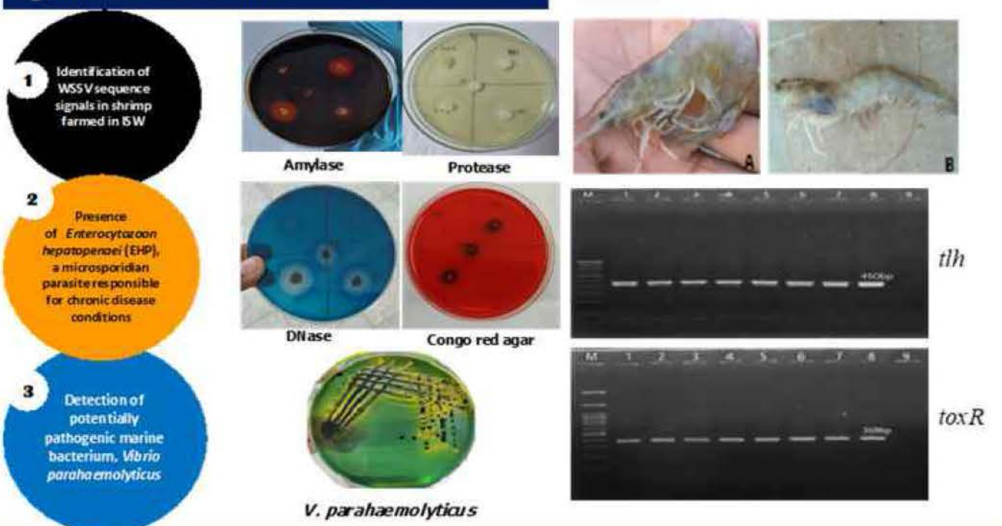


Figure 7 Virus diversity: Comparison of metagenome sequences generated from shrimp reared in inland saline (IS) and brackishwater (BW): BSP- ISW; CWH-BW

Significant Observations



Key Output

- Three key findings from the disease perspective that will help in long-term management of *Penaeus vannamei* in inland saline water

Component 1g.
Genetic Evaluation of Common Carp in Multi-stocks, Multi-inland Saline Environments

Assembling of stocks: Common Carp brooders and seeds were collected from various locations in ten different states i.e; Andhra Pradesh, Odisha, Tamil Nadu, Madhya Pradesh, Punjab and Haryana, Maharashtra, Manipur, Tripura and West Bengal and assembled at different subcentres of ICAR-CIFE i.e; Balabhadrapuram, Powarkheda, Kolkata and Rohtak Centres.

Production of families: A total of 78 full-sib families were produced by adopting single pair mating design and nested mating design.

PIT tagging and rearing: A total of 2200 fish belonging to sixty-two families were PIT tagged and released in two grow-out ponds having two different salinities: a) Less than four ppt salinity (Low Salinity), b) Greater than eight ppt salinity (High Salinity).

Effects of non-genetic and genetic factors on growth: The effect of stock, sex, age, stocking body weight, sire and dam was significant for the final body weight.

Genotype by environment interaction: The ranking of breeding values of families at two salinities indicate significant G x E interaction.

Genetic diversity studies: The genetic diversity was revealed in common carp populations using morphometry and mitochondrial D loop marker.

Heritability estimates

Traits	Overall	HS_Overall	LS_Overall	HS_F	HS_M	LS_F	LS_M
BW	0.39±0.10	0.33±0.13	0.51±0.13	0.28±0.17	0.52±0.21	0.54±0.17	0.47±0.16
SL	0.10±0.05	0.00±0.05	0.57±0.13	0.21±0.16	0.04±0.13	0.68±0.18	0.51±0.16
BD	0.33±0.09	0.18±0.10	0.53±0.13	0.16±0.15	0.24±0.18	0.53±0.17	0.51±0.16

Genetic and Phenotypic correlations

Traits	BW3	SL3	Bd3
BW3	-	0.97±0.02	0.98±0.01
SL3	0.71±0.05	-	0.93±0.04
BD3	0.93±0.01	0.64±0.05	-

Outcome: A base generation for developing salinity tolerant strain of common carp has been formed. Both between and within family variations have been observed for salinity tolerance which may further be used to enhance the performance of common carp in inland saline aquaculture.

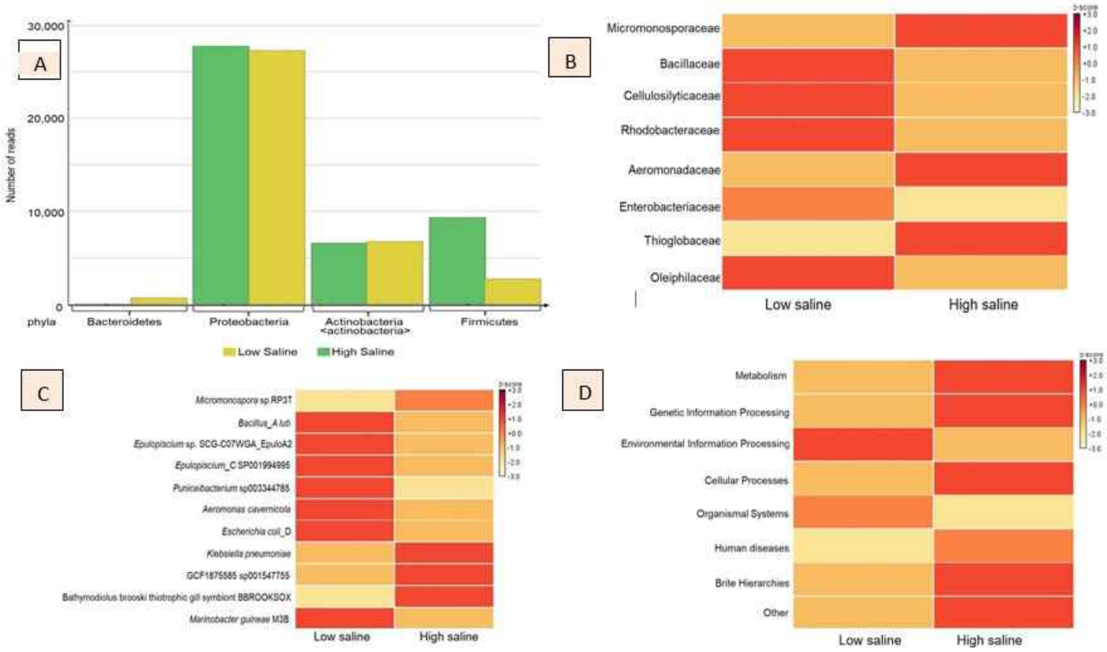
(CIFE/2019/FBT906/SR)

Studies on Gut Microbiome of *Cyprinus carpio* (Linnaeus, 1758) Reared in Different Salinities

Omkar Ingale

Major Advisor: Dr. Gopal Krishna

Common carp (*Cyprinus carpio*) is one of the dominant cyprinid species cultured in over 100 countries. It is known for salinity and cold tolerance owing to which studies have been initiated to propagate this species in Inland saline areas of North India. However,



the rearing of common carp at higher salinities may impact its growth rate. Gut microbiota play an important role in physiological adaptation, balancing the immune response, absorbing nutrients, and maintaining homeostasis in host. In the present study, 12 samples of common carp reared for 10 months in inland saline water at two salinities <4 ppt and >8 ppt were subjected to gut metagenomics analysis. The gut of common carp was divided into three sections viz., foregut, midgut and hindgut. Each of 12 samples belonged to a specific gut region and salinity and were actually pooled from four fish. The sequencing was conducted using Oxford Nanopore technologies. The range for total read length obtained was 176.07 million – 555.47 million base pairs. The N50 values for the sequencing runs ranged between 1945 bp - 7183 bp. The taxonomic and functional binning of sequenced data was performed by DIAMOND+MEGAN pipeline. The taxonomic classification was performed by the GTDB (Genome Taxonomy Database) taxonomy using interval union LCA (Lowest common ancestor) algorithm and the functional classification was performed by KEGG pathways using the best hit approach.

Significant differences in abundance and diversity were observed across gut tissues and salinities. The hind gut of low salinity exhibited the highest alpha diversity. The highest beta diversity was found between the foregut of low saline and hindgut of high saline. Overall, the dominant phyla found was proteobacteria (67.9 percent) followed by actinobacteria (15.72 percent), firmicutes (15.09 percent) and bacteroidetes (1.25 percent). The proteobacteria and actinobacteria were equally represented in both the salinities. However, the phylum firmicutes was three times more abundant in gut belonging to high salinity compared to low salinity. The phylum bacteroidetes was found only in the gut of fish reared in low salinity. The dominant family represented was cellulosilytyceae (35.86%) and thioglobaceae (35.31%) followed by micromonosporaceae (11.80%), Oleiphilaceae (9.81%), rhodobacteraceae (2.54%), Aeromonadaceae (2.54%) and Bacillaceae (1.12%). The family enterobacteriaceae was abundant in hindgut of high saline. The family *Cellulosilyticaceae* and *Micromonosporaceae* were more abundant in the foregut of low saline. The family *Thioglobaceae* was dominant in midgut and hindgut of high saline. The heat map with z scores depicts that *Bacillus luti*, *Epulopiscium*, *Puniceibacterium*, *Aeromonas cavernicola*, *Escherichia coli* and *Marinobacter guineae* were dominant in low saline whereas, *Micromonospora* sp, *Klebsiella pneumonia*, *Bathymodiolus brooski* were dominant in high saline. **This study is the first report on gut microbiota of common carp reared in inland saline water and provides baseline information and clues for nutritional manipulation and modification of the gut microbiota to meet the needs of fish farming in inland saline waters while trying to maintain host health and welfare**.

Studies on Combined Effects of Temperature and Salinity in Common Carp Reared in Inland Saline Water

(CIFE/2019/AQC920/SR)

Bhadade Pranay Dattatray

Major Advisor: Mr. Hari Krishna

Many types of research have been carried out to explore the productivity of inland saline groundwater in salt-affected areas and its potential use for aquaculture purposes. In this regard, an experiment of 45-days duration was carried out at the wet laboratory of ICAR-CIFE, Centre Rohtak, Haryana, in order to investigate the "Combined effects of salinity and temperature in relation to growth and survival of common carp, *Cyprinus carpio* (Linnaeus, 1758) fingerlings reared in inland saline water". In the present study, four different salinities (0 ppt, 4 ppt, 8 ppt, and 12 ppt) and temperature (20°C, 25°C, 30°C) were used to make 12 treatments ($T_0$20, $T_0$25, $T_0$30, $T_4$20, $T_4$25, $T_4$30, $T_8$20, $T_8$25, $T_8$30, T_{12}20, T_{12}25, and T_{12}30) in triplicates. Fingerlings of common carp, initially acclimatized, were stocked @15 no./tank in different treatments. Different physio-chemical parameters of water in the experimental tanks were determined frequently and found to be in the optimal range for the species. The growth performance of the animals was assessed.

The highest specific growth rate, mean percentage body weight gain, lowest FCR, the highest feed efficiency ratio, and protein efficiency ratio could be noticed in T025, and these parameters were significantly changed as the salinity and temperature were increased. Surprisingly 100% survival rate could be noticed in five treatments ($T_0$20, $T_0$25, $T_0$30, $T_4$20, and $T_4$25). The activity of oxidative stress enzymes, including superoxide dismutase and catalase in gills and liver, were evaluated and found to increase with the increase in temperature and salinity. The highest activity of these enzymes could be noticed in T_{12}30. Determination of various haematological parameters indicated significantly higher RBCs, WBCs, and haemoglobin values in higher salinity and temperature treatments. **Thus, the present study suggests that *Cyprinus carpio* fingerlings can be reared in inland saline water with salinity up to 4ppt and temperature up to 25°C.**

Component 1h.
Economically Feasible Technology for Producing Value-Added Fish Products from Fish Grown in ISW

Risk assessment of pathogens in shellfish grown in ISW

The study was conducted on samples (n=45) collected from inland saline aquaculture areas of Haryana, Maharashtra, Punjab, and Rajasthan. The samples included water, sediment, and shellfish (*Litopenaeus vannamei*). Water samples were divided as tubewell/ borewell, pre- stocking pond water, and post stocking pond water according to whether the water samples were collected from groundwater sources or before or after the stocking of shrimp in the ponds. The samples were analyzed for fecal coliforms and pathogenic Vibrio spp according to BAM (2004). Water and sediment samples were negative for fecal coliforms, *V. parahaemolyticus* were detected in samples while, *V. cholerae* was not detected in any sample.

A comparison of mineral content of brackish water reared vannamei (BWRV) and inland saline reared vannamei (ISRV) revealed that mineral content differed significantly. The ISRV contained lower mineral compared to BWRV. BWRV meat had slightly higher (2139.53mg/100 g) contents of all minerals than ISW reared shrimp meat (1979.39 mg/100 g). Significant lower levels of calcium were observed in ISRV. Biochemical analysis comprising of pH, TVBN, TMA and NPN values were significantly higher in ISW shrimp as compared with brackishwater reared shrimp. Fatty acid profiling of ISW grown shrimp meat revealed that the PUFA content of BWR and ISW samples were 41.67% and 46.50%. The contents of EPA and DHA were slightly higher in ISW reared shrimp. Amino acid profile of ISW reared shrimp meat revealed that it comprised 14 amino acids. Arginine, isoleucine, leucine, methionine, threonine, phenylalanine, lysine and valine were slightly higher. The essential amino acids constituted 17.38 g/100g and 16.21 g/100g of total amino acids in BWRV and ISRV respectively.

Refinement of technologies for value addition

Under this key objective, a total of eight value added products were developed which are shrimp patties, coated shrimps, shrimp pickle, wafer, chakli, shev, papad and dehydrated shrimp. The methodology for the preparation of these shrimp product have been standardised. Coated shrimps, developed by using inland saline water shrimp (ISW) had high protein (31.64% w/w) and ash content (1.44%) and low fat (2.51). The storage study of both the coated products was conducted at refrigerated temperature based on biochemical, microbial and sensory analysis. The shelf life of coated products prepared from ISW and BRW shrimp remained acceptable at the end of 21 days of refrigerated storage and 150 days under frozen storage. It was found that ISW grown shrimp were equally suitable for value addition as a breaded tail-on shrimp product which is similar in all characteristics as the brackish water reared shrimps. There is no adverse effect on the overall quality and acceptability of the product.

(CIFE/2019/PHT903/SR)

Meat Quality Assessment of Common Carp (*Cyprinus carpio*) Reared in Inland Saline Water

Dharani M

Major Advisor: Dr. A.k Balange

Soil salinity is one of the serious global issues, posing a threat to profitable agricultural businesses. Inland saline aquaculture is an adaptive solution to this environmental problem. Common carp (*Cyprinus carpio*), which is found in ponds, lakes, and rivers, is one of the best candidate species for inland saline aquaculture as it can withstand moderate fluctuations in salinity and temperature. When fishes are reared in the environment away from their original rearing conditions there is a chance that they will be biologically stressed and lead to changes in their meat quality parameters. Therefore, the study was conducted to assess the meat quality parameters of common carp reared in inland saline water (ISWCC) with those compared with freshwater reared common carp (FWCC).

The protein content was slightly higher in ISWCC than in FWCC. The ash and fat contents were slightly less in ISWCC than in FWCC. Both ISWCC and FWCC meat had excellent sensory scores. There was a reduction in the hardness value found in ISWCC than in FWCC. ISWCC meat had slightly lower contents of all minerals determined than in FWCC meat. Potassium was the dominant mineral in the meat of both ISWCC and FWCC and it was higher in FWCC than ISWCC. Sodium was found higher in ISWCC than in FWCC. The major amino acids in ISWCC were glycine, alanine, glutamic acid, and aspartic acid. Glycine was present in a higher amount in both ISWCC and FWCC. The PUFA content was higher in FWCC than in ISWCC. Among the PUFAs, linoleic was present in a higher amount in both ISWCC and FWCC. EPA and DHA were found at levels of 0.67% and 2.42% from ISWCC. Further, the sausages were prepared from ISWCC mince with the addition of seaweed as an additive. The incorporation of seaweed (*Padina tetrastromatica*) in sausages made from ISWCC mince had an increase in the textural parameters than the control sausages. Therefore, it can be concluded from the present investigation that though there are slight variations in the biochemical composition and nutrient profiling of ISWCC as compared with FWCC, the overall quality and taste of the common carp meat is not significantly affected due to rearing in inland saline water.

Component 4: ICT Based Support System to Develop Inland Saline Aquaculture

Instructional Materials on BMPs for ISA

The illustrated and reader-friendly 'Better Management Practices (BMPs) for *L. vannamei* farming in Inland Salt-affected Areas (ISA): A Field Guide', which was developed during 2019-20, was well received by farmers and extension professionals. Based on feedback and review, it was further revised and the second edition was brought out during 2021. A chapter on the economics of shrimp farming in ISA was also added and the ISBN number obtained for both English and Hindi editions. Bilingual posters and leaflets on various BMPs were prepared and used during the exhibitions and awareness meets conducted during the year. Due to the Covid-19 pandemic, only limited field work could be taken up though. Short video clips on BMPs namely *L. vannamei* farming in ISA, site selection, soil and water quality analysis, seed stocking, and site selection were also made and shared in CIFE's social media and the mobile app mJhinga.

mJhinga Mobile App and Social Media Network

The comprehensive one-stop dynamic bilingual mobile app, mJhinga, custom made and released in 2020 for shrimp farmers in ISA, was updated and a ver. 2.0 was released with additional self-disease diagnostic module, improved pond management module, revised advisories, inclusion of video clips, removal of bugs, etc. Nearly 650 farmers, i.e. more than half the total number of shrimp farmers in ISA benefit from it. On an average 3 queries are addressed a day. Shrimp farmers in coastal states of Andhra Pradesh, Gujarat and Maharashtra also benefit from mJhinga app. A digital repository of activities under NAHEP-CAAST Project (https://kultivatein.wixsite.com/cife) has also been developed. It will also serve as a database for all the information available on Inland Saline Aquaculture.

Social, Economic and Ecological Costs & Benefits Analysis

Baseline survey of 413 farmers on socio-economics, knowledge base and information access in Haryana and Punjab states has revealed significant knowledge gap with regard to shrimp farming technology, though almost all farmers were about salinization and degradation of agricultural land and its effects. There was a palpable social/religious barrier to accept and adopt fish/shrimp farming as an economic activity in parts of rural Haryana, a traditionally non-fish growing and consuming state. This perception, however, is changing

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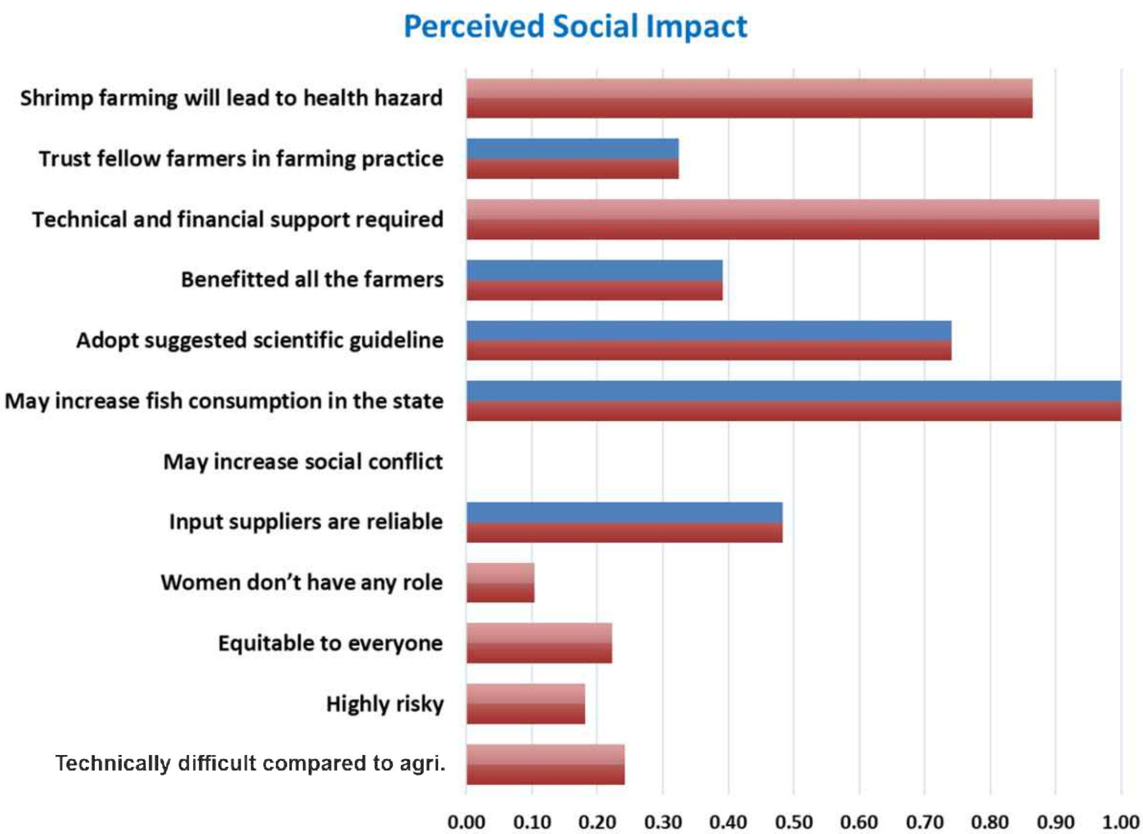
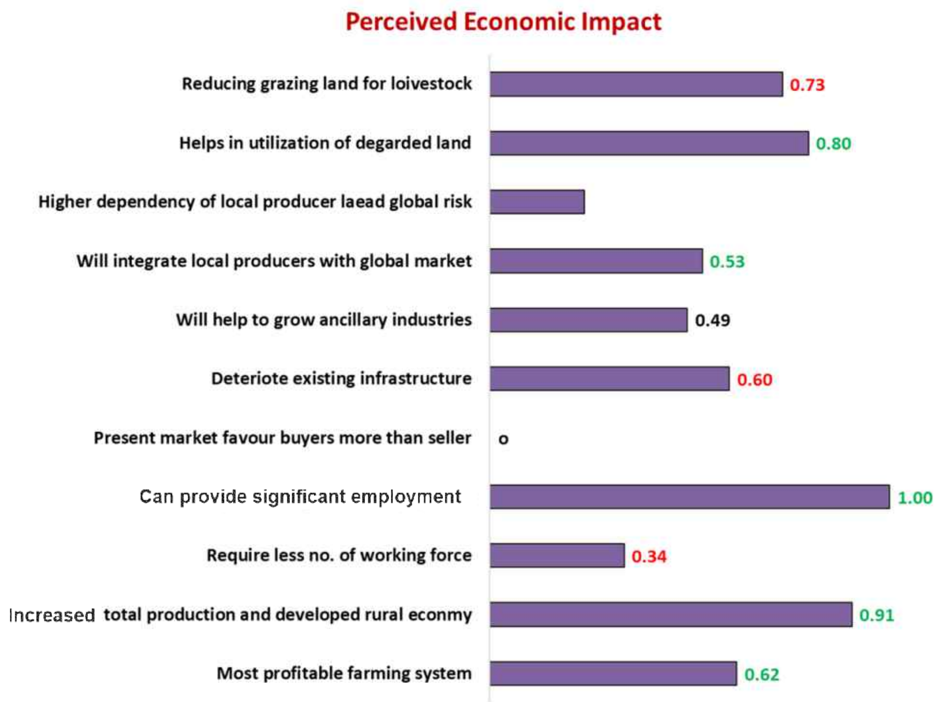




palpable social/religious barrier to accept and adopt fish/shrimp farming as an economic activity in parts of rural Haryana, a traditionally non-fish growing and consuming state. This perception, however, is changing with the success of many farmers in the districts of Rohtak, Hisar, Jhajjar, Sirsa, and Bhiwanni. In Punjab, no such reluctance could be discerned as farmers in Fazilka, Mukstar and Bathinda are increasingly taking to shrimp farming.

The costs and benefits analysis of 63 shrimp farmers and 276 agriculture farmers in Haryana and Punjab revealed interesting results. For example, the farmers in Punjab, whose average land holding was 9.2 acre and had a total of 917 acres of salt affected land with them, had 3 times higher net income (Rs 7,32,156) from shrimp farming compared to income from agricultural crops (Rs.2,37,672) per acre. Shrimp farming had a BCR of 1.6 and a payback period of less than 2 years indicating its economic attractiveness. Fish markets as well as fish consumption was studied in Haryana and Punjab. The average consumption of shrimp in Delhi Gazipur market is around 3 tons/day, with 65-70% coming from Haryana and Punjab farms. Consumers visiting fish markets spent an average of Rs 2523 / month on non-veg food items in Punjab and Rs. 2,029/ month in Haryana, of which 23% and 17% were spent on fish respectively. Perception indices for assessing the social, economic and ecological impacts of ISA have been developed and assessed for Rohtak (Haryana) and Fazilka (Punjab) districts, which indicate an overall positive reception. Ecological concerns such as possible salinization of adjacent lands and discharge of waste water from shrimp farms need to be accounted for in the development strategy.

(B) Research Facility units Establishment

1. Renovation of Molecular Diagnostic Laboratory at ICAR-CIFE, Mumbai
2. Repairing of earthen ponds at ICAR-CIFE, Rohtak Centre
3. Renovation of hostel and office at ICAR-CIFE, Rohtak Centre
4. Repair and renovation of cement tanks and hatchery at ICAR-CIFE, Rohtak Centre
5. Wet Laboratory renovation at ICAR-CIFE, Rohtak Centre
6. SAS and AsREML license for genetic and statistical data analysis
7. RAS facility to carry out indoor experiments related to inland saline aquaculture at ICAR-CIFE, Mumbai

Development of Nursery Based System for Pacific White Shrimp, *Penaeus vannamei*, using Ground Inland Saline Water, and Assessment of Physiological and Immunological Parameters in Single Phase and Two Phase Farming System

(CIFE/2019/101/EF)

Project duration: 2018- 2022

Principal Investigator
Mr. V. Harikrishna

Co-Principal Investigator
Dr. Pankaj Kumar
Dr. Sreedharan K
Mr. Satya Prakash

Budget: Rs.57.0 lakh

Funding Agency:
Department of Biotechnology

Earlier study indicated that nursery stocking of 200/m^2 was better than 400/m^2 and 600/m^2 stocking densities. Therefore, in the current year, 200/m^2 was selected for nursery rearing for the comparative evaluation of single and double phase farming systems. Initially, for single phase farming system, specific pathogen free (SPF) post-larvae of *Penaeus vannamei* (PL10) were simultaneously stocked in 4 nursery rearing ponds (200 No/m^2) and 4 grow out ponds (with two different stocking densities 30 and 45 No/m^2). After 30 days of nursery rearing period, animals from the nursery rearing ponds were shifted to grow out ponds at the stocking density of 30 and 45 No/m^2 in duplicates. The animals from different treatments were harvested after 75 DOC. Regular sampling was performed to check the variability in different water quality parameters and different growth indices. Total heterotrophic bacterial and *Vibrio* count of the water samples were also determined using nutrient agar and TCBS agar, respectively. Expression analysis of different genes, and activity of digestive and antioxidant enzymes were carried out from the tissues collected from different treatments under the single farming system.

Growth parameters, total heterotrophic bacterial and Vibrio count of single-phase farming systems were found to be better in low stocking densities (30 No/m^2). Average body weight, production and survival rate of

animals reared in the double farming system have been found to be less compared to the single phase system. Antioxidant enzymes (superoxide dismutase, catalase and glutathione peroxidase) determined from gill and hepatopancreas were found to be high in T1 (45 No/m^2). All the digestive enzymes were found to be highly activated in animals reared in lowest stocking densities. Expression of selected genes revealed enhanced expression of these genes in the gill of treatment 2, however, no significant differences in the expression could be noticed in the hepatopancreas of both treatment 1 and 2.

Our study suggests that a single phase farming system with a stocking density of 30 No/m2 is the most feasible and optimal.

Table 1: Growth parameters of *Penaeus vannamei* on 75[th] DOC in single phase and double phase rearing systems. T1 and T2 indicate two different stocking densities. i.e., 45 and 30 No/m^2 respectively. Data is presented as Mean ± SE, values with different superscripts in the same column differ significantly (p< 0.05).

Density /Phase	Average length (n=100)	Average body weight (n=100)
T1 (Single phase)	$12.2248 \pm .03^b$	15.2652 ± 0.14^b
T2 (Single phase)	$13.8665 \pm .05^a$	$21.1900 \pm .20^a$
T1 (Double phase)	$11.7928 \pm .041^a$	$14.2117 \pm .14^a$
T2 (Double phase)	$12.4004 \pm .04^b$	$15.3708 \pm .16^b$

Table 2: Total production, FCR and survival rate of *Penaeus vannamei* on 75[th] DOC in single phase and double phase rearing systems. T1 and T2 indicate two different stocking densities. i.e., 45 and 30 No/m^2 respectively.

Density /Phase	Pond code	FCR	Total production (Kg/0.1 ha)	Survival rate (%)
T1 (Single phase)	BSP7	1.27	640.00	91.59
	BSP8	1.32	610.00	90.88
T2 (Single phase)	BSP9	1.12	600.00	93.93
	BSP10	1.15	580.00	91.92
T1 (Double phase)	BSP18	1.53	520.00	82.02
	BSP16	1.43	545.00	85.23
T2 (Double phase)	BSP11	1.32	350.00	84.54
	BSP1	1.56	435.00	85.79

(CIFE/2019/AQC901/SR)

Performance Evaluation of *Penaeus vannamei* (Boone, 1931) Reared at Varying Stocking Densities in Inland Saline Water

Adya Pandey

Major Advisor: Mr. Hari Krishna

The standardized technology for ISW-based *P. vannamei* culture includes ameliorating the culture water with K^+ ion supplementation and amending Ca^{++}/Mg^{++} ratio to 1:2–3, so as to simulate the natural seawater (NSW) equivalence, and replicating the *P. vannamei* NSW-culture parameters in the ISW system. However, for sustained growth and enhanced profitability, there was a need for formulation of ISW specific culture parameters. In view of this, the present study was undertaken wherein, PL8 of *P. vannamei* were experimentally reared in ISW ponds with 3 different stocking densities viz., n=30/m^2 (T1); n=45/m^2 (T2); and n=60/m^2 (T3), for a period of 75 days followed by evaluation of various parameters related to growth, stress and immune system.

From the study, it was revealed that, at lower stocking density, the shrimp showed highest growth in terms of both weight (21.17 g) and length (13.86 cm); highest survival percent (92.93%) and specific growth rate (SGR) of 7.28 and least FCR quotient of 1.14. In addition, it was observed that the net profit (in Rs. /Kg shrimp), in the T1, T2, and T3 groups were 108, 58 and 21, respectively, thereby indicating that in case of ISW system, the profitability reduces drastically (> 5 times in profit margin) at higher density due to lower growth performance. In terms of enzymatic parameters, the highest stocked group displayed significant ($p < 0.05$) increase in the activities of antioxidant enzymes (SOD, CAT, GPx), and decrease in the activities of digestive (protease, amylase, lipase) and metabolic (G6PDH) enzymes. Further, the results regarding haemato-biochemical indices such as lower haemocyte count, haemocyanin concentration, serum protein and triglyceride levels and higher serum glucose and MDA level as well as significant ($p < 0.05$) upregulation of stress related, HSP70 and SOD genes and downregulation of growth related IGFBP gene in the T3 group with respect to T1 group, substantiate the negative impact of crowding density on overall health status of the cultured shrimp. **In conclusion, the present work ascertained the optimum stocking density (n=30/m^2) of *P. vannamei* in ISW ponds for getting higher productivity, disease resistance capacity and better economic returns for such cultivation.** Thus, it can be inferred that wise choice of stocking density can prolong the sustainability and profitability of the system and make it truly an economically efficient aqua venture for the aspiring farmers.

3.2.

Aquaculture Diversification

Effect of Nutrients Supplementation on Selected Vegetables and Herbs in Recirculating Aquaponic System with Pangasius (*Pangasianodon hypophthalmus*)

(CIFE/2019/7/IF)

Project duration: 2019-2022

Principal Investigator
Dr. A.K. Verma

Co-Principal Investigators
Dr. Vidya Shree Bharti
Dr. Tincy Varghese
Dr. Madhuri Pathak

Technical Associate
Dr. Chandrakant M.H.

A 60-day experimental trial was conducted to investigate the effect of different dosages of potassium supplementation on *Pangasianodon hypophthalmus* and *Spinacia oleracea* L. in an aquaponic system. Considering the water quality parameters, fish growth, physiological response, spinach yield, and nutrient content; 150 mg/l potassium could be recommended as optimum potassium dosage for *Pangasianodon hypophthalmus-Spinacia oleracea* L. aquaponic system. Another experiment was aimed at optimizing the component ratio on the growth of *Pangasianodon hypophthalmus* (Sauvage, 1878) and *Ocimum basilium* in an aquaponic system. The *P. hypophthalmus* was stocked at the rate of 2.50 kg/m^3 (control without plants) and at the rate of 2.50 kg/m^3, 2.75 kg/m^3, 3.00 kg/m^3 and 3.25 kg/m^3 respectively in consecutive treatments with Basil at the rate of 12 plants in NFT. The third experiment under this project was done with four different iron dosages of 1.0 mg/l (T1), 1.5 mg/l (T2), 2.0 mg/l (T3), and 2.5 mg/l (T4) were compared with control C (0 mg/l) to determine the most efficient iron dosage for *P. hypophthalmus*-spinach aquaponic system. The system consisted of a 168 l rectangular fish tank (0.78×0.54×0.40 m) with 100 l water volume stocked with *P. hypophthalmus* at 2.8 kg/m^3 and NFT hydroponics with 24 spinach in 12 cups. The experimental data analysis for various water quality parameters *viz.*, dissolved oxygen [DO], alkalinity, hardness, total ammoniacal nitrogen [TAN], nitrite-nitrogen, nitrate-nitrogen, etc. and mineral profile of water (potassium, sodium, calcium, etc.) are being performed weekly; and fish and plant growth are being recorded fortnightly.

(CIFE/2019/AQC913/SR)

Effect of Potassium Supplementation on Growth Performance of *Pangasianodon hypophthalmus* (Sauvage, 1878) and *Spinacia oleracea L*. in Aquaponic System

Venisza Cathy John

Major Advisor: Dr. Ajit Kumar Verma

A 60-day experimental trial was conducted to investigate the effect of different dosages of potassium supplementation on *Pangasianodon hypophthalmus* and *Spinacia oleracea L.* in an aquaponic system. The experiment followed a completely randomized design (CRD). The system consisted of a 168 L rectangular fish tank (0.78×0.54×0.40 m) with 100 L water volume stocked with *P. hypophthalmus* at 2.8 kg m^{-3} and NFT hydroponics with spinach at 28 plants m^{-2}. Four different potassium dosages of 90 mgl^{-1} (T1), 120 mg l^{-1} (T2), 150 mg l^{-1} (T3), and 180 mg l^{-1} (T4) were compared with control C (0 mg l^{-1}) to determine the most efficient potassium dosage for *P. hypophthalmus*-spinach aquaponic system. The physico-chemical parameters and nutrient dynamics in water were within the permissible range for the aquaponic system with no marked variation between the control and treatments except for potassium concentration which was found to vary in response to the increased level of supplementation. The spinach was harvested twice.

The first harvest before potassium supplementation showed no significant difference ($p > 0.05$). In the second harvest, the increased potassium supplementation had a significant ($p < 0.05$) effect on the growth and yield of spinach with the highest yield obtained in T4 (280.07±2.26 g) followed by T3 (277.57±3.02 g), T2 (265.07±4.61 g), T1 (256.80±4.79 g), and C (217.83±4.20 g). No significant difference ($p > 0.05$) was observed in yield of T4 and T3 and of T2 and T1. The mean body weight of fish at harvest showed no significant ($p > 0.05$) difference between the control and treatments and followed the order: C (33.23±0.52 g)>T1 (33.07±0.45 g)>T2 (32.94±0.40 g)>T3 (32.20±0.37 g)>T4 (32.15±0.35 g). The plant analysis revealed that potassium supplementation triggered the nutrient synergism resulting in higher nitrogen, potassium, phosphorus, iron, and sulphur content in T4 followed by T3, T2, T1, and C. The physiological and osmoregulatory response of *P. hypophthalmus* in treatments was comparable with control except for a higher superoxide dismutase (SOD) activity and plasma glucose in T4. Considering the water quality parameters, fish growth, physiological response, spinach yield, and nutrient content, 150 mg l^{-1} K^{+} (T3) could be recommended as optimum potassium dosage for *Pangasianodon hypophthalmus-Spinacia oleracea L*. aquaponic system.

Development of a Multi-species Brackishwater Fish Culture Model

(CIFE/2019/9/IF)

Project duration: 2019-2022

Principal Investigator
Dr. Muralidhar P. Ande

Co-Principal Investigators
Dr. K.V. Rajendran
Dr. Karthireddy Syamala

Technical Associates
Dr. P. Srinivasa Rao
Mr. R.R.S. Patnaik

Progress:

Multi-species brackishwater aquaculture model project was done at brackishwater fish farm, Kakinada. The experiment was carried out in two experimental ponds of 0.25 acre each (1000 m2).

The experimental model of the project consisted of species Grey mullet, *Mugil cephalus*, mud crab, *Scylla serrata* and seabass, *Lates calcarifer*. The standard stocking density followed was grey mullet 2500 no.s/ ha; seabass- 1250 nos/ha and mud crab- 500 nos/ha. The duration of culture of grey mullet was 6 months. The culture duration of crabs was 5 months and two crops of mud crab were cultured in each model. The culture duration of seabass is 5-6 months. The stocking density of fishes in the pond is mullet- 250 nos and seabass- 125 nos. The culture of mud crabs was carried-out in individual floating boxes. A total number of 50 boxes were installed in each experimental pond.

Two different types of feeds were given to the grey mullet during the experimental period i.e., DORB and floating pellet feed (30% CP). The mullet fingerlings with average bodyweight of 39 g were stocked in both experimental ponds. Feeding was given twice daily @ 4% body weight. *M. cephalus* was fed with floating feed attained a weight of 287 g at the end of the 5 months in the ponds and treatment fed with DORB attained 168 g in 5 months culture duration.

The first crop of mud crabs were stocked with crabs of initial weight 72 g and attained a weight of 140 g at the end of the 5 months culture. The mud crabs were fed with chopped fresh fish mixed with 5% vitamin mineral premix. Crabs were fed one time with feeding rates of 10% (1st month); 8% (2nd month); 6% (3rd month), 4% (4th month) and 3% (5th month onwards). The crab boxes were monitored daily to record the moulting of the crabs. The crab boxes were cleaned regularly to remove fouling and uneaten feed.

L. calcarifer fingerlings of 1-2.0 inches (19.5 g) were stocked in the experimental ponds. *L. calcarifer* fish attained a weight of 651.4 g at the end of 7 months culture duration. Live tilapia was used as feed for seabass. Tilapia were stocked two months before stocking the seabass in a ratio of 30:1. Seabass showed a survival of 81% in co-culture with tilapia.

ICAR-Network Project on Precision Agriculture (NePPA)

(CIFE/2019/200/EF)

Project duration: 2021-2026

Principal Investigator
Dr. Ashutosh D. Deo

Co-Principal Investigators
Dr. B.B. Nayak, Dr. K. K. Krishnani, Dr. A.K. Verma, Dr. Vinod Kumar Yadav, Dr Vidyashree Bharti, Dr. Karan Kumar K. Ramteke, Dr. Layana P., Dr. Manish Jayant and Dr Arun Sharma

Budget: Rs. 5.26cr

Funding Agency
ICAR, New Delhi

Lead institute
IARI, New Delhi

The NePPA project is aiming to establish AI assisted intense aquaculture systems, decision support systems for environment assessment and health management in aquaculture and sensor based devices for fish quality assessment. The project was launched on 6th September 2021 and the research work has just been initiated.

Establishment of Amur Common Carp / Jayanti Rohu Hatchery and Seed Production Unit for Quality Fish Seed Dissemination

(CIFE/2019/12/IF)

Project duration : 2018-2021

Principal Investigator
Dr. Sunil Kumar Nayak

Co-Principal Investigators
Mr. Dhalongsaih Reang
Dr. Madhuri Pathak

Budget: Rs. 25 lakh

Funding Agency
NFDB, Hyderabad

Circular eco hatchery was completed with one Breeding pool, two incubation pools and a spawn collection chamber. Procured 14000 numbers of Amur common carp fingerlings from NFFBB, Bhubaneswar. Reared at ICAR-CIFE Powarkheda with biosecurity measures. Broodstock management is on going. Regular sampling and feeding was going. Brood stock will be ready for next breeding season.

Development of Package of Practice for *Anabas testudineus* in Eastern Region of India

(CIFE/2019/10/IF)

Project duration: 2021-23

Principal Investigator
Dr. G. H. Pailan

Co-Principal Investigators
Dr. B.K. Mahapatra, Dr. S. Munilkumar, Dr. S. Dasgupta, Dr. S. Sahoo, Dr. Md. Aklakur and Mr. D.K. Singh

Effect of feeding frequency on fingerlings performances

Climbing perch, *Anabas testudineus* has good market demand as a high value species in Eastern India. Standardized hatchery technology of this species has been popularized among seed producers. The hatchery produced fry are further reared in the indoor system to produce fingerlings suitable for stocking in the grow-out system. During indoor rearing, *A. testudineus* fry mainly subsists on external feed supply. Among different feed management protocols proven to maximize the benefit of feeding, feeding frequency and ration size play an important role in regulating the feed intake, growth and waste outputs of fish. Optimizing feeding frequency may minimize feed wastage, leading to

improvement in culture environment and reduction in size heterogeneity. *A. testudineus* fry (mean weight: 2.1±0.2 g) were stocked in tanks (100 L) at a stocking density of 120 no/ m^3. The fry were fed with a formulated diet (CP 32%) at 6% of biomass per day for the first 10 days, followed by 5% and 4% for the next 10 and 40 days, respectively. Keeping the daily ration identical, differential feeding frequencies were taken as the test variable. Feeding frequencies of one (FF1), two (FF2), three (FF3) and four (FF4) times per day were the four treatments with triplicate tanks for each treatment.

After 60 days, fingerlings attained significantly higher body weight of 7.99 ± 1.61 g at FF3 compared to other groups ($P<0.05$). Although survival did not differ among treatments, higher survival was obtained in FF2 and FF4 treatments ($P>0.05$). Feed conversion ratio was significantly the lowest at FF3 and FF4 ($P<0.05$). Similarly, whole body composition of harvested fingerlings revealed no variation in parameters among treatments. As feed is the single most significant cost involved, it is emphasized to carry out farming with its maximum conversion into fish growth in a cost-effective management approach. Considering this fact, this study suggested that in indoor tank rearing, *A. testudineus* fingerlings can achieve maximum growth, survival and better feed conversion when they are fed a diet containing 32% crude protein with three times feeding daily. The findings of this study have practical importance as a major step for standardising *A. testudineus* indoor seed production practices, that would benefit the seed producers.

Photo thermal effects on gonad maturation

An experiment was carried out to evaluate the photo-thermal effects on the gonad maturation and spawning in Anabas. The Anabas brood fish was stocked in three circular FRP tanks of 1000 L at a density of 4 fish/L and 16.5 g fish/L. The fish was maintained in two photoperiod regimes, i.e., mid to long photoperiod (T1 and T2, fixed 12-14 h) and ambient photoperiod of (Control, 10.6-12.5 h/day). The T2 tank was provided with thermostat regulated heater to maintain a constant average temperature of 26.0 ± 1.5 °C throughout the experimental period, whereas the T1 and control tanks were maintained at ambient temperature ranged from 20-28°C. All the tanks were provided with constant aeration. The fish were fed with feed containing 32% Protein. 20% water was exchanged every day in all the tanks. The fishes were examined for their gonad maturity fortnightly.

The gonad maturation was highest in the fish under T2. In the month of March the optimum gonad maturity was observed in some fishes and those fishes were induced with commercial inducing agents at dosages of 0.5 ml/kg in females and 0.25 ml/kg for males. The spawning responses were 100% in control and T2, whereas, it was 50% in T1. The spawning fecundity varied significantly among the treatments and control. The spawning fecundity was highest in T2 followed by T1 and control. The fertilization rate was between 40 and 70%, whereas the hatching rate ranged between 52 and 80 %. The fertilization and hatching rate were highest in control followed by the T2 and T1 and the spawn recovery was highest in T2 and lowest in T1. The results clearly showed that photoperiod in combination with higher temperature above the ambient advances the gonad maturation in Anabas as reported in many teleosts. This is probably the first report of captive spawning in Anabas in March in Eastern India.

In continuation to the earlier experiment on the effect of photo thermal effects on gonad maturation and spawning the experiment was extended April onwards. In April, 1 female from control and treatments (T1 and T2) spawned completely in response to Gonopro-FH injection. The fertilization rate was in the range of 70-85%, spawn recovery was better in T1 and control compared to T2. In August, 3 females attained gonadal maturity for the second time. All females spawned successfully and the fertilization rate was 68%. The spawn recovery was 75%.

Evaluating Environmental Effects on Pearl Formation in *Lamellidens marginalis* Reared in Indoor Conditions

(CIFE/2021/10/IF)

Project duration: 2021-2024

Principal Investigator
Ms. Sweta Pradhan

Co-Principal Investigators
Dr. Suman Manna
Dr. S. Dasgupta
Dr. S. Munilkumar
Dr. G.H. Pailan

Freshwater mussel species *Lamellidens marginalis* were collected from the local fishers and also purchased from local fish market Barrackpore, Kolkata @ Rs.5 per piece.

Acclimatization at indoor conditions

The collected mussels were kept for acclimatization in indoor conditions at wet laboratory facilities. The mussels were kept in aerated condition. Initially Chlorella and mixed algae were given as feed. During the period the survivability of the mussels were recorded as 70%.

Preparation of nucleus for implantation

The standard procedure was used for preparation of nucleus. The designer moulds/die were purchased for nuclear beads preparation. The materials used were Acrylic material (Rapid Repair-Self Cure Denture Base Material are used. The size of the nucleus 1-1.5cm. Heart shaped designer nucleus were used for the experiment.

Nuclear beads and materials needed for nucleus preparation

Mantle cavity method of implantation is done with speculum and round handle spatula. During the process a nuclear bead (nucleus) is inserted into the mantle cavity of the mussel. The mussels were implanted on both sides of the mantle cavity. The size of the mussels used for implantation were 40-50g and 7-10cm in weight and length respectively.

Experimentation on the effect of pH on implanted mussels

Here the mussels were kept in triplicate under 3 pH treatment as i.e. ambient pH (7-7.4) lower pH (6-6.5) and Higher pH (8-8.5). The initial water quality parameters were recorded. Regular growth and survival of the mussel were recorded. The initial sample and sample at regular intervals were kept for further analysis.

Captive Breeding of hilsa, *Tenualosa ilisha*:Phase II

(CIFE/2021/201/EF)

Project duration: 2021-2024

Principal Investigators
Dr. Subrata Dasgupta

Co-Principal Investigators
Dr. Gayatri Tripathi
Dr. Mujahid Khan Pathan

Budget
69.91 lakh

Funding Agency
NASF, ICAR, New Delhi

The hilsa shad (known as Indian shad), *Tenualosa ilisha*, is the largest clupeid that provides important fisheries contributing a global average annual catch of 2.8 million tons. Availability of hilsa seed on a mass scale is a significant bottleneck in developing aquaculture practices of this precious migratory fish of high demand and price. Currently, fishes kept in freshwater and brackish water ponds do not complete gonad growth and maturation. Female fish attained stage IV ovary, while males showed development and release of milt. However, the percentage of maturation was low, and the maturation of both sexes was not synchronised to facilitate spawning. Therefore, hypothetically, intervention in terms of rearing environment, nutrition and hormonal manipulation are essential to eliminate the causes of failure in attaining optimum gonad stages suitable for hormonal intervention in captive hilsa. In addition, the development of the most potent hormonal preparation and its delivery system will ensure acceleration of final gonad maturation and spawning in the hilsa reared in captive conditions.

Estimation of reproductive hormones and morphological examination of eggs is crucial for assessing the gonad development and selection of broods for carrying out the process of induced spawning. Naturally, it requires the handling of fish several times and for a variable duration. As hilsa is very susceptible to any stress, including handling and operational stresses, it is necessary to develop non-invasive techniques for determining gonad growth and sex of fish. In addition, creating a suitable fish anaesthetic device for hilsa and proper anaesthesia technique will help conduct any operation essential for induced spawning. Different anaesthetic drugs are being used in fish. The dosages of various agents vary depending on the tolerance of species.

Moreover, the mode of delivery also influences the effects of anaesthetic drugs. Depending on the purpose of anaesthesia, dosages and delivery systems need to be standardised for the different life cycle of hilsa, particularly adults. Proper assessment of gonad maturity is one of the critical activities of success in manipulating reproductive performance in fish. Biomarkers predict the accurate time of the physiological events related to reproduction and facilitate optimum therapy for intervening judicially. The non-invasive procedure is a conservative diagnostic or therapeutic approach, which does not require an incision into the body or tissue removal. Based on the available literature, ultrasound imaging of gonad is a non-invasive method to determine sex and to assess the stage of gonad correctly, particularly in females. Such evaluation ensures the right choice of ripe fish for manipulating the process of maturation. Moreover, as a part of the hormonal intervention, it is essential to administer suitable hormonal preparation either through injection or a specific delivery system. The present study was carried out to develop the most appropriate anaesthetic device and method for hilsa to avoid handling stress. Initially the anaesthetic device was standardised for three anaesthesia drugs, such as Eugenol, MS 222 and 2-phenoxyethanol. The experiments were conducted on tilapia in the laboratory. Based on that experiments were carried out on adult hilsa on-boat. In addition, a preliminary experiment was conducted on ultrasound imaging of gonads in hilsa using a high end probe. Brain and pituitary glands were collected from live hilsa and the tissues were processed for isolation of RNA and for evaluating amplification of cDNA encoding partial FSH gene of hilsa.

Significant Achievements

- Analysis of oxidative stress enzymes showed a 2 fold increase in superoxide dismutase and catalase levels in muscle, liver and gills due to handling stress.
- First report on assessment of gonadal maturity in hilsa through ultrasonography.

Network Project on Ornamental Fish Breeding and Culture

(CIFE/2021/202/EF)

Project duration: 2021-2024

Principal Investigator
Dr. Paramita Banerjee Sawant

Co-Principal Investigators
Dr. N.K. Chadha
Dr. B.K. Mahapatra
Dr. Gayatri Tripathi
Dr. Gouranga Biswas

Budget
160.2 lakhs

Funding Agency
ICAR, New Delhi

The project is operational at Mumbai headquarters of ICAR-CIFE and its Kolkata centre. Seven species of indigenous ornamental fishes (three at Mumbai headquarters and four at Kolkata centre) selected for developing package of practices for their captive maturation and breeding along with closing of their life cycles. Broodstock of three species native to the Western Ghats {zebra loach (*Botia striata*), striped Panchax/yellow panchax/malabar killi or golden wonder killifish (*Aplocheilus lineatus*) and jerdon's carp (*Puntius jerdoni*)} developed and being maintained at Mumbai and broodstock of four species native to the north eastern hill regions (NEH) {green rocket shrimp (*Caridina hodgarti*), glassy perchlet (*Parambassis lala*), scarlet/red badis (*Dario dario/Badis bengalensis*) and high fin barb (*Oreichthys crenucoides*)} being maintained at Kolkata.

According to the IUCN, the zebra loach (*Botia striata*) and jerdon's carp (*Hyselobarbus jerdoni*) are currently endangered due to habitat alteration combined with a small native range. In case of loaches, environmental factors play an important role in maturation and breeding. Therefore, experimental trials on habitat mimicking and manipulations in abiotic (specific environmental) parameters being optimized and standardized in a lotic environment in a

pilot scale study for synchronizing sexual maturation and induce natural spawning in Botia striata at Mumbai. Even through sexual dimorphism is not pronounced in loach, males do acquire a brighter colour with prominent transverse yellow and black stripes running through the entire body and the curvature of the caudal fin was evident in many maturing adults. Breakthrough achieved for the first time in captive breeding of *Aplocheilus lineatus*, at Mumbai using artificial substrate. 80% hatching success led to fertilized eggs being reared (F1 generation) for attaining sexual maturity. Rest of the stock is being prepared for a second trial of breeding using a variety of suitable substrates.

Dietary manipulations using a synergistic combination of live (copepod based) and formulated on-farm feed have yielded robust broodstock of jerdon's carp (*Puntius jerdoni*). Among the broodstock of the four species developed at Kolkata centre, breakthrough achieved in breeding of the green rocket shrimp (*Caridina hodgarti)* for the first time at Kolkata and trials for a second round of breeding are promising. Captive maturation of the scarlet/red badis (*Dario dario*), in size range of 14.6-26.9 mm has been achieved by mimicked semi-natural habitat (sandy bottom with gravel and stones along with ornamental plantation). Morphological studies revealed a slightly compressed and moderately elongated body of D. dario. Fin formula recorded was D. XII-XIV, 5-6; P. 8-9; A. III, 4-6; V. 6; C 13-14 and length weight relationship of the fish calculated as Log W= -2.030+3.641L (r^2=0.86). A 'b' value >'3' indicated positive allometric growth. A condition factor of 0.56 indicates well-being of the fish in captivity. The relative gut length (RGL) value increased with increase of total body length. The average gastrosomatic index (GaSI) was 4.76±1.27. Sexual dimorphism was well defined with adult males displaying 7 prominent vertical bars on flanks continuous till the fins. Outlines of fins generally were observed to be white with bluish-white colour on ventral fins. Females were unattractive. The baseline database developed till date for the above selected native /indigenous ornamental fishes are the first reports.

(CIFE/2015/AQC507/SR)

Studies on the Optimization of Stocking Density and Feeding Ration for Rearing of Stunted *Labeo rohita* (Hamilton, 1822) fingerlings Reared in Cages

Vinod Kumar Paswan

Major Advisor: Dr. Kiran Dube Rawat

A study was conducted to evaluate the effect of stocking density and feeding ration on stunted *Labeo rohita* (Hamilton, 1822) fingerlings using cages at Dimbhe Reservoir, Pune, Maharashtra. Stunted fingerling of rohu (14.65 ± 0.30 cm/ 38.23 ± 1.90 g) were stocked and reared for 330 days in cages (3 m × 3 m × 3 m size) at different stocking densities (10, 15, 20 and 25 fish/m^3) and fed with different feeding ration (3%, 4%, 5% and 6% of body weight). Fish fed twice a day with commercial floating pellets (CP 24%). The study followed a 4*4 factorial design and each treatment and level were triplicated. The study found a reduction in final mean body weight, weight gain, and specific growth rate with increasing stocking density and decreasing feeding ration. Significantly highest body weight (732.64±1.31g), weight gain (694.30±1.08g) and SGR (0.89±0.001%/day) were recorded in stocking density10/m^3. Similarly, fish fed with a feeding ration of 6% body weight displayed significantly higher growth performance. However, the interaction effect (SD*FR) revealed that fish reared in 10*6 and 10*5 group displayed similar growth performance, in terms of body weight, and SGR. Interestingly, the study found better feed utilization, in terms of lower FCR (1.71±0.18) and higher FER (0.58±0.006), in the group of 10*5. Highest survival (100%) was observed in low stocking density (10 fish/m^3) groups fed with different feeding rations. Highest Hb (11.20 ± 0.11 g/dl, 11.23 ± 0.08 g/dl), RBC (2.73 ± 0.01 ×10^6 $cumm^{-1}$, 2.83± 0.023 ×10^6 $cumm^{-1}$) and PCV (45.40± 0.20%, 45.76± 0.16%) values were recorded in 10*5 and 10*6 groups. In contrast, significantly higher glucose (97.41±2.54 mg/dl, 95.17±2.17 mg/dl), cortisol (87.30±1.02 ng/ml, and lactate dehydrogenase (25.09±0.85 U/mg, (23.27±0.76 U/mg), were observed in 25*3 & 25*4 groups. Histological examination showed structural changes such as widening of the primary lamellae, bleb and club formation at the tip of the secondary lamellae, upliftment of epithelial layer, intracellular vacuolation, dilated sinusoids, necrosis of pancreatic acinar cells, hemorrhage of parenchyma, pyknotic nuclei in gills and liver of lower stocking densities (10 and 15 nos/m^3). In contrast, in higher stocking density groups (20 and 25 nos/m^3) there was greater damage in gills and liver. Overall, the study suggests that rearing of stunted rohu results in lower stocking density (10 nos./m^3) with optimal feeding (5%) could be an economically viable alternative option for cage culture in Indian reservoirs.

(CIFE/2019/AQC903/SR)

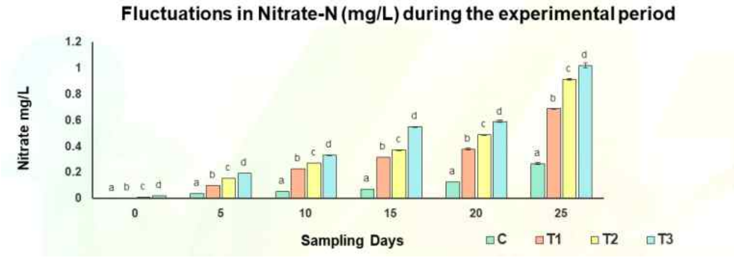
Growth Performance of GIFT Tilapia in Trickling Biofilter Based RAS using Zeolite as Biofilter Media

Amit Jadhav

Major Advisor: Dr. Chandrakant M.H.

A 25-day experiment was conducted at the wet laboratory of ICAR-Central Institute of Fisheries Education, Mumbai to evaluate the growth performance of GIFT Tilapia reared under different stocking densities in a trickling biofilter based recirculating aquaculture system (RAS) in which natural zeolite balls were used as biofilter media. A trickling biofilter was designed and fabricated using 0.20 m dia. PVC pipe, which acted as biofilter chamber. The natural zeolite balls were filled inside the PVC pipe for development of biofilm for the growth of nitrifiers. The volume of biofilter media (i.e. natural zeolite balls) was 0.018 m^3, which was equivalent to 6% of the water volume (300 L) in the tank. The overall height of the biofilter chamber was 0.64 m and height of biofilter media was 0.57 m, and the remaining portion (0.07 m) was used as a free-board. The submersible pump was placed in the fish rearing tank and was covered with nylon screen to prevent the entry of culture species. Water from the submersible pump raised vertically; and through the shower, the water trickled down the biofilter media contained in the biofilter chamber; and finally, through the perforations of the bottom plate, water returned to the rearing tank. The biofilter chamber was mounted on the fish rearing FRP tanks with the support of mild steel stands fitted on the collar of the FRP tank.

The experiment consisted of three treatments and a control with each treatment having triplicates following a completely randomized design. The control did not have biofilter and water recirculation facility. Three trials of GIFT tilapia fry (0.82-0.85 g) under three stocking densities, *viz.*, 30 (100/m^3), 40 (133/m^3), 50 (167/ m^3) per tank (300-liter water) were assigned as treatments. The control had a stocking density of 30 (100/m^3). Fish were supplied with floating feed, and the feed was given @ 10% of body weight for the initial



15 days and @ 8% of body weight for the remaining period. The water quality parameters like temperature, dissolved oxygen, pH, total ammonical nitrogen, nitrite-N, nitrate-N, phosphate, hardness, alkalinity etc. were analyzed at regular intervals. Various growth parameters *viz.*, weight gain (WG), percent weight gain (PWG), specific growth rate (SGR), protein efficiency ratio (PER), feed conversion ratio (FCR) were calculated at the end of the experimental period of 25 days.

The maximum weight gain (6.74 ± 0.13) in fish was observed in treatment (T1) with stocking density (30 per 300 L); however, the maximum biomass production (316.5±12.41) was observed in the treatment T3 with stocking density (50 per 300 L). The present study concluded that the trickling biofilter with natural zeolite balls is an efficient biofilter for maintaining the critical water quality parameters in permissible range and also enhanced the dissolved oxygen concentration for an efficient nitrification. From the point of view of optimum biomass production, a stocking density of 50 per 300 L (167/ m^3) can be recommended as optimum for the culture of GIFT tilapia in trickling biofilter (with natural zeolite balls as biofilter media) based RAS.

(CIFE/2016/AQC601/SR)

Intensive Culture Technique for a Tropical Calanoid Copepod of *Acartia* Species as a Live Feed for Aquaculture

Jess Maria Wilson

Major Advisor: Dr. Boby Ignatius

The present study was targeted to develop a stable copepod culture for marine finfish larval rearing. The calanoid copepod *Acartia tropica,* was isolated from Cochin estuary and experiments were conducted to optimize its culture conditions and to evaluate its live feed potential and egg storage potential. The first set of experiments was meant to standardize the culture conditions for *A. tropica*. Different salinity levels evaluated in the salinity optimization study were 5, 10, 15, 20, 25 and 30ppt. Population growth (1265 ± 418 Ind./L), IEP (33.4 ± 5.8 eggs f^{-1} day^{-1}) and nauplii survival (79.7 ± 4.7%) were recorded to be highest at 15ppt and hence it is taken as the optimum salinity for *A. tropica* culture. It is also found that *A. tropica* can be adapted to higher salinities with multigenerational acclimatization. In the microalgal diet optimization study, the recorded saturation point for *A. tropica* feeding was 1000 µgC L^{-1}. Different dietary treatments evaluated were T1 (*Isochrysis galbana*), T2 (*Pavlova lutheri*), T3 (*Dicrateria inornata*), T4 (Iso: Pav), T5 (Iso: Dic), T6 (Pav: Dic), T7 (Iso: Pav: Dic).

The monoalgal diet of *D. inornata* was the best algal diet supporting maximum population growth (2952±39.1 Ind./L), IEP (39.9±1.4 eggs f^{-1} day^{-1}) and EHS (86.2±3.9%) of *A. tropica*. For the optimization of adult density, the different densities evaluated were 125, 250, 500, 1000 and 2000 adults/L. Based on our results we suggest an adult density of 1000/L which will help to reduce the space and volume requirement for *A. tropica* culture and enable sufficient harvest of egg/nauplii required for aquaculture purposes. Different photoperiod regimes evaluated to optimize the photoperiod were 0L:24D, 8L:16D, 16L: 8D and 24L: 0D. Based on the highest population growth (7811±189 Ind./L), IEP (61.7 ± 2.2 eggs f^{-1} day^{-1}), EHS (83±1.9%) and nauplii survival (76.3±5.6%) recorded, 8L:16D came out as the best photoperiod regime for *A. tropica* culture. The live feed value of *A. tropica* was evaluated using *Amphiprion ocellaris* larvae. Highest total length (6.7 ± 0.4mm), standard length (5.4 ± 0.3mm), eye diameter (0.7±0.04mm), body depth (2.1±0.2mm), mouth gape size (0.6±0.02mm), survival (84.9 ± 5.3%) and opercular band development (72.7 ± 9.1%) after 7 days rearing was recorded in mixed diet (copepod nauplii+rotifer) fed fish larvae followed by copepod nauplii fed fish larvae.

Different conditions were examined to induce quiescence in *A. tropica* eggs. Higher salinities under room temperature as well as under cold storage could not induce quiescence in *A. tropica* eggs. Lower salinities under cold storage could induce 24h quiescence in *A. tropica* eggs with highest egg hatching recorded at 15ppt (69.4±8.1%). Addition of cryoprotectants and antibiotics could extend the egg viability up to 48h with the best treatments were 1M glycerol and 100ppm Kanamycin respectively. The experiments displayed that *A. tropica* can be considered as an efficient live feed for rearing marine and brackish water fish larvae and they can be cultured at 15ppt salinity under 8L:16D photoperiod regime at an adult density of 1000/L by feeding with microalgae *D. inornata* @ 1000 µg C L^{-1}. Our study also revealed that the egg storage conditions examined were not sufficient to retain egg viability beyond 72h.

(CIFE/2014/AQC410/SR)

Studies on Growth and Immunological Responses of *Labeo rohita* (Ham.1822) and *Pangasianodon hypophthalmus* (Sau.1878) in Cage based Polyculture

Himanshu Sekhar Swain

Major Advisor: Dr. B. K. Das

The aim of the present study was to evaluate the growth, survival, haemato-immunological, metabolic and secondary stress responses of *Pangasianodon hypophthalmus* (Pangas) and *Labeo rohita* (Rohu) in cage based monoculture and polyculture system. Stocking of *L. rohita* incorporated with *P. hypophthalmus* primarily to determine their role in controlling the biofouling over cage net and allowing free water exchange between cage and open reservoir. Initially *L. rohita* and *P. hypophthalmus* were evaluated at different stocking densities (R10, R20, R30 and P20, P30, P40, P50 and P60) in cages for a period of 240 days at Salia Dam, Ganjam District, Odisha.The study showed significantly ($P<0.05$) higher growth (680.69±21.30g) and other growth attributes of *L. rohita* in R10. Based on hemato-immunological, metabolic and stress responses, the stocking density R10 was found suitable for cage culture.

The growth performances and total yield of *P. hypophthalmus* at stocking density P40 was considered as the most desirable to achieve the table size production in cages. The most of the hemato-immuno, metabolic and secondary stress parameters of *P. hypophthalmus* in P40 did not vary significantly ($P>0.05$) with compared to lower stocking density of P20 and P30, however higher stocking density P50 and P60 showed significantly ($P<0.05$) lower growth (830.44 ± 28.99 g and725.33 ± 26.13 g) and poor hemato-immuno response and high metabolic and stress responses.Upon best results obtained from the stocking density experiment, the study on polyculture of *P. hypophthalmus* and *L. rohita* was carried out to evaluate the suitable stocking ratio between two species. The pangasius was stocked @ 40 m^{-3} based on previous results. *L. rohita* was incorporated at 5%, 10% and 15% level by replacing *P. hypophthalmus* to control the biofouling organism.

Though the growth, survival and economic return was not found significantly different ($P>0.05$) among the polyculture treatments but the growth of biofouling was significantly controlled ($P<0.05$) in different cages stocked with *L. rohita*. The gut content analysis of *L. rohita* revealed that the similar group of periphyton found in fish gut, cage net and water. All the three experiments were carried out in triplicate. Evidently it can be concluded that the stocking density of *L. rohita* and *P. hypophthalmus* was suitable for inland open water cage culture in tropical reservoirs of India. However, the study recommended the stocking ratio for *P. hypophthalmus* and *L. rohita* polyculture is 90:10 based on the growth, production, economics and control of biofouling organisms.

Growth and Reproductive Performance of *Neolissochilus hexagonolepis* (MeClelland, 1839) in Captivity in Mid- Himalayan Altitude

(CIFE/2016/AQC612/SR)

Pragyan Dash

Major Advisor: Dr. N. K. Chadha

The captive breeding program of threatened chocolate mahseer, *Neolissochilus hexagonolepis,* is essential for its population restoration and aquaculture practices. A series of trials were conducted to achieve the seed production of *N. hexagonolepis*. In Trial I,fish did not spawn in low depth tanks during six months rearing period, while after transfer to high depth tanks with gravel substrate (Trial II), spawning was volitionally triggered. Trial III was conducted to check the preference of substrate for spawning. Fishes were given a choice for three spawning substrates; gravel, small cobble, and coarse sand. *N. hexagonolepis* preferentially chose to spawn on gravel, and the sand was unoccupied. In the absence of the gravel, fish did spawn on the sand, as observed in Trial IV. The behavioral mode of *N. hexagonolepis* included preparation of spawning pits by ready females, a behavior not described for cyprinids so far. The study highlights the first report on the volitional spawning of *N. hexagonolepis* in captivity; further, it was revealed that the use of gravel trays in tanks could also be a feasible approach for seed production as evaluated in Trial V. On average, mean eggs retrieved per female were 3685 ± 564.42 no. with 90.25% fertilization rate, 82.78% hatching rate, and 97.35% free-swimming larvae survival rate. The morula stage in *N. hexagonolepis* began approximately 5:00 hours post fertilization (hpf), and hatching was observed at approximately 141hpfat 20±1°C.The study also aimed to assess the effect of temperatures on egg incubation, growth, standard metabolic rate (SMR), and thermal tolerance of *N.hexagonolepis*. Experiment I (for hatching), eggs were incubated at four temperatures (17, 20, 23, and 26°C). The total hatching and free-swimming larvae percentage were higher at 23°C ($p<0.05$). Experiment II (for validation of the CTmax method) was carried out by incubating eggs at 17°C and 23°C. The CTmax was estimated in response to different warming rates (1 to 18°C h^{-1}), acclimation temperatures (17 and 23°C), and the age of fishes (8, 15, 35 dph). The results suggested that a warming rate of 18°C h^{-1} could be used for the thermal tolerance study of yolk-sac larvae (8 dph) and 35 dph larvae, but free-swimming larvae (15 dph) up to 3°C h^{-1} is suitable. Experiment III (for growth, SMR, and thermal tolerance) was carried out by acclimatizing 15 dph larvae in five temperatures (15, 19, 23, 27, and 31°C) for 60 days. The mean growth rate increased with the increase in temperature from 15°C to 27°C (1.30 to 3.58 % day^{-1}) and decreased at 31°C.The Q_{10} with SMR suggested the preferred temperature of *N. hexagonolepis* ranged between 23 to 27°C. The optimum temperature for growth (ToptG) was estimated to be 25°C. Fish exposed to 31°C showed increased catalase, glutathione S transferase, and glutathione reductase enzyme activities ($p<0.05$). Nitric oxide synthase (NO) level was significantly higher in 19 to 27°C treatment groups than 31°C. Aspartate aminotransferase (AST) and alanine aminotransferase (ALT) activity were lower in fish exposed to 15°C ($p<0.05$). *N. hexagonolepis* is a eurythermal species due to its wide thermal tolerance zone (411.68 °C^2 in 15 to 31°C acclimation temperature range), high ARR values (0.49-0.54), and capability for adaptation to oxidative stress, which is advantageous for aquaculture practices.

Study on Potential and Economic Viability of Distillery Waste: Spent Wash as Fertilizer in Aquaculture

(CIFE/2014/AQC412/SR)

Archit Shukla

Major Advisor: Dr. Chandraprakash

A study was conducted for 120 days to observe the efficacy of different doses of spent wash as fertilizer on growth of rohu (*Labeo rohita*) fingerlings. First experiment was conducted to evaluate the sub-lethal dose of distillery waste: spent wash. The sub-lethal (LC_{50}) value of spent wash for rohu fingerlings was observed as 3.192 ml/L. Based on results obtained, an experiment of 120 days was attempted to estimate the primary productivity, production potential and economic viability of aquaculture under different concentrations of spent wash. Five different concentrations of spent wash and cow dung, as well as, control were used at treatments for rohu. The treatments were T_1 (0.5 ml/L), T_2 (1.0 ml/L), T_3 (1.5 ml/L), T_4 (2.0 ml/L), T_5 (2.5 ml/L), T_6 (cow dung @10,000 kg/ha/y) and control (without fertilization). The growth of fish was significantly higher in T_6 (cow dung) compared to control but not significantly different from T_5 (2.5 ml/L). Weight gain % (WG %) was highest in T_6 (486.44 ± 6.40) but not significantly different from T_5 (485.73 ± 6.39). The specific growth rate (SGR), protein efficiency ratio (PER) and feed efficiency ratio (FER) were higher in T_5 and T_6 as compared to control. Feed conversion ratio (FCR) was lowest in T_6 (1.39) followed by T_5 (1.41), T_4 (1.49), T_3 (1.58), T_2 (1.65), T_1 (1.78) and control (1.85). The maximum value of gross primary productivity (GPP) and net primary productivity (NPP) were noted in T_5 (442±2.11 and 322±4.15 mg C/m^3/hr). The water quality parameters were monitored fortnightly and they were within the favourable range for fish culture. Digestive enzymes, stress parameters as well as immunological parameters were also observed. There were no any significant sign of stress or other health related problems. By using spent wash as replacement of cow dung, fish farmer can save up to Rs. 50,000 per ha per year. From present experimental study, it was concluded that distillery waste: spent wash with 2.5 ml/L dilution can efficiently replace cow dung as organic manure in aquaculture practices.

Studies on Biological nutrient recovery from culturing of pangasius, *Pangasianodon hypophthalmus* (Sauvage, 1978) by seasonal vegetable & herbs in aquaponic system

(CIFE/2019/12/EF)

Project duration: 2019-2022

Principal Investigator
Dr. Sunil Kumar Nayak

Co-Principal Investigators
Dr. A.K.Verma
Mr. Dhalongsaih Reang
Dr. Arun Sharma
Mrs. Harsha Haridas

Technical Associates
Mr. Hasan Javed

An experiment was conducted with control (30 pangasius fingerling with no okra plant), T1 (30 pangasius fingerling with 3 okra plant), T2 (40 pangasius fingerling with 3 okra plant), T3 (50 pangasius fingerling with 3 okra plant) and T4 (60 pangasius fingerling with 3 okra plant) groups. For maintaining a fixed hydrolic loading rate, every 30 minutes the pump was operated for 2 minutes.

Water quality Parameter: Water quality parameter taken in every 15 days interval

	C	T1	T2	T3	T4
Temperature (oC)	27.39±0.29	27.50±0.26	27.56±0.29	27.22±0.39	27.22±0.41
Dissolved oxygen (mg L-1)	8.33±0.22	8.47±0.10	8.27±0.16	8.33±0.12	7.90±0.27
Alkalinity (mg CaCO3 L-1)	221.0±19.8	226.6±9.5	238.1±17.3	244.0±14.0	230.3±8.8
pH	7.24±0.25	8.07±0.21	7.97±0.16	7.84±0.27	7.81±0.24
Total Ammonia Nitrogen (mg L-1)	1.05±0.28	0.69±0.31	0.84±0.19	0.97±0.29	0.99±0.20
Nitrate - N (mg L-1)	5.35±0.12	4.22±1.17	4.25±1.01	4.45±0.94	5.65±1.00
Nitrite - N (mg L-1)	0.36±0.01	0.31±0.09	0.33±0.07	0.34±0.07	0.34±0.07

Growth Parameter:

PWG (%)	$138.26±2.13^b$	$151.59±2.82^c$	$151.38±3.95^c$	$134.15±0.62^b$	$125.54±0.53^a$
SGR(% day^{-1})	$0.96±0.01^b$	$1.03±0.01^c$	$1.02±0.02^c$	$0.95±0.00^b$	$0.90±0.00^a$
FCR	$3.07±0.04^b$	$2.90±0.04^a$	$2.90±0.06^a$	$3.12±0.02^b$	$3.29±0.01^c$
FCE	$0.33±0.004^b$	$0.35±0.004^c$	$0.34±0.007^c$	$0.32±0.002^b$	$0.30±0.001^a$
PER	$0.93±0.012^b$	$0.99±0.012^c$	$0.99±0.019^c$	$0.91±0.005^b$	$0.87±0.003^a$
Survival (%)	$66.67±1.92^a$	$91.11±1.11^c$	$90.00±1.44^c$	$76.00±1.15^b$	$69.44±0.56^a$
Biomass (g)	$309.59±6.55^a$	$446.91±4.08^b$	$588.54±18.69^c$	$578.40±10.22^c$	$610.85±6.17^c$

Significant achievement:
Treatment 2 with 40 number of pangasius fish with 3 okra plant yielded with better FCR and survivability.

Nutrition and Feed Technology


1000 ml
BOROSIL

Biomass production and downstream processing of *Spirulina* (*Arthrospira*) *platensis* for high-purity colorant grade Phycocyanin extraction

(CIFE/2017/300/EF)

Project duration: 2017- 2021

Principal Investigator
Dr. S.P.Shukla

Co-Principal Investigator
Dr. G.R.Bhuvaneswari

Budget: 38.8 lacs

Funding agency:
Department of Biotechnology

Progress:

In this project, the scope for developing *Spirulina* cultivation units with low-cost materials to improve the yield with respect to conventional open raceway ponds was assessed. There is now a worldwide trend of downstream processing of *Spirulina* biomass for value added products such as pigments. Therefore, the thrust at present is to market the products instead of raw *Spirulina* biomass. This can lead to several fold increases in earnings as compared to raw powdered biomass. For example, while one kg of food grade *Spirulina* is sold at Rs.800, 25mg of pure phycocyanin can be sold at Rs. 15000-25000.

In India, *Spirulina* biomass production has gained considerable momentum, however, down-stream processing of the biomass for phycocyanin production is still in its infancy. There is a need for proactive research in the area of Phycocyanin production. The bioreactor designed under this project facilitated optimum light availability and hence, ensured a considerable improvement in the yield of *Spirulina* biomass.

Three types of photobioreactors were developed and trials were completed. 1. Indoor continuously stirred and aerated system 2. Semi-outdoor culture system with outdoor tubular component 3. Outdoor/indoor culture system with integrated tubular component. The photobioreactors with tubular components were equipped with a harvesting module. The tubular culture systems were suitable for operation throughout the year without any interruption during the rainy season.

Yield of biomass in the continuously stirred photobioreactor showed an increase of 37.03 % after six days of culture period. The increase in culture density is comparatively lesser than the tubular bioreactor where an appreciable increase of 3.2 folds was recorded after the same duration of culture period. On the sixth day the yield (dry wt g/L) was 1.73 folds higher in the tubular bioreactor. The lower yield in continuously stirred bioreactor can be attributed to a higher inoculation density (2.2g/L) for the experiment. It was noticed that if the inoculation density is lesser (0.5-1.5 g /L fresh weight), the growth and yield was higher in open continuously stirred bioreactors. The growth was arrested in a tubular bioreactor at lower inoculum densities. The availability of light throughout the water column in open continuously stirred bioreactor at lower density supports the growth however, in tubular bioreactor, the initial mechanical shock due to circulation and release of oxygen radicals in the tubular portion (the de-gasifier was not incorporated in the system) lesser availability of carbon dioxide in the tubular portion are the plausible reasons for the difference in the yield of the biomass.

The quality of the biomass was compared on the basis of protein content in the harvested biomass. A remarkably higher protein content was recorded (640-678 mg/g dry wt.) in the biomass produced in SCOB and tubular bioreactor. It is apparent from the finding that the quality of the biomass is not varied in both the bioreactors.

In order to enhance the yield of Phycocyanin (Pc) through the downstream processing of the harvested biomass, an attempt was made to compare the yield of Pc in different salt solutions. Among the salts used (1% w/v), calcium chloride exhibited the highest yield (121.2 mg/g dry wt) however, the initial purity was lesser than Ferrous sulphate. Considering the negligible difference in the yield in calcium chloride and ferrous sulphate and an initial higher purity (44.28 % higher) in ferrous sulphate. Therefore, ferrous sulphate (10 %) was used for extraction.

The phycocyanin yield for each harvest after 6 days showed no considerable variation. The yield was 108 to 114 mg/g dry wt in the biomass harvested from the continuously stirred bioreactor whereas the yield ranged between 106.2-116.6 mg/g for the tubular bioreactor.

Nutritional Intervention for Reducing Solid and Dissolve Wastes in Recirculating Aquaculture System of GIFT tilapia, *Oreochromis niloticus*

(CIFE/2020/7/IF)

Project duration: 2020-2023

Principal Investigator
Dr. Sikendra Kumar

Co-Principal Investigators
Dr. Ashutosh D. Deo
Dr. A. K. Verma
Dr. Md. Aklakur
Dr. Tincy Varghese

The waste management in aquaculture systems is an important aspect and the solid wastes and dissolved wastes generated in RAS systems should be efficiently removed for ensuring a healthy environment for cultured organisms. Hence, a 36-days feeding experiment was conducted by stocking different number of GIFT tilapia fingerlings in the recirculating aquaculture system (RAS) to estimate the release of dietary nitrogen and phosphorus during the culture period. The GIFT tilapia fingerlings of average weight 15.34g ±0.59 were stocked at different stocking densities and designated as T1 (230g/0.06 m^3), T2 (330g/0.06 m^3) and T3 (430 g/0.06 m^3.

Significantly ($P<0.05$) higher weight gain, weight gain %, specific growth rate and protein efficiency ratio was found in the T1 group where stocking density was lower (230g/0/06 m^3) compared to T2 and T3. The T3 group manifested lower weight gain, weight gain %, specific growth rate and protein efficiency ratio. The T1 group stocked with lower stocking density (230 g/0.06 m^3) reported significantly($P<0.05$) lower release of phosphorus 4.29mg/l in comparison to T2 and T3. The highest phosphorus level 7.49 mg/l was reported in the T3 group stocked with 430g/0.06 m^3. The release of dietary total ammonia nitrogen and nitrite vary non-significantly ($P>0.05$) among the treatment groups. T1 group manifested lower release of dietary total ammonia nitrogen and nitrite than T2 and T3 groups. The T3 group had higher levels of total ammonia nitrogen and nitrite.

(CIFE/2019/FNT902/SR)

Evaluation of Dietary Nitrogen and Phosphorus Release in Recirculating Aquaculture System of GIFT tilapia, *Oreochromis niloticus*

E. Anusha Patel

Major Advisor: Dr. Sikendra Kumar

A 36 days feeding experiment was conducted by stocking a different number of GIFT tilapia fingerlings in the recirculating aquaculture system (RAS) to estimate the release of dietary nitrogen and phosphorus during the culture period. The GIFT tilapia fingerlings of average weight 15.34g ±0.59 were stocked at different stocking densities and designated as T1 (230 g/0.06 m^3), T2 (330g/0.06 m^3) and T3 (430 g/0.06 m^3). In addition to the findings listed on the previous page, the study revealed the following. The serum protein profile was also analysed which varied significantly ($P<0.05$) among the treatment groups. The higher serum total protein was found in the T1 group followed by T2. The T3 group manifested a lower value of serum total protein. The higher serum albumin and globulin were found in the T1 group followed by T2. The T3 group manifested lower values of serum albumin and globulin. The SOD and catalase activities were also analysed and these did not vary significantly ($P>0.05$) among the treatment groups. The T1 group stocked with lower stocking density (230g/0.06 m^3) reported higher survival % compared to other treatments. The T3 group had lower survival% at the end of the experiment. Over all it can be concluded that better growth performance with minimum release of dietary phosphorus (4.29 mg/L), total ammonia nitrogen (0.016 mg/l) and nitrite (0.009 mg/l) in the RAS of GIFT tilapia fed with 30% crude protein and 6 % lipid diet was found at stocking density of 230 g/0.06 m^3.

Strategies to Enhance Feed Intake and Growth in Carps During Winter Months

(CIFE/2019/5/IF)

(CIFE/2020/5/IF)

Project duration: 2019-2022

Principal Investigator
Dr Ashutosh D Deo

Co-Principal Investigators
Dr. Shamna N.
Dr. Md. Aklakur
Dr. Manish Jayant
Dr. Subodh Gupta
Dr. N. P. Sahu

The low water temperature is a crucial factor in fish farming especially for the tropical fishes, leading to a reduction in feed intake, growth reduction and often results in metabolic and immunological disorders. It has been already reported that the growth rate of cultured freshwater carps decreases by 20-40% during winter months. If fishes are to be marketed during the winter, it would be prudent to follow a winter feeding program. The changes in mitochondrial properties (membrane phospholipids, enzymatic complement, and cristae densities) in response to lower temperatures can enhance the oxidative capacity of muscle. Therefore, the addition of antioxidants derived from natural plant and fruit wastes has potential to be incorporated into the fish feed. Two separate feeding trials were conducted to delineate the effect of dietary lemon peel extract and dietary onion peel extract on feed intake and growth in *Labeo rohita* (Rohu) fingerlings reared at low temperature (18 ± 1 ⁰C). Graded levels of extracts (0 to 2%) were used in the study for preparing diet .

The results showed that the inclusion of lemon peel extract in the diet had a significant increase in feed intake in all levels of extract fed groups and the highest feed intake was observed in LPE 0.5 fed group. Higher weight gain and TGC was recorded in LPE 0.5 group, while protein efficiency ratio (PER), Lipid efficiency ratio (LER), alanine aminotransferase (ALT) and protease activity were significantly higher in both LPE 1.0 and LPE 0.5 group. The hepatosomatic index (HSI) and Intestinal index (ISI), aspartate aminotransferase (AST), and citrate synthase were higher in LPE 1.0 group. Serum total protein and albumin also followed the same trend. From these results, it can be concluded that feeding lemon peel extract at 0.5-1.0% level had increased feed intake and metabolic activities in rohu reared at low temperature. Similarly, 0.5 % crude onion peel extract showed higher weight gain and TGC, protein efficiency ratio (PER), Lipid efficiency ratio (LER), alanine aminotransferase (ALT) and protease activity.

(CIFE/2019/FNT908/SR)

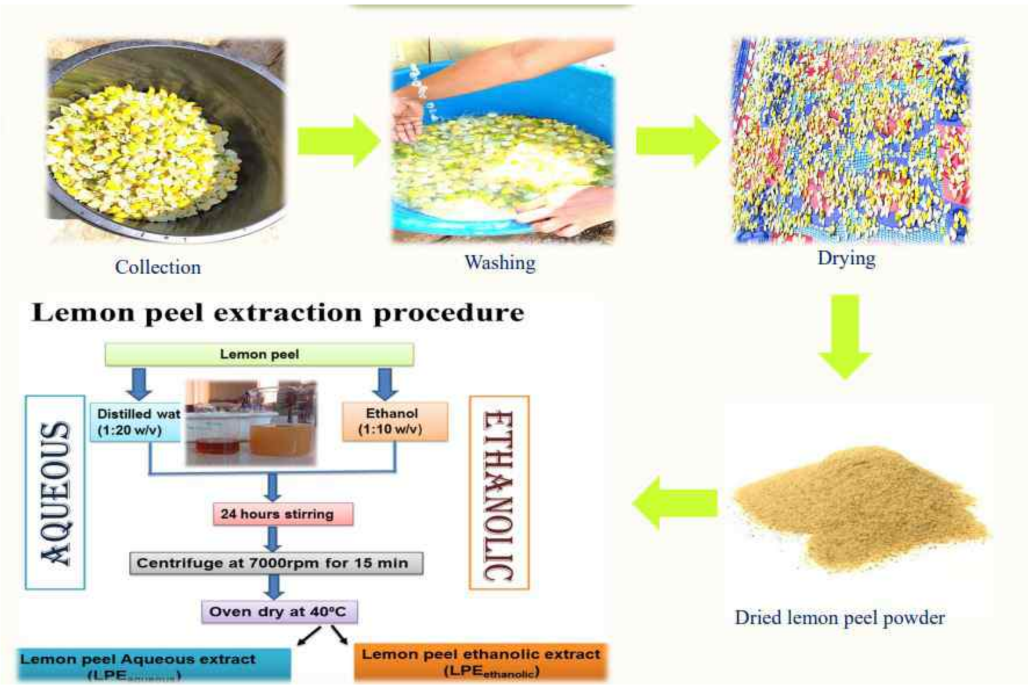
Effect of Flavanone Rich Lemon Peel Extract on Feed Intake and Growth of *Labeo rohita* (Hamilton,1822) Fingerlings Reared at Low Temperature

Kinnera Tejaswini

Major Advisor: Dr. Ashutosh D Deo

A 60-day feeding trail was conducted with an aim to delineate the effect of dietary lemon peel extract on feed intake and growth in *Labeo rohita* (Rohu) reared at low temperature (18 ± 1 ^{0}C). Aqueous and ethanolic lemon peel extracts were prepared and their antioxidant activities were analyzed by DPPH, TPC and FRAP assays. It was found that the antioxidant activity in all the three assays was higher for ethanolic extract. Hence ethanolic extract was selected for the inclusion in the diets. For feeding trial five iso-nitrogenous (30.0%) and isocaloric (388.52 Kcal DE/100 g) practical diets with varying levels of metabolic modifier (lemon peel extract) *viz,* Control (0.0% lemon peel extract), $LPE_{0.25}$ (0.25% lemon peel extract), $LPE_{0.5}$ (0.5% lemon peel extract), $LPE_{1.0}$ (1.0% lemon peel extract), $LPE_{2.0}$ (2.0% lemon peel extract) were prepared. The experiment was conducted in a low temperature (18 ± 1 ^{0}C) re-circulatory aquaculture system (RAS) with a flow rate of 1.5 L/min. Feed intake and growth parameters *viz.,* weight gain, weight gain%, SGR, FCR, TGC, FCR, PER, LER; digestive enzymes *viz.,* protease, amylase, lipase; metabolic enzymes *viz.,* AST, ALT, LDH, MDH, citrate synthase; haematological parameters *viz.,* serum total protein, albumin, globulin, A/G ratio, RBC and haemoglobin concentration were studied.

The result showed that inclusion of lemon peel extract in the diet had a significant increase in feed intake in all extract fed groups and highest feed intake was observed in $LPE_{0.5}$ fed group. Similarly, highest growth rate was recorded in $LPE_{0.5}$ group. The protease activity was also significantly higher in $LPE_{0.5}$ group, whereas amylase activity was higher in control and 2.0% extract fed group and lipase activity showed an increasing trend with the inclusion level. HSI and ISI values were higher in $LPE_{1.0}$ group. Metabolic enzymes like ALT, MDH and citrate synthase showed an increasing trend up to 1.0% level of inclusion. Serum total protein and albumin also followed the same trend. From these results it can be concluded that feeding lemon peel extract at 0.5-1.0% level had increased feed intake and metabolic activities in rohu reared at low temperature.



(CIFE/2019/FNT906/SR)

Effect of Dietary Crude Onion Peel Extract (COPE) on Feed Intake and Growth in Rohu (*Labeo rohita*) Fingerlings Reared at Low Temperature

Revathi A.

Major Advisor: Dr. Manish Jayant

Two subsequent experiments were conducted to evaluate the effect of dietary crude onion peel extract (COPE) on feed intake and growth in rohu, *Labeo rohita* fingerlings reared at low temperature. In first experiment, aqueous and ethanolic extracts were prepared from onion peel with a dry matter recovery of 7.10 % and 4.36 %, respectively. The anti-oxidative property of the COPE were evaluated by using 2,2-diphenyl-1-picryl-hydrazyl-hydrate (DPPH), Ferric reducing antioxidant power assay (FRAP) and total phenolic contents (TPC) assays. Ethanolic extract of onion peel exhibited significantly higher DPPH inhibition, FRAP activity and TPC contents than aqueous extract ($P<0.05$). In second experiment, five iso-nitrogenous (30.35 CP %) and iso-caloric (383.50 kcal DE/100g) experimental diets were prepared with graded inclusion of crude onion peel extract *viz*. 0, 0.25, 0.50, 1.0 and 2.0 g/100 g diet. The experimental diets were denoted as C, T1, T2, T3 and T4, respectively. One hundred and fifty *L. rohita* fingerlings (average initial weight, 11.74 ±0.5 g) were randomly allocated to 5 treatment in triplicates (10 fish per tank) in a low temperature (18.0±1.0 °C) recirculatory aquaculture system (RAS) ensuing the completely randomised design.

Feed intake was significantly higher in COPE supplemented fed groups ($P<0.05$) than non-supplemented group (C). Fish fed with T2 and T3 experimental diets exhibited maximum weight gain, growth rates {(weight gain (%) and specific growth rates (SGR)} and feed conversion ($P<0.05$) while minimum in control group ($P<0.05$). Protein efficiency ratio and Lipid efficiency ratio followed the same trend as growth rates ($P<0.05$). Negative linear trend was observed between hepato-somatic index (HSI) and COPE inclusion ($P<0.05$). Survival (%) was higher in COPE supplemented fed groups than control ($P<0.05$). Protease activity was increased with COPE inclusion and were in correlation with growth rates. Amylase activity was decreased with COPE inclusions whereas lipase exhibited an increasing trend with dietary COPE inclusion ($P<0.05$). Alanine aminotransferase (ALT) and malate dehydrogenase (MDH) and citrate synthase (CS) activities exhibited a linear trend in rohu fingerlings fed with COPE ($P<0.05$). Lactate dehydrogenase (LDH), and superoxide dismutase (SOD) activities were maximum in T2, T3 and T4 fed groups ($P<0.05$). Serum total protein, albumin, globulin and albumin-globulin ratio were significantly affected by dietary COPE ($P<0.05$). Total erythrocyte count and haemoglobin content were also influenced by dietary COPE inclusion. Based on the results, 0.5 % crude onion peel extract in the diet *L. rohita* fingerlings reared at low temperature could be suggested for enhancing the feed intake and growth performance.

Evaluation of the Toxico-physiological Effect of Dietary Cyanotoxin in Selected Carp

(CIFE/ 2019/11 /IF)

Project duration: 2021-2024

Principal Investigator
Dr. Md. Aklakur

Co-Principal Investigators
Dr. Ashutosh D Deo
Dr. D.K. Singh
Dr. G. H. Pailan

Technical Associate
Parmanand Prabhakar

Total 11 farms associated with mortality in Catla and other carps, especially grass carp in winter months were tracked. There was no marked physical diagnostic difference in appearance or mark or physical damage. In all the fishes after mortality, the scale was found to be loose especially in grass carp. The watercolor of such farms was yellowish or reddish-green with bloom on the surface or turbidity due to bloom. Total 3 experimental trials completed in the project and three trials under progress at present. Two genera Microcystis and Anabaena have been tested for their toxicity in dietary formulation from 0.5 % to 15 % inclusion. The dietary inclusion of Microcystin after 5 % showed reduced growth without any significant impact on survival. The mix powder of *Anabaena, Nostoc*, etc. did not show any negative impact on the growth of fish. The Microcystis has been found to reduce the growth in *Catla catla* above 5 % inclusion. The feed performance was best reported at 2 % inclusion of Microcystin in feed-in *Catla catla*.

The study of 100 days revealed that the growth performance showed a decrease after 2 % inclusion. FCR was found to increase significantly from the 2 % group while PER decreased significantly from the 2 % and above inclusion group. But body composition of the experimental fish was not affected by the inclusion of graded levels of MBGA and 100% survivals were observed in all treatment ponds. Protease activity was found to decrease significantly from the 1 % inclusion group, whereas Lipase activity was found to decrease significantly ($P<0.05$) from the 2 % and above inclusion group. Amylase activity reduced significantly in 4 % and above treatments compared to control. Stress enzyme activity was found to increase significantly in high dosage MBGA. SOD and catalase activity was found to increase significantly from 2 % inclusion. Hematological parameters, such as RBC, Hb and Hct were decreased significantly after 2 % inclusion of microcystin groups while WBC count was enhanced in these groups.

(CIFE/2019/FNT901/SR)

Effect of Microcystis Rich Dietary Cyanobacteria on Physio-Metabolic Responses of *Catla Catla* (Hamilton, 1822)

Adarsh K.C

Major Advisor: Dr. Md. Aklakur

A study was conducted to evaluate the *in vivo* toxicity of Microcystis rich cyanobacteria (blue green algae) in the diets of *Catla catla* (Hamilton, 1822) fingerlings. The crude protein (%) content of Microcystis rich blue green algae (MBGA) was 32% and found as adequate for inclusion in *Catla catla* feed. A Feeding trial of 100 days was carried out to evaluate the physio-metabolic responses of Microcystis-rich cyanobacteria in the diet of *Catla catla* fingerlings. Fish were fed six iso-nitrogenous (30% CP) and iso-caloric (363.10 ± 3.09 Kcal/100g) diets for 100 days. The diets were C (0% MBGA), T1 (0.5% MBGA), T2 (1% MBGA), T3 (2% MBGA), T4 (4% MBGA), T5 (8% MBGA).

The study revealed that the growth performance indices such as WG (%) and SGR varied significantly ($P<0.05$) among the treatments, with a decrease in growth performance observed in T3, T4 and T5 groups. Feed conversion ratio (FCR) has increased significantly ($P<0.05$) from the T3 group while Protein efficiency ratio (PER) decreased significantly ($P<0.05$) from the T3 group. But body composition of the experimental fish was not affected by inclusion of graded level of MBGA and 100% survivals was observed in all treatment ponds. Digestive enzyme activity varied significantly among the treatments. Protease activity was found to be decreased significantly ($P<0.05$) from the T2 group, whereas lipase activity was found to be decreased significantly ($P<0.05$) from T3 group. Amylase activity reduced significantly ($P<0.05$) in T4 and T5 treatments compared to other treatments. Stress enzyme activity was found to be increased significantly in high dosage MBGA. SOD activity was found to be increased significantly ($P<0.05$) from T3 and catalase activity also increased significantly from T2. Hematological parameters, such as RBC, Hb and Hct decreased significantly in T4 and T5 groups while WBC count was enhanced in these groups. Thus, it is concluded that the microcystis rich cyanobacteria cannot be included in the diet of *Catla catla* beyond 1%.

Effect of Phytoestrogens on the Reproductive Performance of Fish and its Mitigation through Nutritional Intervention

(CIFE/2019/6/IF)

Project duration: 2019-2022

Personnel:

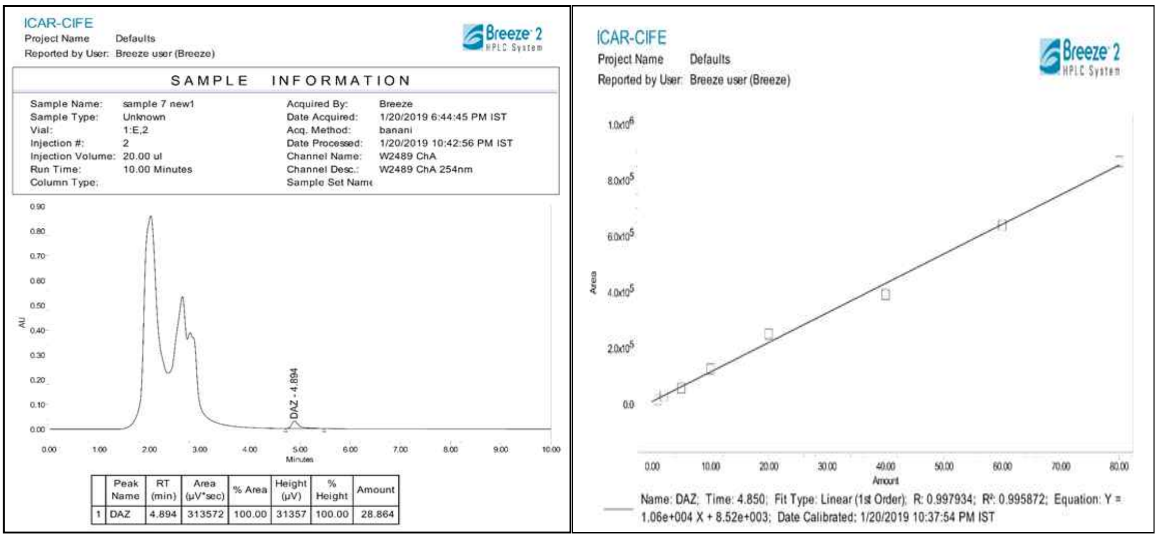
Principal Investigator
Dr. S. Gupta

Co-Principal Investigator
Dr. P. P. Srivastava (On deputation)
Dr. Tincy Varghese
Dr. Sunil Kumar Nayak

Impact of graded level soybean origin phytoestrogen, daidzein on female common carp, *Cyprinus carpio* were studied. Detection of daidzein from soybean meal by HPLC was obtained at 254 nm wavelength with retention time 4.8 min. The mobile phase was isocratic acetonitrile: water (70:30) and the column was C-18. Daidzein content of soybean meal was quantified to be 21.56 ± 0.05 µg/g. A 60-days feeding trial to evaluate the estrogenic activity of pure daidzein alone or soybean meal containing equivalent quantity of daidzein in the broodstock diet of female common carp (Fig 1). The gravid female and oozing male fishes were selected for breeding experiment. The male: female ratio was 2:1 by number and 1:1 by wet weight basis. The level of estradiol increased after the 7th day which may induce synthesis of vitellogenin level on the 15th day. At a higher dose of daidzein, the vitellogenin level was high, which was correlated with an increase in the estradiol level Table 1.

Table 1: Sex hormones and vitellogenin level in *C. carpio* fed with different experimental diets for 60 days

Treatments	Estradiol (ng/L)	Vitellogenin (µg/L)	Testosterone (nmol/L)	Progesterone (pg/L)
Control	5.11c ± 0.43	10.93a ± 0.38	4.61b ±0.09	62.99d ± 1.76
T1	3.21a ± 0.04	10.18a ± 0.51	4.81b ±0.17	81.95e ± 1.67
T2	3.99b ± 0.05	14.43b ± 0.48	3.29a ±0.21	36.46a ± 2.33
T3	4.25b ± 0.03	17.43c ± 0.28	4.45b ±0.03	56.65c ± 2.69
T4	3.64ab ± 0.05	9.43a ± 0.67	2.87a ±0.26	45.65b ± 1.27
P value	0.001	0.000	0.001	0.001



Combinatorial Effects of Dietary Genistein and Daidzein on Sex Steroid Profile in Female *Cyprinus carpio* (Linnaeus, 1758)

(CIFE/2019/FPB905/SR)

Samikshya Mishra

Major Advisor: Dr. Subodh Gupta

The aim of this study was to evaluate the combinatorial effects of genistein and daidzein, which are phytoestrogens derived from soybean, on female common carp, *Cyprinus carpio*. The genistein and daidzein contents were estimated as 22.57mg and 2.156mg per 100 gram of soybean meal, respectively. A 45-day feeding experiment was conducted to assess the effects of dietary genistein and daidzein supplemented to the broodstock female common carp. Three different treatments were used namely control (completely phytoestrogen free diet), T1 (purified diet with 50% genistein and daidzein of 17.5% of soybean meal equivalent), T2 (purified diet with 100% genistein and daidzein of 35% of soybean meal equivalent).

The combinatorial inclusion of genistein and diadzein diets had no significant effect on the growth performance of female C*yprinus carpio*. Sex steroid profile viz estradiol (E2), testosterone (T), progesterone (P), cortisol was assayed and ovary histology were examined to understand the reproductive performance of female common carp. Both 50 % and 100 % doses of combined genistein and daidzein treatment showed a significant ($p<0.05$) increased serum estradiol levels whereas there were no significant changes in serum testosterone and progesterone level. There was no difference in cortisol level with combined inclusion of genistein and daidzein. 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 gonadosomatic index of treatment groups did not alter significantly. As a result, the study indicated that inclusion of both of 50% dose of genistein and daidzein and 100% dose of genistein and daidzein has shown no negative impact on sex steroid profile except female hormone estradiol (E2) and drastic increases in vitellogenic oocytes population in female common carp. There is a need for more research to see whether long-term genistein and daidzein combined feeding has any harmful implications.

Effects of Alfalfa (*Medicago sativa*) Meal Based Phytoestrogens on Gonadal Development and Sex Steroids in Female *Cyprinus carpio* (Linnaeus, 1758)

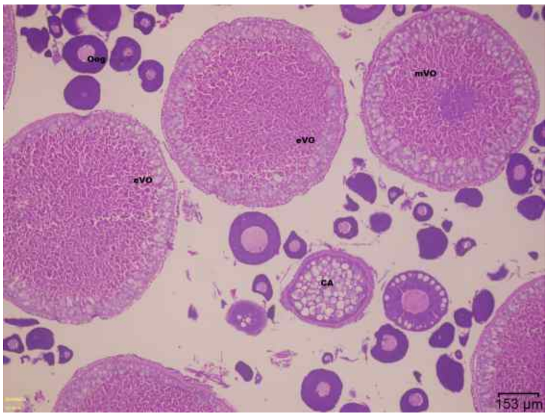
(CIFE/2019/FPB901/SR)

Arunashri A

Major Advisor: Dr. P.P. Srivastava

The present study was conducted to evaluate the effect of alfalfa (*Medicago sativa*) seed meal on the steroid profile of female common carp, *Cyprinus carpio*. The fish were divided into four treatment groups fed with graded levels of alfalfa seed meal incorporated diets, including a control (0%), T1 (5% alfalfa seed meal), T2 (10% alfalfa seed meal) and T3 (15% alfalfa seed meal). The growth parameters, the concentrations of serum estradiol (E2), testosterone, progesterone and cortisol were estimated, and the histological sections of the ovary were examined after 45 days of feeding trial.

The study observed an increase in the weight gain of *C. carpio* in all the alfalfa seed meal fed groups with the highest weight gain in the T2 group. Serum estradiol (E2) level was higher in the T3 group than in other groups. There were no significant differences observed in the level of serum testosterone and progesterone among the treatment groups. Serum cortisol level was decreased with an increase in the inclusion of alfalfa seed meal. The percentage of vitellogenic oocytes in *C. carpio* was reduced in all the alfalfa seed meal fed groups. However, the gonadosomatic index did not differ significantly among the treatment groups. The study concluded that alfalfa seed meal in feed at 15% cause adverse effects on the reproduction of female *C. carpio*. Hence, alfalfa seed meal inclusion in the broodstock diet should not be more than 10% for female common carp.



Effect of Dietary Supplementation of Sugar beet Forage on Sex Steroid and Gonadal Development of Female *Cyprinus carpio* (Linnaeus, 1758)

(CIFE/2019/FPB903/SR)

Mathumitha S. P.

Major Advisor: Dr. P.P. Srivastava

The present study was aimed to evaluate the effect of dietary sugarbeet forage on sex steroid and gonadal development of female *Cyprinus carpio.* A 45-day feeding trail was conducted to evaluate the effect of phytoestrogens present in sugarbeet forage on the sex steroid hormones and gonadal development in the diet of female *C. carpio*. The three isonitrogenous (34% CP) and isocaloric (374±9.5) diets, namely, control (0% SBLP and 30% DORB) T1 (15%SBLP and 15% DORB) and T3 (30% SBLP and 0% DORB) were prepared. Gonadosomatic index, serum estradiol (E2), testosterone, progesterone, cortisol level and histology of ovary were examined.

It was observed that feeding sugarbeet leaf powder at the level of 15 and 30%, there was significant ($P<0.05$) increase in the serum estradiol concentration. Gonadosomatic index were significantly reduced in SBLP fed *C. carpio* compared to control groups. The histological study showed that out of the total number of oocytes, the proportion of vitellogenic oocytes decreased with increase in the inclusion level of sugarbeet leaf powder. Serum testosterone, progesterone and cortisol level did not differ significantly among different treatment groups. Hence, the study concluded that the inclusion of sugarbeet forage upto 30% has no influence on the level of testosterone, progesterone and cortisol. Overall, it is concluded from the results that inclusion of sugar beet forage from 15% inclusion level has disrupted vitellogenesis and ovarian growth.

Identifying Physio-biochemical parameters as welfare indicator of Indian major carps and Pangasius under different culture condition

(CIFE/2020/10/IF)

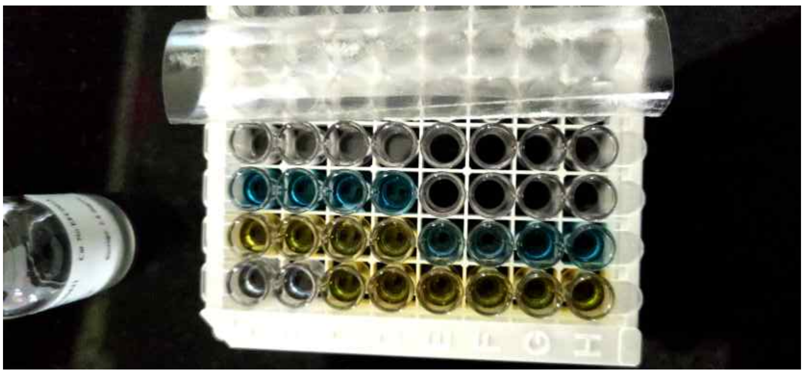
Project duration: 2020-2023

Principal Investigator
Dr. Sujata Sahoo

Co-Principal Investigators
Dr. D. K. Singh
Dr. S. Dasgupta
Dr. Gayatri Tripathi
Dr. G. H. Pailan
Dr. N. P. Sahu

Fish welfare is often neglected in comparison to other animal welfare. For proper health monitoring and better production, standard physiological indices of candidate species are extremely useful. The physiological status of a population can be assessed using biochemical and haematological parameters which in turn can be their welfare indicators. In this work, Indian major carps from different culture systems were evaluated with haemato-biochemical parameters with respect to their environments.

Water samples from extensive, sewage-fed aquaculture and semi-intensive aquaculture were collected and analyzed. Water quality parameters of the sewage-fed system were on a higher side. Condition factor of ***Labeo rohita*** from sewage-fed aquaculture and semi-intensive aquaculture were calculated. Fishes were



grouped in two categories according to weight i.e. (I) Advanced fingerling stage (below 120 gm) and (II) Grow-out stage (above 120 gm).

In group I from sewage fed aquaculture, the condition factor ranged from 0.89 to 1.32. In group II, the condition factor ranged from 0.87 to 1.3. In terms of condition factor both groups did not show any variation. In group I from semi-intensive aquaculture, the condition factor ranged from 0.92 to 1.24. In group II, the condition factor ranges from 0.94 to 1.13. In terms of condition factor, group I showed higher values. Similarly, condition factor of ***Catla catla*** from sewage-fed aquaculture and semi-intensive aquaculture were calculated. Fishes are grouped in two categories according to weight i.e. (I) Advanced fingerling stage (below 120 gm) and (II) Grow-out stage (above 120 gms). In group I from sewage fed aquaculture, the condition factor ranges from 0.9 to 1.2. In group II, the condition factor ranges from 0.1 to 1.34. In terms of condition factor group II showed better growth. In group I, from semi-intensive aquaculture, the condition factor ranges from 1.08 to 1.31. In group II, the condition factor ranges from 0.93 to 1.24. In terms of condition factor, group I showed higher values.

Outcome

- Data generated for water quality parameters for semi-intensive and sewage-fed aquaculture.
- Data generated for Condition factor, haematological parameters and blood biochemical parameters in *Catla catla* and *Labeo rohita* from sewage-fed and semi-intensive aquaculture

The blood samples were collected from fishes and different blood parameters like, RBC, WBC, Haematocrit, Hemoglobin, Thrombocytes, MCV, MCH, MCHC and PCV. The blood parameters showed wide ranges and further sampling is needed for establishment of ranges.

Results showed that in *Labeo rohita,* haematological parameters like RBC, Haemoglobin, WBC values were significantly higher in sewage fed aquaculture than semi-intensive system, whereas other parameters showed no significant difference. In *Catla catla,* in the sewage-fed system leucocytes count is significantly higher and erythrocyte count, hemoglobin and hematocrit value were significantly lower in comparison to semi intensive aquaculture. Blood biochemical parameters like glucose, total protein, triglyceride, cholesterol, uric acid, Albumin/globulin ratio, creatinine, Urea, total bilirubin, direct bilirubin, HDL and LDL of *Catla catla* and *Labeo rohita* from sewage-fed and semi-intensive aquaculture were estimated using standard protocols. Similar trend was observed in the values irrespective of species. The mean values of total protein, albumin, A/G ratio, HDL were significantly higher in semi intensive culture systems. Whereas, the mean values of glucose, triglyceride, cholesterol, total bilirubin, direct bilirubin and LDL were significantly higher in sewage fed culture systems. Uric acid and creatinine values showed no significant difference for both the culture systems.

Biochemical and Hematological Profiling of *Catla catla* (Hamilton, 1822) in Different Culture Systems

(CIFE/2019/FPB907/SR)

Siddhartha Shankar Sahoo

Major Guide: Dr. Sujata Sahoo

The fish samples of *Catla catla* (Hamilton, 1822) were collected from three different culture systems viz sewage-fed, semi-intensive, and extensive systems in North 24 praganas and nearby areas of West Bengal. Then, the blood and serum parameters were analyzed for hemato-biochemical profiling along with water analysis of the culture ponds. The experiment was conducted from February to August 2021 at ICAR-Central Institute of Fisheries Education, Kolkata centre. Significant changes ($P<0.05$ level) in the hemato-biochemical profile of the fish were observed in the three farming systems. Condition Factor (CF) was significantly highest in the semi- intensive system, i.e. 1.23±0.03a suggesting fish were in better growth and health conditions in this system. In the sewage-fed system, leucocytes count is significantly higher, and erythrocyte count, hemoglobin and hematocrit value were significantly lower compared to other systems. Glucose content was significantly higher in sewage-fed systems. Other parameters like bilirubin (total and direct), ALT, AST, and LDH are significantly highest in the sewage-fed system, and lowest in the semi-intensive system, which indicates fish is under more stress in sewage-fed ponds. Total protein, albumin: globulin ratio, calcium, phosphorus, sodium, potassium are significantly lower in the sewage-fed system but highest in semi- intensive systems. Water quality parameters like ammonia, BOD, COD, TDS, hardness and alkalinity exceed the permissible limits in the sewage-fed systems but were within the optimal range for the semi-intensive pond. The above hemato- biochemical parameters show a significant difference in different culture systems; hence it is suggested that these parameters can be conveniently used as potential welfare indicators.

Haemato-biochemical Profile of Indian Major Carp, *Labeo rohita* (Hamilton, 1822) Under Different Culture Systems

(CIFE/2019/AAH903/SR)

Abhinav Prakash

Major Advisor: Dr. Gayatri Tripathi

The present study investigated the health status of farmed *Labeo rohita* in semi-intensive, extensive and sewage culture systems during April to May 2021. Sample of 30 fishes were collected from each system to determine and compare the haematological, biochemical and histological parameters. Growth performance exhibited significantly higher Fulton's condition factor in semi-intensive culture fishes (1.22±0.03) and lower in sewage culture fishes (0.98±0.03). The haematological parameters such as red blood cells ($2.32\pm0.07\times 10^6/mm^3$) and haemoglobin content (10.14±0.39 g/dl) in the semi-intensive culture system displayed higher values than the extensive and sewage culture system. White blood cell count ($181.8\pm5.23\times10^3/mm^3$) MCH and MCHC were significantly higher in sewage culture fishes.

Biochemical parameters such as protein profile and albumin: globulin ratio were found to be significantly higher in semi-intensive culture fish. Oxidative stress enzymes (SOD and Catalase), cortisol, glucose, lysozyme activity as well as the lipid profile (cholesterol and triglyceride) of the fishes were found to be significantly higher in sewage culture fishes. The serum urea and bilirubin content were also higher in sewage and extensive culture fishes. Histological analysis revealed that prominent pathological alterations were observed in gills, liver and kidney tissues of sewage culture fishes. Besides, moderate pathological changes were seen in the fish tissues of the extensive culture system whereas normal tissue architecture was observed in semi-intensive culture systems. Overall, stress in the semi-intensive culture system was found to be minimal compared to the other systems. The current study compared and documented the health status of fishes cultured in extensive, semi-intensive and sewage culture systems through haematological, biochemical and histological observations.

(CIFE/2019/FPB902/SR)

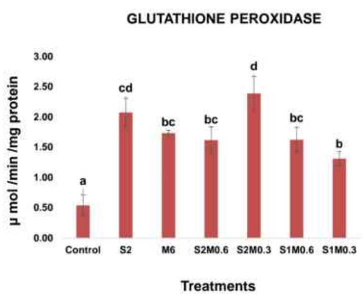
Evaluation of the Synergistic Effects of Nano-selenium and L-methionine Supplementation on Growth Performance and Biochemical Responses in *Labeo rohita* (Hamilton, 1822) Fingerlings

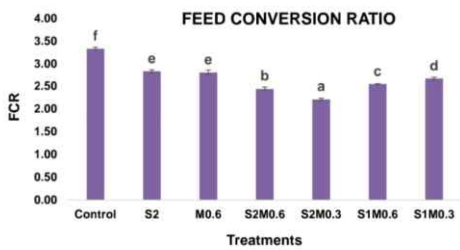
Kondareddy Gari Hymavathi

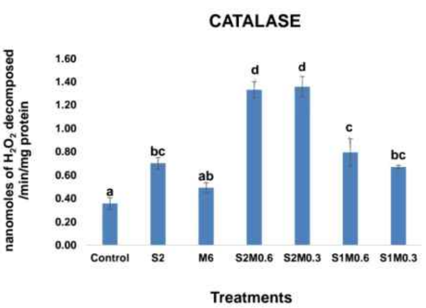
Major Advisor: Dr. Subodh Gupta

The present study evaluated the effect of dietary selenium nanoparticles and L-methionine in *Labeo rohita* fingerlings. Selenium nanoparticles were prepared and they exhibited a mean particle size of 60 nm and zeta potential of -66.1 mV. Seven isonitrogenous (30%) and isocaloric (381 Kcal DE/100 g) practical diets were prepared with varying levels of selenium nanoparticles (SeNPs) and L-methionine (M) *viz*, C (Control without SeNPs and M), S_2 (2 mg/ Kg SeNPs), $M_{0.6}$ (0.6%M), $S_2M_{0.6}$ (2mg/Kg SeNPs and 0.6% M), $S_2M_{0.3}$ (2mg/Kg SeNPs and 0.3% M), $S_1M_{0.6}$ (1 mg/Kg SeNPs and 0.6% M), $S_1M_{0.3}$ (1mg/Kg SeNPs and 0.3% M) respectively.

Significantly higher weight gain %, specific growth rate (SGR) and protein efficiency ratio (PER) were observed in $S_2M_{0.3}$ group ($P<0.05$) compared to all other groups. The antioxidant enzymes such as catalase and glutathione peroxidase (GPx) activity of $S_2M_{0.3}$ group varied significantly ($P<0.05$) from the control group (C) whereas superoxide dismutase (SOD) did not show any significant difference ($P>0.05$). The haematological profile of differential blood count did not show any significant difference ($P>0.05$). Significantly ($P<0.05$) highest total serum protein and globulin were found in S_2 group whereas highest albumin was found in the control (C) group. A/G ratio showed significant difference ($P<0.05$) with lowest values in $S_2M_{0.6}$ group. Based on the result of present study, it can be suggested that combination of selenium nanoparticles 2mg/Kg and 0.3 % methionine in the diet would be beneficial for optimum growth and antioxidant status in *Labeo rohita* fingerlings than providing methionine or selenium in higher doses.







(CIFE/2014/FPB403/SR)

Responses on Dietary Manipulation of Protein-carbohydrate Ratio on the Development of *Clarias Batrachus* (Linnaeus, 1758) Female Broodstock

Sanap Bhushan Nanasaheb

Major Advisor: Dr. P.P. Srivastava

A well balanced cost-effective diet delivering optimal reproductive performance with adequate protein-carbohydrate ratio (P:C ratio) has to be developed for economically important species, *Clarias magur* (Ham. 1822) To this end, three experiments were conducted. In the first 60 days experiment, fish of average weight of 3.44±0.35g were used and in the second 90 days experiment, fish of average weight of 90.15±4.76g (female broods) were used. The third experiment was conducted for 10 days and the larvae were used for this experiment. The feeds for all the experiments were formulated with six different protein (ranging from 15 to 40%) and carbohydrate (ranging from 36 to 74 %) levels, with different protein:carbohydrate ratios (D1 - 1.05:1; D2 - 1:1.26; D3 - 1:1.70; D4 -1:2.32; D5 – 1:3.25 and D6 – 1:4.87). Total weight gain and dry matter production were directly related to dietary protein level and P:C ratio, but were similar in D1, D2 and D3, indicating that a P: C ratio in D3 can be adopted.

Maximal wet weight gain and dry matter production were observed at dietary protein levels above 30% and P:C ratio ratios below 1:1.70 in both experiments. However, in experiment II, gonado-smatic index (GSI), morphology of ovary, ova size and gonad dry matter production of the D2 group was superior compared to other feeds. GSI and dry matter production were lowest in individuals fed diets with 15% protein, irrespective of the P:C ratio or carbohydrate level. Absolute fecundity, fertilization rate and hatching rate achieved highest without a shift of spawning time in D2 and D1 groups compared to other groups. At the end of the second experiment of 90 days, the fatty acids were measured as a percentage of total lipids. Fatty acid composition derived from ovary of fish fed with different experimental diets. Total saturated fatty acids (SFA) were highest in D6 (25.13%) followed by D5 (23.97%) and lowest value was observed in D1 (21.61%). A similar trend observed in monounsaturated fatty acids (MUFA) i.e. The mean value of n-6 and n-3 fatty acids of eggs from broodstock fed D1 and D2 diets, were highest and the lowest was observed in D6. Histology of oocyte maturation and expression analysis of vitellogenin showed that D1 and D2 group broodstock were more in more advanced stages than the other groups fed higher carbohydrates in diet. The highest vitellogenin expression was in D1, D2, and D3 groups on the 60th day compared to that of D4, D5 and D6 groups and this trend continued up to the 90th day.

These results reveal that the onset and progress of vitellogenesis was best observed in groups fed with higher protein: carbohydrate ratios. In experiment III, larval quality of all the experimental groups was studied with osmotic and shelter stress, which showed that larvae from D1 and D2 were more resistant to stress than larvae of another group of females. The results indicated that a diet with a P:C ratio of 1:1.7 containing 30% protein and 51% carbohydrates was optimum for growth of broodstock whereas 35% protein and 44% carbohydrates are optimum for superior gonadal development, maturation and growth of fingerlings. For the optimum stress tolerance and survivability of larvae a P:C ratio of 1:1.7 with 30% protein and 44% carbohydrate is recommended.

(CIFE/2016FNT604/SR)

Evaluation of Dietary Herbal Stimulants on Nutrients Digestibility, Growth and Immune Responses in *Labeo rohita*

Dilip Kumar Chowdhury

Major Advisor: Dr. N.P. Sahu

Three experiments were conducted to find out the potential of some dietary herbal stimulants (HS) on nutrient utilization, growth, body composition, digestive, metabolic, antioxidant enzyme activities and innate immune functions of *Labeo rohita* fingerlings. Eleven experimental diets were prepared by supplementing fennel, coriander, cumin, fenugreek, turmeric, black pepper, ginger, bay leaf, onion or garlic meal at 1% level along with a control diet (no HS). Turmeric, garlic or ginger meals appear to be more effective for enhancing digestive, metabolic, antioxidant enzyme activities and innate immune functions than the other herbal supplements. The physio-metabolic effects of HS tested in *Labeo rohita* fingerlings were in the order of turmeric > garlic > ginger > onion > fenugreek > cumin > coriander > fennel > black pepper > bay leaf meal.

In experiment IIA, best three herbs viz., turmeric, ginger and garlic meal in different combination were evaluated for their synergistic effect and found that dietary turmeric in combination with either ginger or garlic (1:1) at 1% level could improve nutrient utilization, growth, body composition and health status of fish. In experiment IIB, all three herbal stimulants were mixed in different proportion as T1 (10.9:1), T2 (10:7:3), T3 (10:5:5), T4 (10:3:7) and T5 (10:1:9) ratio of turmeric, ginger and garlic, respectively and found that feeding of turmeric, ginger and garlic mixture at 10:9:1 (T1) or 10:1:9 (T5) ratio at 1% could improve the growth, activities of digestive, metabolic and antioxidant enzymes and innate immune function in *Labeo rohita* fingerlings. In experiment IIC, the best two from IIA and IIB were compared T1 (Turmeric :Ginger at 1:1), T2 (Turmeric :Garlic at 1:1), T3 (Turmeric: Ginger :Garlic at 10.9:1), T4 (Turmeric: Ginger: Garlic at 10:1:9 ratio) and found that 1% inclusion of turmeric, garlic and garlic mixture at 10:9:1 ratio was found to be the best herbal mixture in relation to growth, gene expression, nutrient digestibility, digestive, metabolic & antioxidant enzymes immunity and disease resistance against *Aeromonas hydrophila*. In the final experiment, the dose of the best herbal stimulants mixture (turmeric, ginger and garlic at 10:9:1 ratio) based on experiment IIC was optimized in the diet of *L. rohita* fingerlings.

Accordingly, five experimental diets with graded level of HS *viz*. control (0%), T1 (0.5%), T2 (1.0%), T3 (1.5%) and T4 (2.0%) were prepared and fed to the fish for 60 days. At the end of the experiment, significantly higher ($P<0.05$) growth, nutrient utilization and lower FCR were recorded in T2, T3 and T4 groups. Digestive enzymes (protease, amylase and lipase) activities were significantly higher ($P<0.05$) in all the herbal mixture fed groups than the control group. Hepatopancreatic and gill antioxidant enzymes (SOD and CAT) activities were found to be enhanced in all the HS supplemented groups. Serum total protein and albumin, NBT value and serum lysozyme activity were significantly higher ($P<0.05$) in T1, T2 and T3 groups. According to second order polynomial regression analysis in relation to WG%, the optimum dose of turmeric, ginger and garlic mixture in the diet of *L. rohita* was 0.97% (~1%) at 10:9:1 ratio. Hence, dietary supplementation of 1% herbal conglomerate of turmeric, ginger and garlic at 10:9:1 ratio is found to be effective in enhancing growth and immune status of *Labeo rohita*.

Evaluation of Herbal Extracts of Arjuna, *Terminalia arjuna* on Growth, Immune Responses and Disease Resistance in *Labeo rohita* (Ham, 1822)

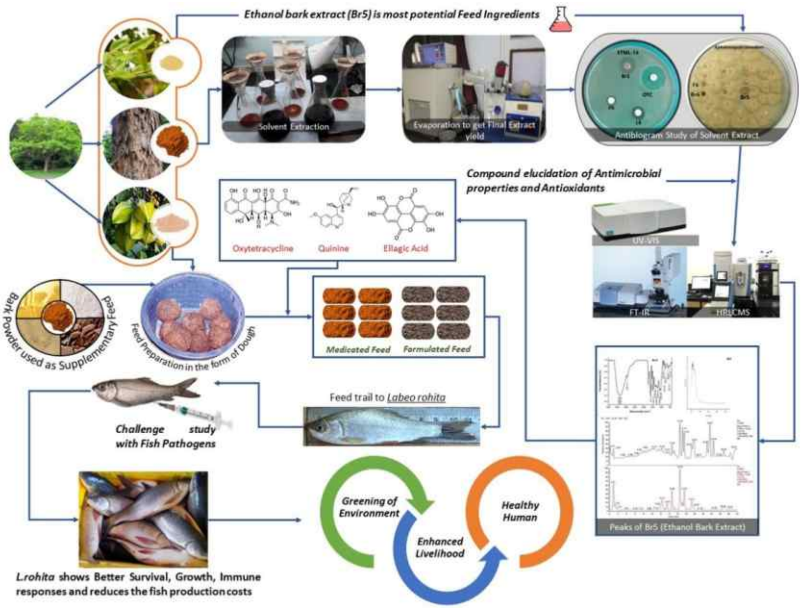
(CIFE/2016/FNT605/SR)

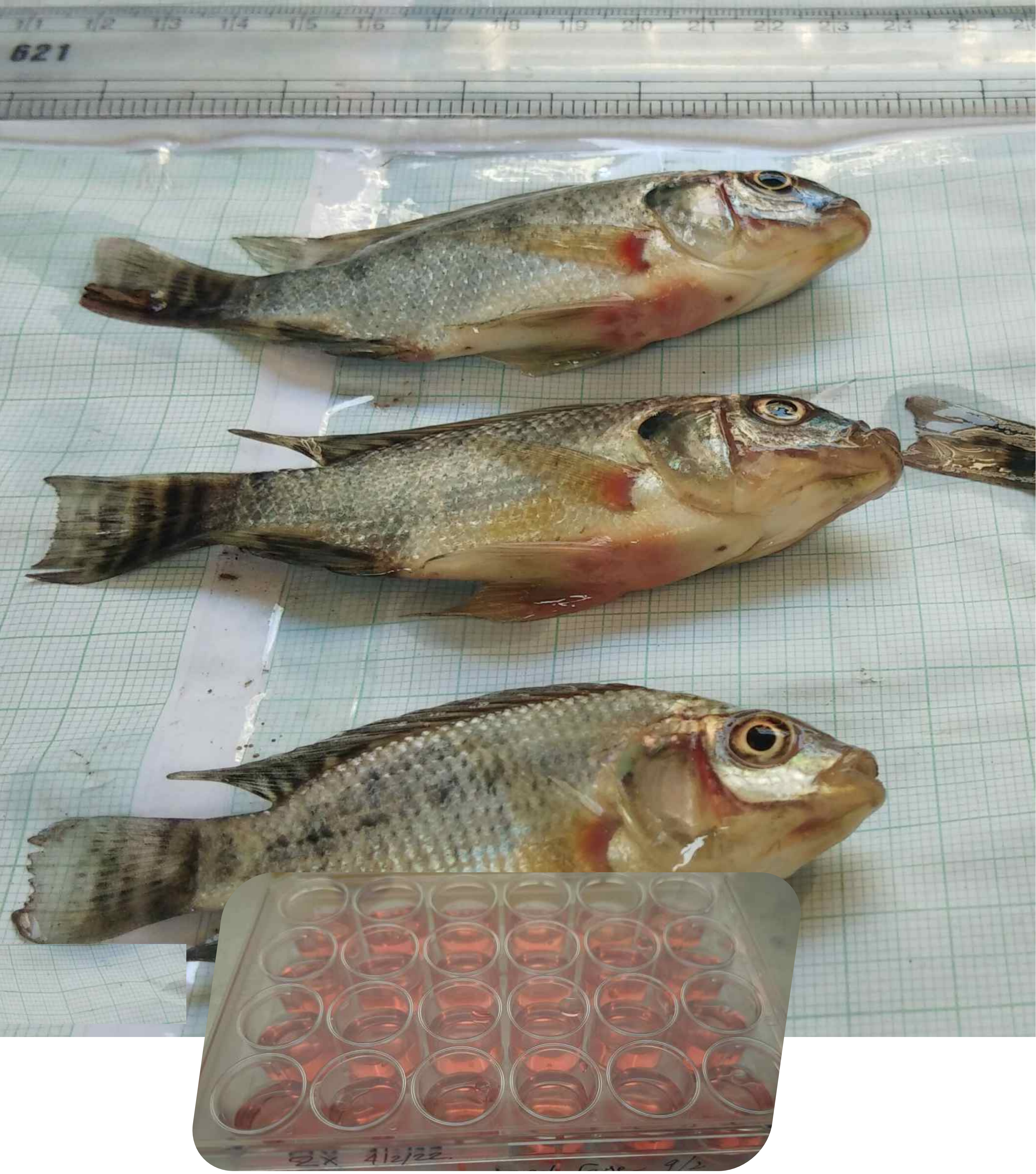
Dharmendra Kumar Meena

Major Advisor: Dr. B.K. Das

The current study investigated the effects of a solvent extract of *Terminalia arjuna* on growth, disease resistance, and immune responses in *Labeo rohita*. The ethanolic bark extract demonstrated broad spectrum antimicrobial activity against 17 different bacterial strains, as well as a fungal strain, *Aphanomyces invadans*, and a parasite, *Argulus bengalensis*, followed by methanolic bark extract & gt, acetone bark extract & gt; methanol fruit extract and ethanol leaf extract. Gallic acid (m/z 170.0208 g/mol) and Ellagic acid (m/z 302.0063 g/mol) were discovered as potential antioxidants in solvent extracts. Myrecetin and quercitin were common flavonoids found in leaf and bark extracts. In both indoor and outdoor pond feed trials, dietary *T. arjuna* bark powder (TABP) at 10g/kg feed yielded promising results in terms of growth, disease resistance, and immune responses. The intraperitoneal inoculation experiment yielded the best results (120 µg/ml per fish). The maximum weight gain percentages during the indoor feed trial (90 days) and the pond feed trial (60 days) were 148.41±0.854 and 134.51±3.31, respectively. While in intraperitoneal inoculation experiment (30 days) maximum weight gain percentage was recorded in first 15 days as compared to 30 days' time interval. Mx had the highest level of expression in the indoor feed trial, followed by ISG15 and STAT1, and the same trend was seen in the intraperitoneal inoculation experiment.

However, after infection, an increased level of Mx and STAT1 was observed in the indoor feed trial and intraperitoneal inoculation experiment. Digestive enzymes, serum parameters of various functions, oxidative stress enzymes, and hemato-biochemical indices differed according to the graded level of TABP and its extracts, and followed the same trend as in growth studies. The optimal dose of TABP in both the indoor and outdoor pond feed trials was found to be 7.9 g/kg and 8.5 g/kg, respectively. The histoarchitectural changes in vital organs matched the feed trial results. Gut microbiome studies have also found strong evidence that TABP has a positive impact on the gut microbiota, lending support to the normobiosis hypothesis. As a result, the current study suggests that TABP can be used effectively as a feed supplement. Furthermore, ethanolic bark and methanolic bark extracts have been found to be safe for hosts and could be used to develop bio-pesticides against potential fish pathogens.





AQUATIC ANIMAL HEALTH

National Surveillance Programme For Aquatic Animal Diseases

(CIFE/2018/400/EF)

Project duration: 2018- 2025

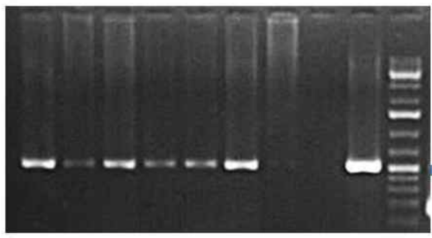
Principal Investigator
Dr. K. Pani Prasad

Co-Principal Investigators
Dr. R.P Raman

Budget: Rs. 149.70 lakhs

Funding agency
National Fisheries Development Board, Hyderabad

The baseline information of shrimp farms and shrimp samples from five districts in Maharashtra (Raigad and Thane), Gujarat (Valsad, Navsari and Surat) were collected. Biological samples were collected from 57 shrimp farms (20 - 30 samples from per pond) for screening of viruses includes WSSV, HPV, MBV, AHPND, IHHNV, IMNV, YHV & EHP by using polymerase chain reaction (PCR). Samples collected from farms in Thane and Raigad districts (Rahul Deshpande Farm, Thane, collected at 63 DOC during June 2021 ; Samarun Aqua Farm and Rambhau Laxman Farm, Raigad, collected at 55 DOC and 60 DOC respectively during August 2021 and December 2021) were WSSV positive. EHP was positive by Nested PCR in a sample from Raigad District, Maharashtra in the month of August 2021 from Shri Gharat Aqua Farm at 61 DOC. The Data generated were updated on the NSPAAD website by ICAR-NBFGR as per the technical programme. Emergency harvesting in disease infected farms saved from great economic loss to farmers. Farmers were advised to take precautions to avoid recurrence of disease.



Gel image of WSSV +ve

Prevention and control of diseases: Advice to farmers

- It is advisable that ponds are stocked with SPF seed.
- The most important measure is to prepare ponds appropriately as per the BMP protocols to ensure that the pond is free from pathogens before the seed is stocked.
- After every harvest, it isvery important that the ponds are disinfected and thoroughly dried.
- Application of lime (CaO) at the rate of 6 tons per hectare, followed by thorough ploughing and maintaining moist condition for about a week to raise the soil pH to 12 has been also suggested for the disinfection of ponds.
- It is essential to focus efforts on producing high quality seed, follow improved better management practices, routine farm biosecurity measure and responsible trade practices to prevent epizootics in shrimp farming.

All India Network Project on Fish Health

(CIFE/2015/401/EF)

Project duration: 2015-2025

Principal Investigator
Dr. K. Pani Prasad

Co-Principal Investigator
Dr. Swadesh Prakash

Budget: Rs.55 lakhs

Funding agency
Indian Council of Agricultural Research, New Delhi

Micro dilution assay was performed using antibiotic florfenicol (Cat. No. F1427-500MG, Sigma Aldrich, USA) to determine its MIC and MBC against fish pathogen *Staphylococcus aureus* and *Aeromonas hydrophila.* The standard solution of 40 µg/ml florfenicol was prepared using sterile distilled water. The final concentrations of 20, 10, 5, 2.5, 1.25, 0.6, 0.3, 0.15, 0.08, 0.04 and 0.02 µg/ml were prepared by two-fold dilution. Each well was inoculated with 100ul of 10^6 CFU/ml of bacterial isolate in triplicates using ATCC cultures as control. After an incubation period of 24 hr the optical density (OD) of wells was observed at 620 nm in a microplate reader. 50 µl of suspension from each of the wells was inoculated into Müller-Hinton agar and incubated at 25°C for 48 hr. The lowest concentration of florfenicol showing bacterial inhibition in microplate reader is considered as MIC and lowest concentration showing no growth after 48 hr of incubation is considered as MBC.

Evaluation of the pharmacokinetics of in-feed administered florfenicol (FFC) to freshwater fishes

The antibiotic florfenicol (Cat. No. F1427-500MG, Sigma Aldrich, USA) was used in the study. Common carp (*Cyprinus carpio*) with the size of 115-125 g body weight and fish feed was procured from Raigad, Maharashtra. The health status of the fish was monitored daily. After acclimatization, the fish were divided into two groups: control (n=150) and treatment (n=150) with each group having three replicates. For the experimental study, medicated feed was prepared by blending the drug in feed to deliver a dose of 15 mg/kg BW. The treatment group was given in-feed administered florfenicol 15 mg/kg BW and the control group with non-medicated feed. The blood, skin, muscle, liver, kidney, gill, bile and intestine from three fish in each tank are pooled at 0, 2, 3, 4, 6, 8, 12, 16, 24, 32, 48, 64, 96 and 128 hr after administration of the drug. All samples are immediately frozen and stored at -20 °C for analysis. Pooled samples were submitted to ICAR-CIFT, Kochi for estimation of FFC and florfenicol amine using LS-MS-MS.

Plasma concentrations of florfenicol after single-oral administrations at 15 mg/ kg (body weight) in Common carp *(Cyprinus carpio)*

MIC and MBC results

Bacteria	MIC	MBC
S. aureus	5	10
S. aureus ATCC	10	20
A. hydrophila	2.5	10
A. hydrophila ATCC	5	10

Pharmacokinetics of florfenicol and florfenicol amine in plasma

Parameter	Florfenicol	Florfenicol amine
t1/2 (h)	14.70	24.32
Tmax (h)	4	32
Cmax (ng/ml)	7203.33	36.41
AUC (μg*h/ml)	148.239	1.903
MRT (h)	25.05	52.18

Time(h)	Concentration (ng/mL, mean± SD)
0	0.60±0.90
2	2.25±2.39
3	6.34±6.73
4	9.37±5.79
6	8.32±8.46
8	15.83±7.78
12	14.66±7.81
16	16.48±18.30
24	26.91±4.86
32	36.42±28.08
48	22.86±17.83
64	20.09±25.73
96	3.32±1.76
128	3.14±0.93

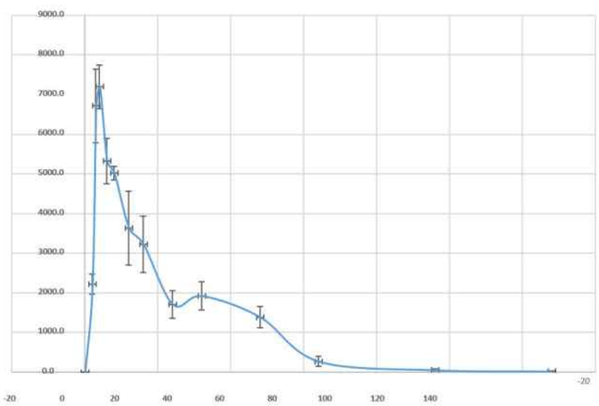
Time(h)	Concentration (ng/mL, mean± SD)
0	000±000
2	2222.75±437.90
3	6721.07±1608.92
4	7203.33±952.59
6	5330.00±992.92
8	5025.00±295.00
12	3637.46±1614.48
16	3230.00±1233.81
24	1710.63±605.54
32	1925.86±617.49
48	1391.00±468.50
64	275.33±217.77
96	53.20±35.50
128	22.03±9.43

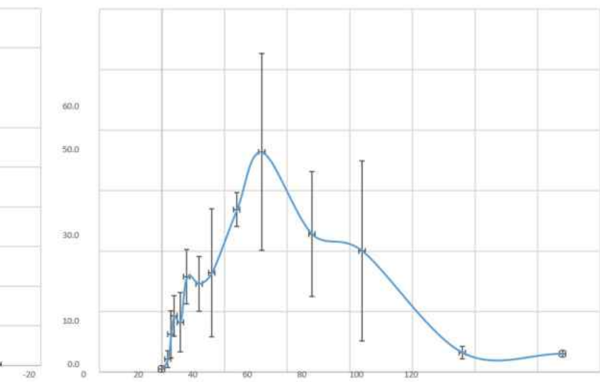
Florfenicol concentration in different tissues

Tissue	Tmax (h)	Cmax (ng/ml)	t1/2B
Skin	3	3285	19.743
Bile	3	4900	61.786
Intestine	2	10225	16.994
Kidney	3	4510	12.691
Liver	2	4390	30.626
Muscle	3	10070	17.63
Gill	3	3705	15.391

Withdrawal time for florfenicol amine

Days	FFA concentration (ng/g)	Log concentration
1	204	2.30963
2	50.64	1.704494
3	16.128	1.207581
4	9.435	0.974742
5	4.56	0.658965
6	3.55	0.550228
7	1.98	0.296665
8	1.1	0.041393
9	0.365	-0.43771
10	0.14	-0.85387





Mean concentrations of florfenicol and florfenicol amine in plasma versus time

Evaluation of withdrawal period of florfenicol (FFC) administered as feed top dressing to fishes

The medicated feed was prepared by adding florfenicol powder to a solution of Tween-20, polyethylene glycol, DMSO and ethanol. This solution containing the antibiotic was sprayed on the feed pellets. The treatment group was administered with feed which was top dressed with florfenicol (FFC) 15mg/kg BW and the control group with feed without the drug. Survival (%) and average body weight (g) was recorded on 0, 5, 10, 15 and 20th day. Pooled samples were submitted to ICAR-CIFT – Cochin for estimation of FFC and Florfenicol amine LS-MS-MS.

Evaluation of the safety of florfenicol (FFC) administered as feed additive to common carp. After acclimatization, the fish were divided into control and four treatment groups (n=150) that were administered with feed top dressed with florfenicol (FFC) 30, 50, 75, 150 mg/kg BW. The samples collected for histopathological analysis were collected once in 10 days for 40 days for the effect of drug on vital organs.

Achievements under objective "Economic impact of aquatic animal diseases occurrence"

- Survey of farms for economic loss assessment of fish diseases were conducted in Fish farms of Haryana, Andhra Pradesh and Telangana; Fish and Shrimp farms of Maharashtra. The number of farms surveyed were recorded and updated in excel and the data was fed in Google forms.
- Information regarding farming practices was collected during the surveys. The main fish species cultured are IMCs, CMCs, pangas catfish, magur, tilapia. Mortality is commonly due to bacterial, fungal and water quality problems. Domestic sewage, agricultural run-off and industrial effluents (some farms of Haryana) mainly contribute to the pollution of water supply of the fish farms. Water quality such as ammonia, pH and dissolved oxygen is the main concern of the farmers.

(CIFE/2019/AAH904/SR)

Study on Pharmacokinetics of Florfenicol in Common carp, *Cyprinus carpio*

Ashish P. M.

Major Advisor: Dr. K. Pani Prasad

The present study was undertaken to explore the pharmacokinetics of florfenicol following single-dose administration of in-feed incorporated medicated feed at 15mg/kg body weight in common carp *(Cyprinus carpio).* Following the single oral administration, blood and tissue samples were collected at 0, 2, 3, 4, 6, 8, 12, 16, 24, 32, 48, 64, 96 and 128 h. Plasma and tissue samples were analysed for florfenicol (FF) and its major metabolite florfenicol amine (FFA) concentrations using liquid chromatography with tandem mass spectrometry (LCMS/MS) technique. The drug was absorbed rapidly after administration with a Cmax of 7203 ng/mL at 4h (Tmax). The data was fitted into one-compartment open model to obtain other pharmacokinetic parameters using PK Solver 2.0. The predicted values for Cmax of 5747.84 at 6 h (Tmax), absorption half-life (t½ka) of 1.42 h, elimination half-life (t½β) of 11.72h, distribution volume (V/F) of 0.00195 (mg/kg)/(ng/mL), apparent total clearance of the drug from plasma after oral administration of 0.000115 (mg/kg)/(ng/mL)/h, $AUC_{(0-\infty)}$ of 130192.70 ng/mL·h and mean residence time of the drug in the body (MRT) of 18.97 h were noted for FF. The observed Cmax value of FFA, 26.4 ng/L was observed at 30.45 h (Tmax) post administration, t½ka of 19.28 and t½β of 23.16 h signifying its formation in the body post the drug metabolism. It was also found that FF was extensively distributed in all the tissues in quantifiable amounts that exceed the MICs of most of the bacterial pathogens. Hence, the outcome of the study is helpful to establish the safety and usage of florfenicol for the treatment of bacterial infections in common carp.

Study on Tissue Depletion and Withdrawal Period of Florfenicol in Common carp *(Cyprinus carpio)*

(CIFE/2019/AAH909/SR)

Allakonda Sunanda

Major Advisor: Dr. K. Pani Prasad

The aim of this study was to evaluate the depletion and withdrawal period of florfenicol in common carp (*Cyprinus carpio*). Fishes with an average weight of 20 ± 3.0 g were administered florfenicol in-feed at a dose of 15 mg/kg body weight per day for 10 consecutive days. Post the feeding window, muscle tissues were collected at different time points *viz.*, 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 days and stored in -20 °C. Withdrawal period of florfenicol and its major metabolite florfenicol amine were analysed in LC-MS/MS and calculated using log transformed linear regression analysis. As per EU, the MRL of florfenicol is 1000 µg/kg and withdrawal time 500 °days, as established by Directive 2004/28/EC. The withdrawal period of florfenicol in common carp muscle was estimated to be 1.89 days or 45.36 h. Further, the complete elimination time for florfenicol and florfenicol amine at concentration (0.001 ng/g) at an average temperature (28.4 °C) was estimated to be 11.23 days or 318 °days and 16.91 days or 480.2 °days respectively. Hence the study forms a base for further studies on the use of florfenicol and for future applications in treatment of bacterial disease in fish.

Network Program on Assessment of AMR in Micro-organisms Associated with Fisheries and Aquaculture in India

(CIFE/2018/402/EF)

Project duration: 2018- 2025

Principal Investigator
Dr. K. Pani Prasad

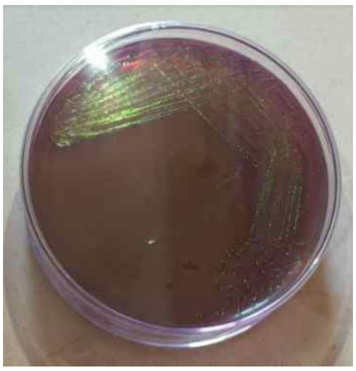
Co-Principal Investigator
Dr. K. Jeena

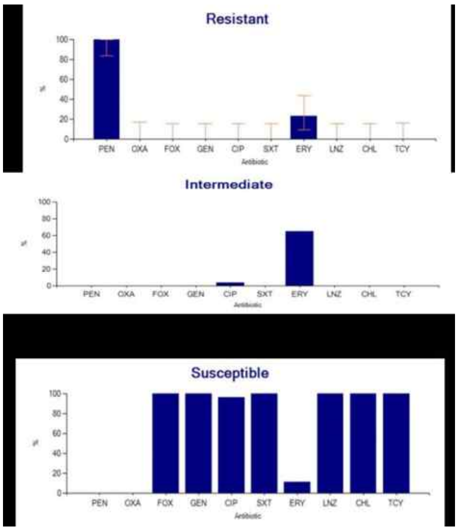
Budget: Rs.40 lakhs

Funding agency
Indian Council of Agricultural Research, New Delhi

During the reporting period a total no of 37 shrimp farms were sampled from Maharashtra and Gujarat of which 22 farms were from Thane, 2 farms from Ratnagiri and 8 and 5 farms each from Surat and Valsad respectively. *Escherichia coli, Vibrio parahaemolyticus, Staphylococcus aureus* and Coagulase Negative *Staphylococcus* species were isolated from the shrimp samples by following the standard protocols. The susceptibility pattern of all isolates to a panel of antibiotics were analysed by performing Antibiotic Susceptibility Testing using Kirby Bauer Method.

A total of 31 isolates were confirmed as *Escherichia coli* based the differential isolation on Eosin Methylene Blue (EMB) agar, distinguished by the green metallic sheen (Fig 1). The isolates were confirmed as methyl red +ve, Voges Proskeur, Citrate Utilization and Oxidase –ve and Indole +ve. *E. coli* isolates were resistant to Ciprofloxacin (7.1%), followed by Tetracycline (3.57%) and Cefotaxime (3.4%); 25%, 13.7% and 6.6% were intermediately resistant to Ciprofloxacin, Cefotaxime and Chloramphenicol respectively.





A total of 42 *Staphylococcus sp.* were isolated from the samples, out of which 6 isolates were identified as coagulase negative (CONS) and 36 isolates as *S. aureus.* Further, biochemical characterization and the AST were performed. The *S. aureus* isolated were catalase +ve, mannitol and glucose fermentative and coagulase +ve. Also they are depicted as clear opaque zones around the black colonies on Baird Parker Agar (Fig 3). *S. aureus* were resistant to Penicillin (100%), Erythromycin (23%) and 65.3% of the isolates were intermediarily resistant to Erythromycin (Fig 4). A total of 35 *V. parahaemolyticus* isolated from the samples, 60% were found resistant to Penicillin and 40%, 28%, and 25% of the isolates were intermediarily resistant to Ampicillin, Cefoxitin and Ciprofloxacin respectively.

Understanding Molecular Basis of Host-Pathogen Environment Interaction of Tilapia Lake Virus Disease

(CIFE/2019/403/EF)

Project duration: 2019-2022

Principal Investigator
Dr. K.V. Rajendran

Co-Principal Investigators
Dr. Megha K. Bedekar
Dr. Saurav Kumar

Budget: Rs.86.34 lakh

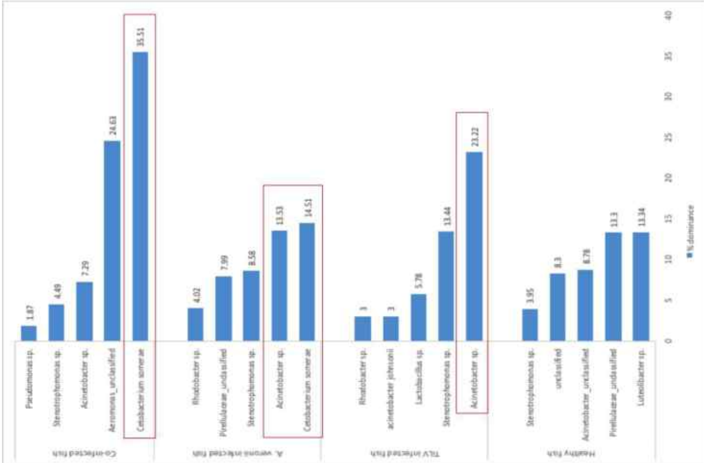
Funding agency
National Agricultural Science Fund (NASF)

Determination of LD50 of Aeromonas veronii for co-infection study

During the period under report, a co-infection experiment involving TiLV and one of the dominant bacteria isolated from tilapia collected during a natural disease outbreak, *Aeromonas veronii*, was carried out. For determining the LD50 of *A. veronii* isolated from *Oreochromis niloticus* naturally co-infected with TiLV, the juvenile tilapia (10-15 g) were challenged with different concentrations starting from $1{\times}10^7$ to $1{\times}10^4$ CFU/mL of *A. veronii*. Each animal was injected intraperitoneally with 100 µL of the respective dilutions prepared in PBS and the mortality pattern was observed for a period of 10 days. As per the cumulative mortality pattern over the time course, the determined LD50 of the *A. veronii* isolate was found to be approximately 10^5 CFU/mL. The targeted bacterium was re-isolated from the moribund or dead animals to confirm the experimental infection.

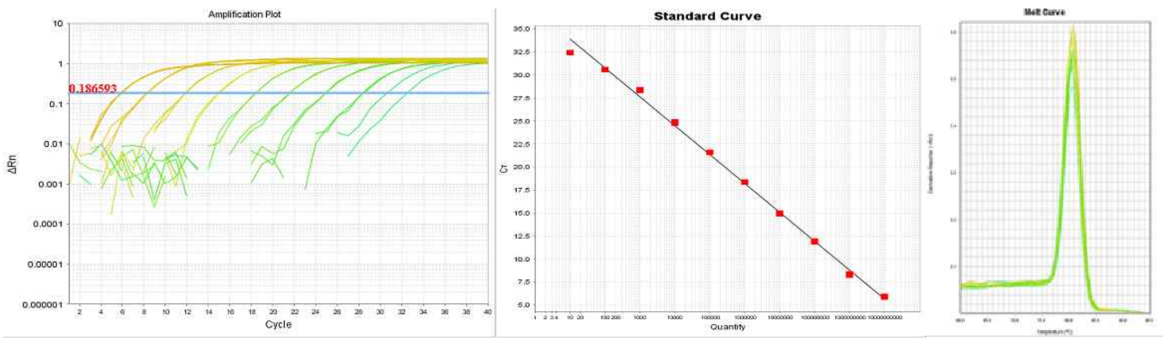
Co-infection of TiLV and A. veronii

The effect of co-infection in TiLV disease cases was evaluated through an experimental co-infection by TiLV and *A. veronii* in juveniles of *O. niloticus.* Before conducting the experiment, the animals were acclimatized for one week and the absence of TiLV infection and *A. veronii* was ascertained through qRT-PCR or bacterial isolation from internal organs of healthy animals. For TiLV infection, the fish were challenged with 150 µL of supernatant of TiLV-infected OnH cell line as described previously (Yadav et al., 2021). While, two sub-lethal concentrations of *A. veronii* such as 10^6 and 10^5 CFU/mL were used in the experiment and denoted as '*bacterial high dose*' and '*bacterial low dose*', respectively. In the experiment, there were a total of six experimental groups containing thirty fish in each. The six experimental groups were control (100 µL of PBS injection / 150 µL sterile cell culture media), TiLV (150 µL of supernatant of infected OnH cell line), *bacterial high dose* (100 µL of 10^6 CFU/mL *A. veronii*), *bacterial low dose* (100 µL of 10^5 CFU/mL *A. veronii*), TiLV + bacterial high dose (150 µL of supernatant of infected OnH cell line + 100 µL of 10^6 CFU/mL *A. veronii*), TiLV + bacterial low dose (150 µL of supernatant of infected OnH cell line + 100 µL of 10^5 CFU/mL *A. veronii*). The experiment was conducted for over a period of 10 days with sequential sampling from all the groups. Initially, at 0 days post-infection, the animals in three groups including TiLV and co-infection groups were injected with 150 µL of TiLV-infected cell culture supernatant and animals in the rest of the groups were injected with 150 µL of cell culture media. At 4 dpi, control and TiLV groups were injected with 100 µL of sterile PBS, while respective bacterial and co-infection groups were injected with 100 µL of 10^6 or 10^5 CFU/mL bacterial dilutions in PBS. Following the experimental infection, three fish each from all the groups were sacrificed and tissues such as liver, brain and spleen were collected in RNALater, while different portions of the gut were preserved in 70% ethanol for microbiome analysis at 6, 8 and 10 dpi. In a concurrent experiment, 10 fish each from all the six groups were kept separately for estimating the cumulative mortality in the groups.



In the control group, mortality or clinical signs of either TiLV or *A. veronii* infection were not noticed. In the TiLV group, the animals showed typical signs of infection including bilateral exophthalmia, bulged belly with scale protrusion and ascitic fluid in the abdominal cavity. Further, in the co-infection group, increased mortality was observed compared to the groups infected with either TiLV or bacteria alone. However, different concentrations of bacteria did not have any significant difference in exhibiting infection or mortality in the co-infection with TiLV. DNA for metagenomic sequencing was isolated from fish gut using CTAB EDTA method and sample DNA extracted from gut tissues (pooled from 3 fish) collected from uninfected (control) and both were subjected to amplicon sequencing using Illumina MiSeq Platform.

- The bacterial diversity drastically diminished with certain bacteria being predominant such as *Cetobacterium, Acinetobacter and Pseudomonas*.
- *Cetobacterium* (Bacteroides type A) was dominant throughout the co-infection study.
- *Cetobacterium* (Bacteroides type A) was also dominant in group of fishes infected bacterial alone.
- *Acinetobacter* abundance increased in TiLV-infected group and peaked in S 4.1.
- *Acinetobacter*, *Cetobacterium*, *Stenotrophomonas*, *Bifidobacterium* & *Lactobacillus* were dominant in virus-infected samples, while *Cetobacterium* was more dominant in co-infected samples.
- Intestines of pathogen-infected groups had higher levels of harmful genera such as *Sphingomonas, Atopostipes, Staphylococcus* and *Acinetobacter* .



Lane Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	N	P
Sample code	S1C	S11	S2C	S21	S24	S25	S3C	S31	S34	S35	S4C	S41	S44	S45		
PCR result	-	++	-	+	+	++	-	+	++	++	-	++	++	++	-	+++
Viral copy number		$1.4x10^7$		$4.9x10^5$	$4.1x10^6$	$2.7x10^8$		$5.7x10^7$	$1.3x10^8$	$1.0x10^8$		$1.0x10^8$	$8.0x10^6$	$5.3x10^6$		
Sample		TiLV-4 dpi		TiLV-6 dpi	High dose-2 dpi	Low dose- 2 dpi		TiLV-8 dpi	High dose-6 dpi	Low dose- 6 dpi		TiLV-10 dpi	High dose-8 dpi	Low dose-8dpi		

To develop and standardize a quantitative, consensus real-time PCR for TiLV, PCR analyses were carried out on cDNA prepared from liver tissue of experimentally-challenged fish using the PCR primers reported previously targeting the genome segments such as 1, 3, and 5. The nested PCR reported earlier had shown variability in the detection of TiLV. Therefore, after comparing the sequences of all the genomic segments, new primers targeting the conserved region of TiLV genomic segments 1 and 10 were designed and tested in the conventional PCR format. The primers targeting segment 10, when used in a single-step PCR format, showed better detection compared to the PCR protocols reported earlier. Further, primers and TaqMan probes were designed targeting the sequences of segments 1 and 10 for the real-time PCR and employed in quantifying the viral load in experimentally-challenged fish (Fig.2). Further standardization of the real-time assays is under progress.

Characterization of Mucosal Immunoglobulins in Tilapia and Development of ELISA for Diagnosis of Tilapia Lake Virus (TiLV) Infection

(CIFE/2019/404/EF)

Project duration: 2019-2022

Principal Investigator
Dr. Megha K. Bedekar

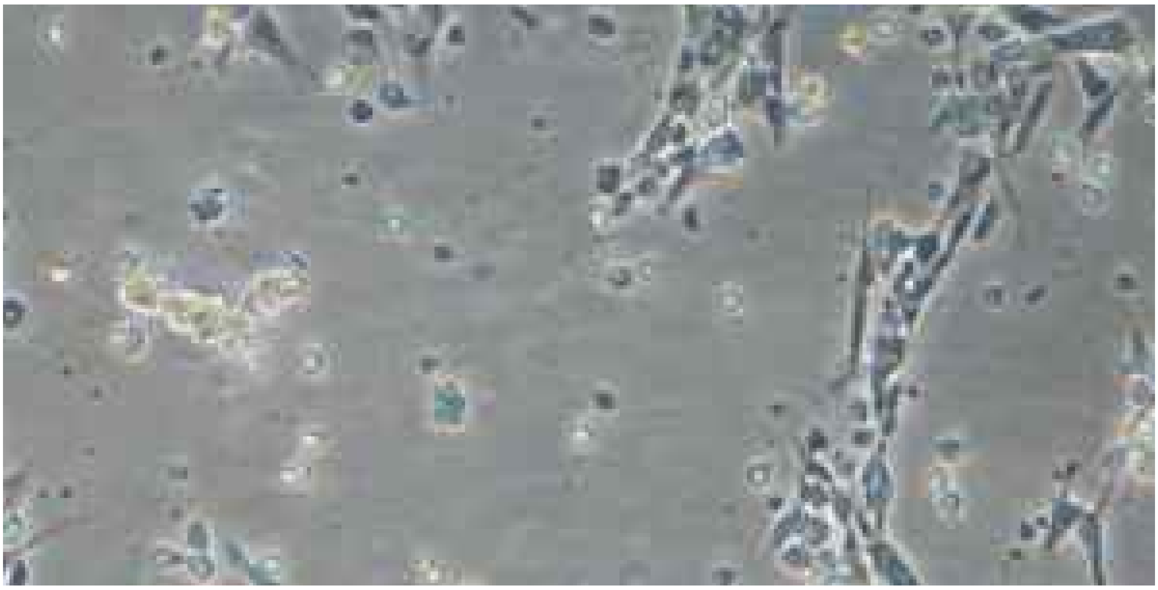
Co-Principal Investigators
Dr. Rajendran K.V.
Dr. Jeena K.

Budget: Rs. 29 Lakhs

Funding agency
Department of Biotechnology, New Delhi

During the study period TiLV strain and *O. niloticus* liver cell lines were procured from NBFGR, Lucknow. The virus was propagated in cell line (OniL). Cells were maintained in the laboratory as per standard protocol. Briefly, cells were maintained in L–15 medium containing 20% Fetal Bovine Serum (FBS) (Gibco by Life technologies, USA) and 1× concentration of antibiotic-antimycotic solution. The nested RT-PCR amplification of segment 3 in infected OniL cell lysate, mucous and pooled liver tissues from suspected fish were done. Positive amplification was observed in the samples received from tilapia farms near Mumbai and NBFGR. These were positive for TiLV as detected by RT PCR and AGID. Further samples received during the reporting period from various farms were also tested for TiLV.

Spiking of mucosal samples with TiLV and further confirmation for virus detection: Mucous collected from tilapia fingerlings were spiked with TiLV and incubated at 28 °C. The samples were tested for TiLV at 4 different time points post spiking. Mucous spiked with TiLV showed detection of virus till 12h. AGID confirmed the specific reactivity of antibodies for detection of TiLV in known positive and suspected samples by AGID; and further confirmed by RT-PCR.



Development of Monoclonal Antibody against *Flavobacterium columnare* & its Use in Rapid Disease Diagnosis

(CIFE/2019/1/IF)

Project duration: 2019-2022

Principal Investigator
Dr. Megha K. Bedekar

Co-Principal Investigators
Dr. Rajendran K.V.
Dr. Gayatri Tripathi
Dr. Jeena K.

The project is aimed to develop monoclonal antibody (MAb) against *Flavobacterium columnare* (fish origin) strain isolated from local area. *F. columnare* strain/ bacteria isolated during project period cultured and confirmed by following biochemical and microbiological tests. Hyper immune sera raised in rabbit against *F. columnare* was used to detect the *F. columnare* in suspected samples. Pathogenicity evaluation of *F. columnare* was done through immersion route in *L. rohita* fingerlings @ 1×10^6, and 1×10^7 CFU/mL for 2 hr.

Sampling from fresh water fish farms around Mumbai and fish farms from Gujarat areas were done during the months of April-November 2021. Any fish brought in wet lab were screened for *F. columnare* infection at 2-3 days of introduction, confirmatory diagnosis was done by symptoms, lesions microbiological, biochemical and molecular detection and polyclonal antibody based iELISA. The protocol for indirect ELISA that was optimized using polyclonal anti-flavobacterium sera and was used for screening of samples that were also screened by PCR. Efficacy testing of the test recorded 85% sensitivity and 100% specificity.

Immunization of mice with specific immunogenic peptides

Based on the *in silico* analysis of proteins of *F. columnare* gene Chondroitin AC lyase (AY912281) sequences which was selected for targeting MAb production was further curated for highly immunogenic peptides using *http://tools.immuneepitope.org/bcell*. Based on best score *F. columnare* strain B067 collagenase gene, complete cds GenBank:KR014146.1 two peptide fragments are selected for further immunization. Overall screening of 100 passive and suspected samples was done for *F. columnare* infection by ELISA. Rohu, catla and gold fish were found positive for infection whereas tilapia and mrigal were tested negative for infection.

Development of Dual Combination Vaccine for Protection of *Labeo rohita* to Bacterial Pathogens *Flavobacterium columnare* and *Edwardsiella tarda*

(CIFE/2015/405/EF)

Project duration: 2015-2022

Principal Investigator
Dr. Megha K. Bedekar

Co-Principal Investigators
Dr. Kundan Kumar
Dr. Saurav Kumar

Budget: Rs. 168 Lakhs

Funding agency
ICAR- Consortia Platform for Vaccines and Diagnostics

Edwardsiella tarda used for vaccine development was procured from (Himedia, India). *E. tarda* ATCC® 15947 was revived using brain heart infusion (BHI) broth. According to Reed and Muench (1938), LD 50 value was estimated and relative percent survival of rohu treated with formalin-killed *E. tarda*, formalin-killed *E. tarda* plus adjuvant and adjuvant alone was calculated. In the first group, fish were injected intraperitoneally with 0.1 ml of formalin-killed *E. tarda*, with concentration (1.7×10^7 Cfu/ml) and designated as T1. In second group, fish were injected intraperitoneally with 0.1 ml of formalin-killed *E. tarda* and adjuvant (MUKTAVAC ® 825F) in 1: 1 ratio and designated as T2. In the third group, fish were injected intraperitoneally with 0.1 ml of adjuvant (MUKTAVAC ® 825 F) and PBS in 1: 1 ratio and designated as T3. On 60th day post vaccination, the fish from all the four groups including control were challenged with lethal dose, and mortality was recorded for 10 days. Relative percent survival was calculated by using the formula (Amend, 1981) and were found 45, 54.16 and 21.43 for T1, T2, and T3 respectively. The results reveal a better survival could be achieved by the addition of adjuvant. Formalin-killed *E. tarda* vaccine along with adjuvants could give better immune response than vaccination with formalin-killed *E. tarda* alone or adjuvant alone.

(CIFE/2019/AAH906/SR)

Study on Effect of Emulsion Based Adjuvant on Protection and Immune Response of *Labeo rohita* Immunized by Formalin-killed Cells of *Edwardsiella tarda*

Mohiadeen Shajia Banu S.

Major Advisor: Dr. Megha K. Bedekar

Edwardsiella tarda is a bacterial pathogen that can infect many different fish species cultured worldwide. Various types of vaccines have been developed. Inactivated vaccines are cost effective but exhibit poor immune protection against edwardsiellosis in some reports. Adjuvants are immune enhancers that are often used in vaccination to augment the immune response of a vaccine, thereby enhancing the protective immunity against the targeted disease. In this study, we aimed to evaluate the protective efficacy of formalin-killed cells (FKC) against *E. tarda* in *Labeo rohita* with a commercial emulsion-based adjuvant named Muktavac® 825 F. As a result, the relative percent survival (RPS) of the fish group vaccinated with FKC reached 54.16% in the presence of the adjuvant whereas the RPS was 45% in the absence of adjuvant. Moreover, blood and serum parameters like peroxidase activity, creatinine level and albumin assay also indicated that both humoral and cellular immune responses were induced by the adjuvanted vaccine. The group injected with adjuvant alone, was also found to produce some non-specific immune response and showed 21.43% RPS. In summary, addition of an emulsion-based adjuvant enhanced the protective efficacy of formalin-inactivated *E. tarda* vaccine.

(CIFE/2015/AAH503/SR)

Mucosal Immune Response Studies Following PLGA Conjugated DNA Vaccine Construct Delivery Through Immersion Method in *Labeo rohita* Against *Edwardsiella tarda*

Tasok Leya

Major Advisor: Dr. Megha K. Bedekar

A DNA vaccine is an important tool to elicit both humoral and cellular immunity. The present study investigates the mucosal immune response of *Labeo rohita* (15 ± 04 g) to plasmid DNA (pDNA) vaccine macromolecule complexed with nanoparticles (NPs). Poly lactic-*co*-glycolic acid (PLGA), Chitosan (Chit), and PLGA-Chit-NPs were synthesized by double emulsion solvent evaporation method. Synthesized NPs were complexed with pDNA (pGPD+IFN) vaccine construct. Size and Zeta potential of PLGA-NPs, Chit-NPs, and PLGA-Chit-NPs-pDNA complex were recorded to be 120 nm and +0.5mV, 117nm and +32 mV, 189 nm and +11mV, respectively. Immunization by immersion was carried out in three groups receiving PLGA-Chit-NPs-pDNA (T1), PLGA-NPs-pDNA (T2), and Naked pDNA (T3), respectively. After immersion, samples were collected on 0, 2, 4, 7, 15, and 30 days from mucosa-associated lymphoid tissues (MALT) for mRNA expression studies of IgM, IgD, IgZ, and pIgR, using qRT-PCR. Significant up-regulation of the mRNA expression of IgM, IgD, IgT, and pIgR were observed in MALT in immunized fish compared to control. A polyclonal antibody was also developed to estimate IgM titre in the serum and mucosal-associated tissues (MAT) using ELISA. IgM level in serum and mucosal tissues (skin, gill, and gut) increased significantly 2 days post-vaccination compared to the control group, also non-specific immune parameters (myeloperoxidase and lysozyme levels) showed significant increase in the vaccinated fish.

Furthermore, histological examination confirmed minor damage in the physiological structure of the kidney and the liver cells in vaccinated fish. Vaccinated groups also exhibited a significant increase in the total serum protein, and globulin concentration. Survival rate study revealed that highest RPS was recorded in the T1 (64.7 %) group followed by T2 (52.94%), and T3 (47.05%), respectively. Knowledge of the immune gene expression at MALT in *L. rohita* primed with the PLGA-Chit-NPs-pDNA vaccine complex provides better protection against *E. tarda*. The normal physiology findings of this study will aid in monitoring changes in the health status of fish when the animals undergo vaccination.

(CIFE/2019/AAH907/SR)

Assessment of Protective Immune Response Induced by Inactivated *Aeromonas spp.* in Tilapia (*Oreochromis niloticus*, Linnaeus 1757)

Sanjaykumar Rathod

Major Advisor: Dr. Megha K. Bedekar

Aeromonas veronii is a frequently observed bacteria, causative agent of disease in freshwater fish. Many vaccine trials at laboratory levels have been taken-up against *Aeromonas* sp. pathogen, but commercial vaccines are not yet available in India. In the process of developing an inactivated vaccine against *A. veronii*, inactivation *of* bacteria was carried out by 0.3% formalin. Fish were immunized with inactivated *A. veronii* cells through immersion method. After booster dose on 21st day, fish were challenged at day 35 post vaccination with live *A. veronii* by intra peritoneal route. The relative percentage of survival was higher in the immunized group (59.3%). After the first vaccine dose and booster immunization, the values of WBC count, HCT and Hg increased significantly but RBC count showed significant reduction. Immunized fish did not show significant pathological reaction after post challenge. Histological alteration like hyperplasia, upliftment of gill basement, infiltration of cells and curling of filaments are observed in unvaccinated fish infected with *A. veronii* at 7th day post challenge. Kidney of vaccinated fish exhibited well-arranged proximal and distal renal tubule cells and slightly detachment of basement, whereas in unvaccinated fish kidney necrotic lesions in renal tubule cells were recorded. Specific antibody level was significantly increased in mucus secretions and serum in immunised fish. It is concluded that inactivated *A. veronii* cells induced significant protective immune response through immersion route of vaccine in tilapia fingerlings.

(CIFE/2019/8/IF)

Studies on Important Diseases of *Clarias magur* and to Develop Appropriate Management Strategies

Project duration: 2019-2022

Principal Investigator
Dr. Arun Sharma

Co-Principal Investigators
Dr. Thongam Ibemcha Chanu
Dr. Sunil Kumar Nayak
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Technical Associates
Dr. P. Srinivasa Rao
Mr. Hasan Javed

The causative agent of infected magur larvae collected from ICAR-CIFE, FWFF Balabhadrapuram was identified and characterized using biochemical test, 16sRNA, and gyrB gene sequencing and reported as *Aeromonas caviae* strain BLBM-05. To study the pathogenicity, the isolate was screened for five known virulence genes, namely *β-hemolysin*, *lafA*, *exu*, *ompA1*, *ascV*. Among them, three virulence genes related to pathogenicity, including aerolysin (aer), outer membrane protein (*ompA1*), lateral flagella

(*lafA*), were identified in the *A. caviae* isolate. The median lethal dose (LD_{50}) of the BLBM-05 isolate for magur was determined as 1.53×10^{6} CFU/mL. The histopathological analysis showed that the BLBM-05 isolate induced considerable histological lesions in the magur fish. This includes necrosis, hemolysis of erythrocytes, myolysis, hemorrhage and desquamation in the intestinal tissue, tissue loosening and infiltration of inflammatory cells. Drug sensitivity test showed that the isolate was susceptible to Gentamicin, Ceftazidine, Ceftrioxone, Amikacin, Tetracycline, Meropener, Oxytetracycline (fig. 1). The present results provide a scientific basis to identify *A. caviae* and also understand the pathogenicity in farmed magur infected by *A. caviae*.

(CIFE/2014/AAH404/SR)

Immunological and Pathological Responses in *Clarias magur* (Hamilton, 1822) following Challenge Against *Aeromonas hydrophila*

Chinmayee Muduli

Major Advisor: Dr. Gaurav Rathore

Motile *Aeromonas* septicaemia (MAS), caused by *Aeromonas hydrophila*, is one of the most significant problems among the bacterial diseases responsible for causing mortality in numerous freshwater fish species including catfishes. A virulent strain of *A. hydrophila* (9C strain) was isolated, identified and characterized. Sequential changes in bacterial load, histopathology, innate immune parameters, expression of *TLR2* and its downstream signalling molecule were studied in Indian catfish, *Clarias magur* following intra-peritoneal injection with *A. hydrophila* at 3, 8, 24, 72 and 144 hours post infection (hpi). Enumeration of bacterial load in tissues of infected magur by quantitative PCR was carried out using newly designed primers from the AscU gene of type-III secretory system (T3SS). At 3hpi, *A. hydrophila* was detectable in liver, spleen, intestine, and kidney indicating that bacteria spread rapidly leading to systemic infection. At 3 and 8 hpi, intestine harbored the highest bacterial load while at 24 hpi, the kidney harbored highest load. Histopathological examination of infected fish revealed the accumulation of melano macrophage centers (MMC), dilated sinusoid with lipid vacuoles, congestion and hepatocyte degeneration in liver. Similarly, hyaline droplet accumulation, lymphocytes infiltration, and diffuse necrosis of renal tubule in kidney. At 3 to 8 hpi, respiratory burst activity, myeloperoxidase, protease, total antiprotease and α2 macroglobulin increased significantly ($p < 0.05$) indicated that host mounted immune response against pathogen invasion at early stage of infection. Bactericidal activity, lysozyme activity and bacterial agglutination titer were increased significantly at 24 hpi. Significant up-regulated expression of immune genes belonging to TLR2 pathway i.e., *mTLR2*, *IRAK1*, *MyD88*, *NF-kb* and *IL-1β* was observed at 3 to 24 hpi in important immune organs such as spleen, intestine and kidney. This study suggested that the innate immune response in magur is modulated for self-protection following *A. hydrophila* infection.

(CIFE/2019/AAH905/SR)

Screening of Integrons in Selected Gram Negative Bacteria Isolated from Shrimp Farms

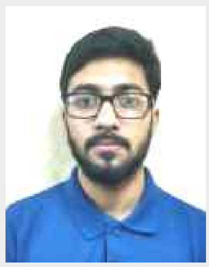
Khakchang Debbarma

Major Advisor: Dr. Jeena K.

Bacteria acquire antibiotic resistance from both vertical and horizontal gene transfers, mediated by mobile genetic elements such as integrons, transposons and plasmids. The integrons have been found to carry multiple gene cassettes conferring resistance against both old and new generation antibiotics. The present study aimed to detect the class 1 and class 2 integron in *Escherichia coli* isolated from shrimp farms. The isolated bacteria were characterized biochemically and were recorded as indole +ve, MR +ve, VP –ve and citrate utilization –ve. The isolates were further subjected to molecular characterization and were identified as *E. coli*. The susceptibility of the bacterial isolates to a panel of antibiotics was estimated by performing antibiotic sensitivity tests. The resistance pattern was confirmed by targeting genetic determinants. The confirmation of resistance in the isolates were done by performing PCR targeting the genetic determinants of β-lactamases. Out of the 11 isolates tested, 9 isolates showed resistance to various antibiotics, mostly towards multiple drugs. Class 1 and 2 specific primers were used to detect the presence of integrons in the isolates by PCR. PCR could detect class 1 integrons in 5 isolates out of the 11 isolates tested of which all were resistant to one or more antibiotics. In contrast, 4 isolates that were resistant to different antibiotics did not show the presence of class 1 integron. Two isolates neither showed resistance against antibiotics nor showed the presence of class 1 integron. The study forms baseline information on the antibiotic resistance pattern and the presence of class 1 integrons in *E. coli* isolated from shrimp farms. However, the association and role of integrons in transfer of resistance in shrimp farms are to be further investigated in the isolates used in the study.

(CIFE/2019/AAH905/SR)

Studies on the Host-range of *Enterocytozoon hepatopenaei* (EHP)



Shirsak Mondal

Major Advisor: Dr. K.V. Rajendran

Enterocytozoon hepatopenaei (EHP), an obligate intracellular parasite has emerged as a serious pathogen impacting farmed shrimp, *Penaeus vannamei* in Asian countries including India. EHP replicates in the cytoplasm of epithelial cells of hepatopancreatic tubules and causes hepatopancreatic microsporidiosis (HPM) and often causes retarded growth and white faeces syndrome. Polymerase chain reaction (PCR)-based detection employing primers targeting genes coding for SSU rRNA, spore wall protein (SWP) and β- tubulin were the established protocol. However, PCR using SSU rRNA can lead to false-positive detection, the other two primers are recommended. In the present study, a range of farmed and wild invertebrates and other cohabiting fauna which include shrimp (*Litopenaeus vannamei, P. monodon* and *P. indicus*), mud crab (*Scylla serrata* and *S. olivacea*), marine crab (*Portunus* sp and *Charybdis sp.*), freshwater carb (*Sartoriana spinigera),* marine shrimp, aquatic insect (*Dytiscus* sp.), and molluscs such as green mussel, violet clam and snail. Different hosts were collected from Maharashtra, Gujarat, West Bengal and Haryana. PCR analysis with SSU rRNA primers showed positive amplification (nested step; 176 bp) in *P. vannamei*, *P. monodon*, marine shrimp, aquatic insect, mud crab, freshwater crab and violet clam. Among these, the highest prevalence (80%) was detected in *P. monodon* and *S. serrata* followed by freshwater prawn and aquatic insects (66.65 and 60%, respectively).

However, none of the samples examined showed PCR amplification in the first step PCR. One the other hand, PCR using SWP primers detected EHP in the first step (514 bp amplicon) in *P. vannamei* and nested step (148 bp amplicon) in aquatic insects, *S. serrata* and marine crab. Among these, *P. vannamei* showed the highest prevalence (80%) followed by aquatic insects (70%). Interestingly, PCR using β- tubulin primers showed amplification in one of the *P. vannamei* samples in the first-step (618 bp) and four in the second-step PCR. However, other than *P. vannamei* and *S serrata* none of the host species examined showed positive amplification in the two-step PCR. The PCR products obtained in the different PCR reactions were sequenced and sequence analysis was carried out using BLAST. The 176 nt sequence obtained from aquatic insects using SSU rRNA sequence showed 100% identity with all EHP sequences reported from shrimp and polychaete worm. Similarly, comparison of the sequences (148 nt) showed 100 identity among the sequences identified from *P. vannamei, P. indicus* and aquatic insect. Further, Blast analysis of the identified sequence revealed 100% identity with spore wall protein gene sequence of EHP reported in the GenBank. Further, sequence analysis of PCR products obtained in the first step PCR using β- tubulin primers showed 99% identity (494 nt) with the β-tubulin gene of EHP available in the GenBank. This also forms the first record of the detection of EHP in aquatic insects, mud crab, freshwater crab and violet clam and the observation is of great significance, as these aquatic organisms have the potential to be carriers of EHP and can transmit the pathogen to farmed shrimp.

(CIFE/2019/AAH902/SR)

Study on Antiparasitic Effect of Nootkatone against Argulus Infection in Goldfish (*Carassius auratus*)

Avijit S. Pramanik

Major Advisor: Dr. R. P. Raman

Goldfish (*Carassius auratus*) is one of the most traded ornamental fish, but highly prone to argulosis caused by *Argulus sp*., a crustacean ectoparasite. To combat argulosis, phytotherapy is now gaining attention, especially the use of plant bioactive compounds. The present study aimed to evaluate the antiparasitic efficacy (AE%) of Nootkatone against Argulus infesting on goldfish under *in vitro* and *in vivo* conditions. AE of Nootkatone against Argulus under in vitro condition was 33.3, 50 and100% at 60, 70 and 80 ppm, respectively in 6 hrs with estimated median effective concentration (EC50) 65.68 ppm. An acute toxicity test of Nootkatone for goldfish showed the median lethal concentration (LC50) at different time intervals 12, 48, 72 and 96 h were 23.604, 19.230, 18.365 and 17.579 ppm, respectively. Further, under *in vivo* test, the lowest dose (18.4 ppm) of Nootkatone was noticed when almost 100% Argulus detached from goldfish. Furthermore, the detached Argulus were left with the same treatment solutions that showed complete mortality of parasites in additional 3hrs exposure. The 12 h therapeutic index (TI) of Nootkatone is calculated 1.98, which shows a relatively safe dose for *in vivo* application for argulosis in goldfish. Haematological and histopathological study was conducted for the fish acutely exposed to Nootkatone. The results show little variations in the blood parameters with increased WBC count whereas histological study of the gill, liver and kidney tissue sections shows moderate changes. In conclusion, Nootkatone can be recommended as a promising antiparasitic agent against Argulus in goldfish. However, further study is warranted to assess the efficacy of Nootkatone under field conditions, and mechanistic explanation of its mode of action on parasites for developing adequate phytotherapy.

(CIFE/2016/AQC613/SR)

Evaluation of Antifungal Potential of Selected Himalayan Herbs and Peptide in Mitigating Oomycetes Infection in Rainbow Trout, *Oncorhynchus mykiss* (Walbaum, 1792)

Tandel Ritesh Kumar Shantilal

Major Advisor: Dr. N. K. Chada

Among the oomycetes, Saprolegniales are responsible for devastating fish health, and environmental damages which leads to economic losses to rainbow trout aquaculture industries worldwide. The present study was carried out to isolate, identify and characterize pathogenic oomycetes affecting different life stages of rainbow trout (*Oncorhynchus mykiss*) from farms and hatcheries of Himachal Pradesh and Uttarakhand, India. Also, the study further aimed to evaluate the efficacy of selected Himalayan plant extracts, natural plant compounds and synthetic antifungal peptides against isolated pathogenic oomycete species. Around 28 isolates were recovered which showed asexual and sexual morphological characters such as sporangia, mycelium shape, antheridium origin, and ornamentation in oogonium. Two oomycete species i.e. *Saprolegnia parasitica, S. australis*, and fungus, *Fusarium oxysporum* were morphometrically described (sporangial length, and breadth, cyst diameter, oogonium no. and diameter) and molecularly characterized through ITS 1 and ITS 4 gene sequence.

Among the seven screened plant extracts *Myrica esculenta, Thymus linearis* and *Butea monosperma* showed inhibition effects on the hyphae growth showing minimum inhibitory concentration (MIC) values of 25, 100, 50 mg ml-1 against *S. parasitica* and 25, 50, 25 $mgml^{-1}$ against *S. australis.* Among the five screened natural plant compounds, curcumin, cinnamaldehyde and eugenol showed MIC of 16 mgl^{-1}, 25 mgl^{-1}, and 25 mgl^{-1} against both *S. parasitica,* and *S. australis*.The effectiveness of peptides KK12YW, and RH 12 on *S. parasitica* and *S. australis* were tested for the MIC on zoospores, mycelium growth inhibition, and spore germination inhibition and colonization assay. The KK12YW and RH 12 peptides could completely inhibit zoospore production at MIC level of 15.62 µM and 7.8 µM of both *Saprolegnia* spp. The peptides exhibited little haemolytic activity, low cytotoxicity and high stability in the physiological environment. Molecular docking of the synthesized peptide KK12YW and plant bioactive compounds myricetin (from *M. esculenta*), carvacrol and phytol (from *T. linearis*) was carried out with four effector proteins of *S. parasitica* to investigate the target binding sites. However, results need to be validated under field conditions before recommending to the fish farmers and aquaculture industry.

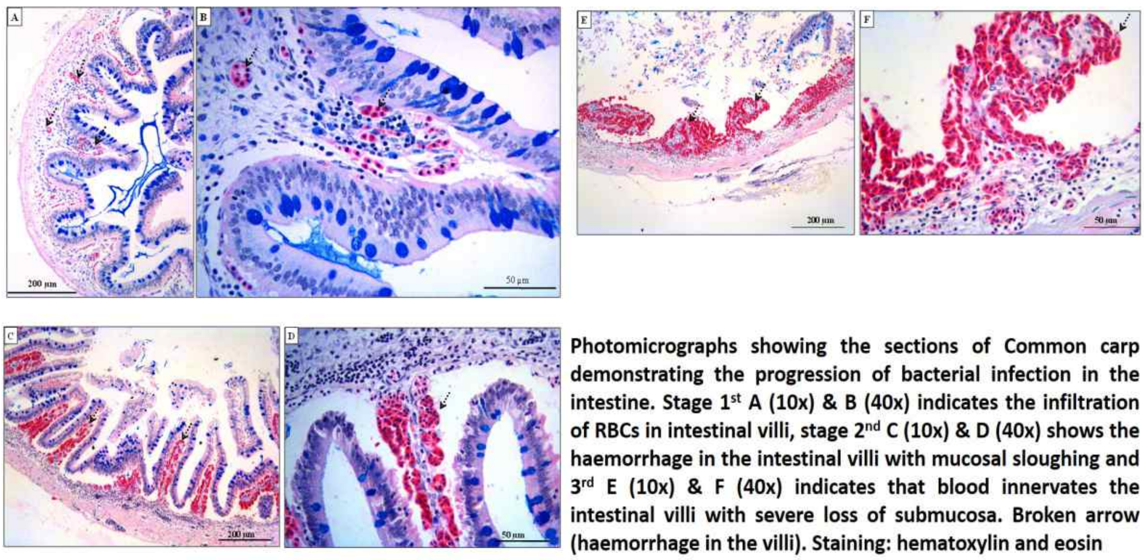
(CIFE/2014/AAH401/SR)

Assessment of Antimicrobial Potential of Novel Synthetic De-novo Designed Peptides against Fish Pathogens

Raja Aadil Hussain Bhat

Major Advisor: Dr. Debajit Sarma

Antimicrobial peptides (AMPs) are a highly promising alternative to classical antibiotics and may become an excellent candidate to tackle antimicrobial resistance in aquaculture. In the present study, seven novel short, and compositionally simple AMPs having potent antimicrobial activity were designed. The AMPs were synthesised by Fmoc chemistry and characterised by various *in silco* tools. The AMPs are helical, amphipathic with a net positive charge. The molecular docking study results showed that KK14XZ AMP has a strong affinity towards two protein targets of *A. hydrophila and A. salmonicida*; aerolysin and outer membrane protein (omp). The MIC values of designed AMPs ranged from 0.98 to 500 µM, and MBC values of *A. hydrophila*, *E. tarda*, *S. aureus*, *V. parahaemolyticus*, *P. aeruginosa* and *E.coli* ranged from 4 to 900 µM against the selected bacterial and fungal pathogens. The intense antimicrobial activity of the designed peptide was reported against *A. sob* at low concentration. In comparison to other peptides, KK14XZ AMP showed good activity against *A. salmonicida* and *S. parasitica* zoospores. The AMPs were stable at higher temperature and retained their antimicrobial activity in serum and salt, indicating there *in vivo* stability. The peptides seem to be less haemolytic to fish



Photomicrographs showing the sections of Common carp demonstrating the progression of bacterial infection in the intestine. Stage 1st A (10x) & B (40x) indicates the infiltration of RBCs in intestinal villi, stage 2nd C (10x) & D (40x) shows the haemorrhage in the intestinal villi with mucosal sloughing and 3rd E (10x) & F (40x) indicates that blood innervates the intestinal villi with severe loss of submucosa. Broken arrow (haemorrhage in the villi). Staining: hematoxylin and eosin

RBC even at higher concentrations. The DNA binding assay indicated that the designed AMPs can bind with the genetic material of the bacteria and may inhibit its replication. The bacterial viability assay reported that the KK14XZ and RY12WY AMPs interfere with bacterial membrane integrity. CD spectroscopy showed that KK14XZ peptide adopted ordered helical conformations in a membrane like environments. *In vivo,* experimental studies revealed that KK14XZ AMP does not induce any behavioural or histological changes in the common carp. Further, 80% survival was reported in common carp challenged with *A. salmonicida* after treatment with 500 µg KK14XZ AMP. The results indicate that the designed synthetic AMPs are stable, possess potent antibacterial activity, less cytotoxic to host cells, and could prove to be a promising therapeutic agent in aquaculture for combating the common microbial infections.

(CIFE/2014/AAH402/SR)

Dactylogyrosis In Indian Major Carps: Understanding Host-Pathogen Interaction towards Designing Prevention Strategy

Anirban Paul

Major Advisor: Dr. P. K. Sahoo

The monogenean *Dactylogyrus* is one of the major parasites of fish ubiquitously present in the aquatic environment causing severe economic loss. A study was carried out to estimate the prevalence and species-spectrum of *Dactylogyrus* in Indian major carp farms of Odisha state, and to elucidate the modulation of the immune system of the host during infection process with an aim at developing immunoprophylaxsis. The prevalence of *Dactylogyrus* spp. infection in IMCs was studied during September 2018 to March 2020 in thirteen districts of Odisha and found to be 64.50% (n=786). While winter was found to be the most favoured season, rohu was the most preferred host for *Dactylogyrus* infection. A total of 25 *Dactylogyrus* isolates i.e. twenty-two *D. catlaius*, two *D. vastator* and one *D. scorpius* were identified using 28s rDNA PCR and sequencing. *D. scorpius* was reported for the first time from India. A co-habitational challenge study confirmed *D. scorpius* as 'specialist' infecting only rohu and *D. catlaius* as 'generalist' parasite among Indian major carps.

Gill samples of rohu from co-habitational challenge study with *D. scorpius* at different time intervals i.e. 0, 1, 3, 5, 10 and 20 days post infection (dpi) was subjected to expression analysis of different immune-related genes viz., genes involved in specific immunity (IgM, IgZ, MHC I), recognition molecule (TLR 22), pro-inflammatory cytokines (IL-1β, IL-6, IL-8, IL-15, TNF α), anti-inflammatory cytokine (IL-10), antioxidant molecules (MnSOD, GPx, catalase) and antimicrobial peptides (apolipoprotein A-I, lysozyme G). A significant upregulation (P <0.05) of all immune-related genes except MHC I and IL-15 was noticed at different time points. This indicates the role of both specific and non-specific immune responses against *D. scorpius* infection. The progressive rise in parasitic load corresponding to the days of post-infection clearly indicated immune evasion mechanism for the co-existence of the parasite. It is also the advent of upregulation of an array of immune-related genes in the host. In a preliminary study, crude antigenic preparation of *D. catlaius* was intraperitoneally injected to rohu with a single booster. However, no significant difference (P <0.05) in the parasite load was evident in vaccinated and non-vaccinated fish at any of the time points after challenge. In spite of the increase in expression level of immunoglobulin genes (IgM and IgZ) in gills and blood, thus indicating the need for alternative vaccine candidates.

(CIFE/2016/AQC607/SR)

Effect of Selected Medicinal Herbs on Growth, Immunity and Metabolic Response of *Labeo rajasthanicus* (Datta and Majumdar, 1970)

Naresh Raj Keer

Major Advisor: Dr. N. K. Chada

Five experiments were conducted to evaluate the effect of ethanolic extract of Shatavari root (SR) and Mucuna seed (MS) individually and in combination on growth, feed utilisation and digestive, metabolic and haemato-immunological responses of *Labeo rajasthanicus*. The fingerlings were stocked in 1000 L capacity FRP tanks @ 15 nos./ tank randomly for all experiments. Six groups were selected *viz.* 0.00 (C), 0.50 (T1), 1.00 (T2), 2.00 (T3), 3.00 (T4) and 4.00 (T5) g/kg of herbal extract mixture (HEM). The iso-nitrogenous (30% CP) and iso-caloric diets (390 kcal/ 100 g) were fed @3% of body weight daily (twice) to *L. rajasthanicus* for 90 days for the experiments. The physicochemical parameters of water were found favourable for the growth during all experiments. The growth performance and feed utilisation parameters improved significantly ($P< 0.05$). The protease and amylase activities, serum-protein, albumin and globulin, serum glucose, respiratory burst activity, lysozyme activity, and haematological indices were improved significantly ($P< 0.05$) in experimental fish.

The LDH, MDH, and G6PDH activities did not show a significant difference ($P> 0.05$) within the groups in the earlier experiment. LDH and MDH activities of liver and muscle improved ($P< 0.05$) in T4 for experiment V. The G6PDH activity of the liver in the T4 group of experiment V improved significantly ($P< 0.05$). It can be concluded that growth performance, feed utilisation and, digestive, metabolic and, haemato-immunological responses of *L. rajasthanicus* could be improved by incorporating the ethanolic extract of Shatavari root, mucuna seed, and/or a combination of both could be used @0.10, @3.00 and @3.00 g/kg in the diet, respectively. The present study can be further tried at the field level to augment production for the future in the aquaculture sector.

Genetics & Breeding


70
150
152
69
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50

Development of Laboratory Strains of Zebrafish (*Danio rario*) for Biological Studies

(CIFE/2019/4/IF)

Project duration: 2019- 2022

Principal Investigator
Dr. Mujahidkhan A. Pathan

Co-Principal Investigator
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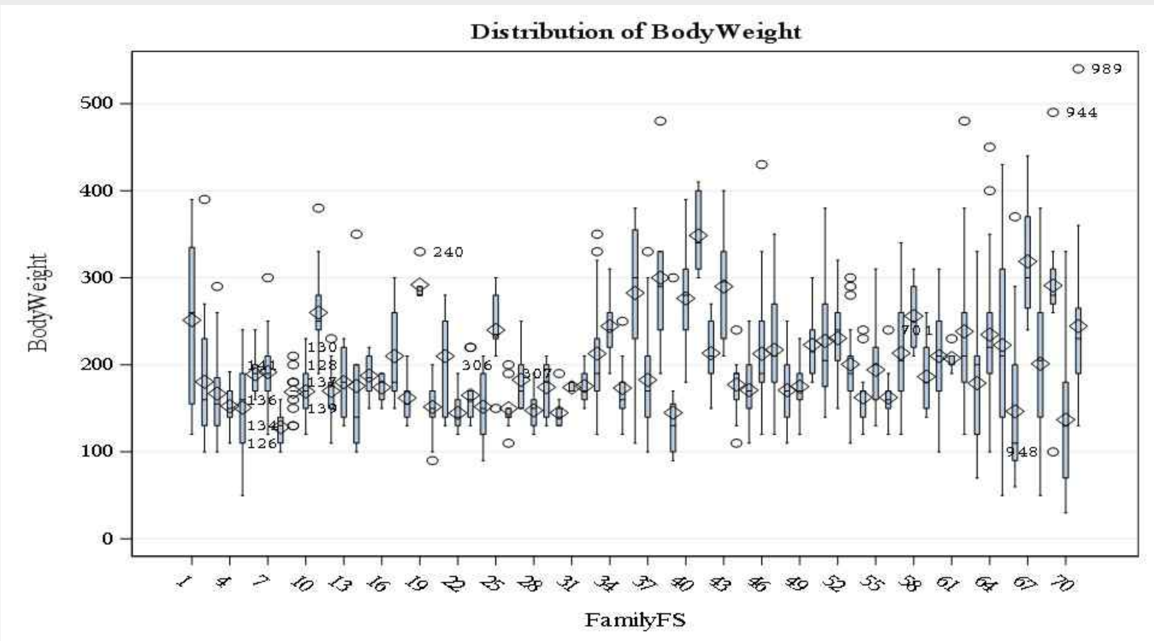
Mr.Angom Lenin Singh

TIFR, Mumbai
Dr. Mahendra Sonawane,
Dr. Kalidas Kohale

Modern genomic research is heavily dependent on zebrafish strains. Development of inbred and polymorphic strains will be of immense use for biomedical and genetics research. Under the inbreeding program of zebrafish, the inbred stock is developed which has a genealogical F in the range of 0 to 0.5469.

There were 130 successful spawning attempts out of 179. About 61 families were produced by inbreeding and remaining by random mating. There are six families with adequate family size in the sixth generation of inbreeding programs with genealogical F=0.5469 (Line 1). About 27 families in fifth generation of inbreeding with F= 0.5 (Line 2) and three families in third generation of inbreeding with F= 0.25 (Line 3). Overall the inbred stock has a genealogical F in the range of 0 to 0.5469. The zebrafish population by random mating is also generated and maintained in cement tanks. For genetic characterisation of inbred stocks the primers for 53 microsatellite loci have been standardized for PCR amplification. The genotyping of inbred stock is in progress.



Identification of Epigenetic Markers Associated with Growth Performance in *Clarias magur* (Hamilton, 1822)

(CIFE/2021/2/IF)

Project duration: 2021- 2024

Principal Investigator
Dr. Kiran D. Rasal

Co-Principal Investigator
Dr. Aparna Chaudhari
Dr. Manoj Brahmane
Dr. Mujahidkhan Pathan
Mr. Dhalongsaigh Reang

Epigenetics plays a vital role in mediating gene regulatory response, and is a key process affecting phenotypic plasticity and adaptation. The present study is intended to identify growth related epigenetic markers i.e. methylation pattern in the Indian catfish, *Clarias magur* (Hamilton, 1822), which is being selectively bred for growth trait improvement at ICAR-CIFE. High-throughput sequencing approach has been used to decipher molecular events associated with performance traits such as growth and disease in magur. This work is designed to identify key methylation marks in growth related genes and will be screened in high and low growth performing magur families. The fin tissue samples (200 nos) from high and low breeding values of magur families were collected at Powarkheda, Madhya Pradesh and Balabhadrapuram, Andhra Pradesh, ICAR-CIFE centre. The collected tissues were preserved in ethanol for DNA extraction and followed by the sequencing (outsourcing) for identification of global DNA methylation patterns in growth-selected magur.

(CIFE/2019/FGB901/SR)

Analysis of Genetic Combining Abilities of Various Populations of Rohu (*Labeo Rohita*, Hamilton 1822) for Growth Traits

Akshaya Mayekar

Major Advisor: Dr. S. Jahageerdar

Rohu is the primary species cultured in India, and the State Government fish hatcheries are the major suppliers of the seed. The reports suggest that the hatchery stocks of rohu are inbred. When inbred lines are crossed, the offspring usually express hybrid vigour. Identification and combining of the appropriate lines are essential to exploit the heterosis effects. The diallel analysis helps identify the proper combination of male and female lines to use various gene effects. The present study aimed to quantify the effects of non-genetic factors on growth traits and genetic combining abilities among four rohu stocks. Fish were bred in 2007 and 2008, employing a 3 X 3 partial diallel mating design, and a total of 37 full-sib families that also consisted of 22 half-sib families were produced. A total of 2104 observations were recorded. The least-squares mean body weight at stocking was 5.53 ± 1.03 g and 62.18 ± 1.07 g at pond-age 4. The effects of non-genetic factors were found to be significant on body weight at all ages. The heritabilities and genetic and phenotypic correlations were estimated by adopting different models. Heritability estimates for body weight at different pond-age ranged from 0.02 to 0.77. The genetic and

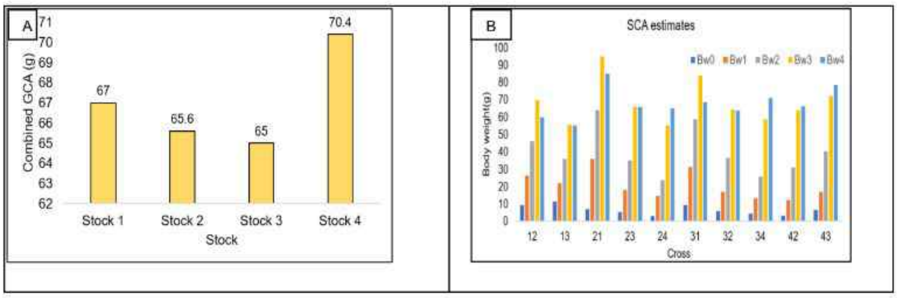
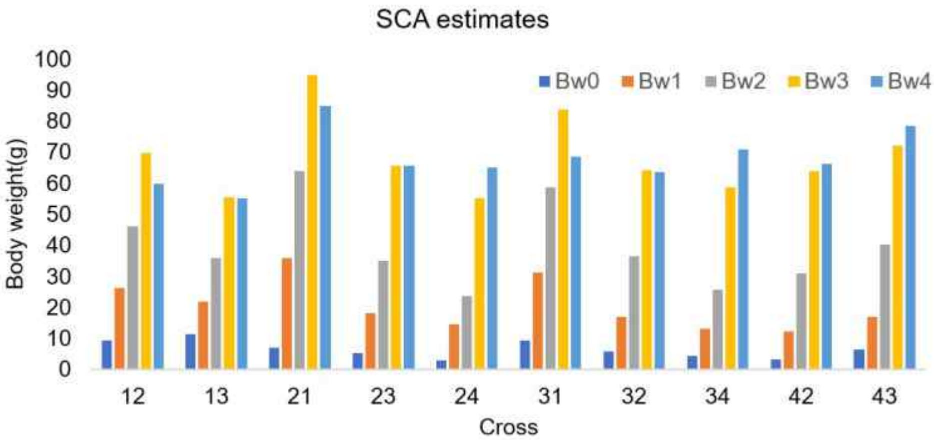


Fig: A) Graph depicting combined GCA estimates for stocks for the body weight of rohu at pond age-4 from Griffing method -3 model I B) Graph depicting SCA estimates for stocks for body weight at different ages from Grriffing method-3 model I



phenotypic correlations between body weight at different ages varied both in magnitude and direction. Griffing's method-3, models I and II, were employed to estimate the combining abilities for body weight at different ages. The General Combining Ability for the body weight at pond-age 4 ranged from -0.6 to 7.6 per cent. The highest Specific Combining Ability was found for the cross between Stock-2 as the male and Stock-1 as the female lines. The overall heterosis effects for body weight at different ages ranged from -5.7 to 7.5 per cent. The result suggests that by adopting a suitable mating design, the heterosis effect can be exploited to enhance the growth rate in rohu.

Improvement of Harvest Body Weight of *Clarias Magur* through Genetic Selection

- During the breeding seasons of 2021-22, 39 families were produced at Balbhadrapuram and 6 families at Powarkheda, totalling 45 families. They include 12 half-sib families and 33 full-sib families.
- A total of 1126 Magur fish were PIT-tagged in March-April 2021, and are being reared under commercial aquaculture practice at Balbhadrapuram and Powarkheda. (Number of fish PIT-tagged at Balbadrapuram are 980 and 146 at Powarkheda). These fishes belonged to 47 families and were stocked during March 2021, and communal rearing is underway at Balbhadrapuram and Powarkheda.

(CIFE/2021/2/IF)

Project duration: 2021- 2024

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Dr. Sunil Kumar Nayak
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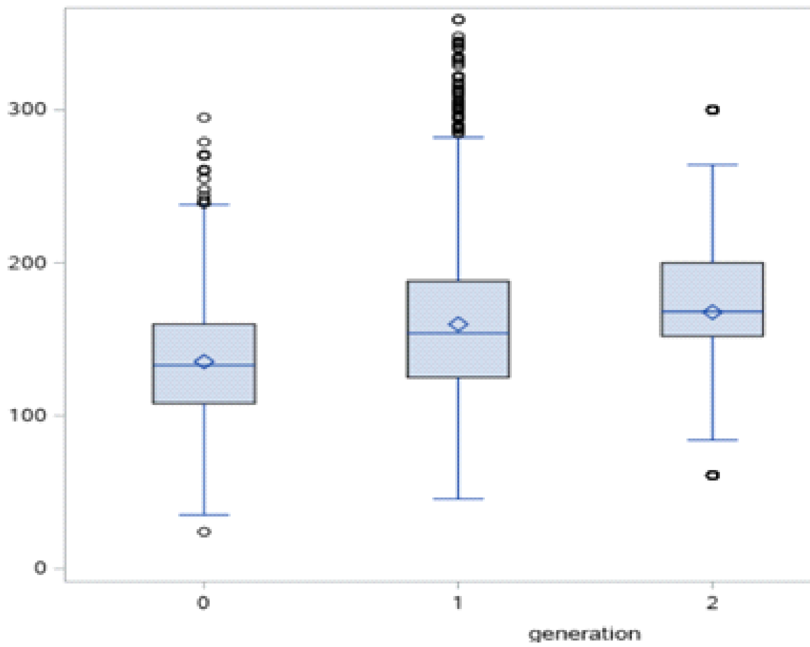


Fig1. Generation-wise Boxplots of body weight at harvest

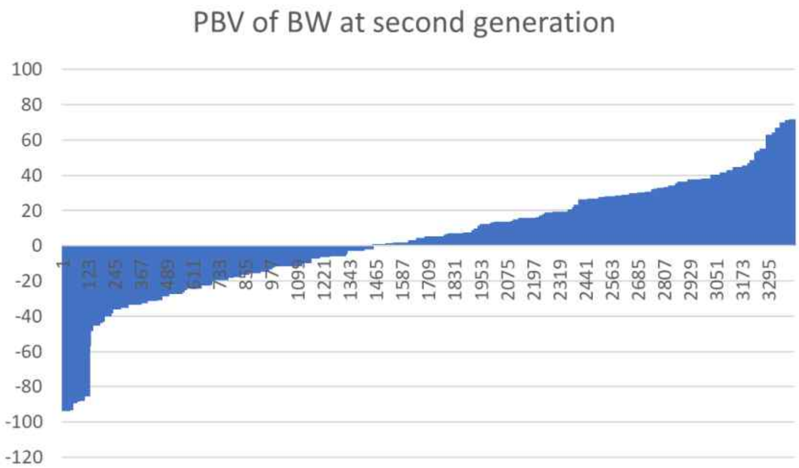


Fig 2. Predicted BLUP Breeding Values for body weight at harvest (Second Generation)

(CIFE/2015/FGB503/SR)

Evaluating Alternate Models to Estimate Genetic Parameters of Economic Traits in *Clarias magur*

Rameez Roshan P.M.

Major Advisor: Dr. S. Jahageerdar

Clarias magur is an Indian catfish species with the potential for aquaculture. Presently, the magur aquaculture is constrained by suboptimal quality and quantity of the seed. The genetic selection has the potential for the sustainable supply of quality seeds in optimum quantities. To maximize the selection response, the knowledge of reliable genetic parameter estimates is essential. Hence, the present work aimed to study the genetic parameters of economic traits in magur by implementing different models and methods. The non-genetic factors viz., batch, stock, pond and sex had a significant effect on the growth of magur. The culture type did not contribute significantly to body

weight at harvest, which precluded the development of multiple strains for both mono and polyculture systems. The high heritability of body weight (BW) at stocking (0.74) decreased towards harvest (0.44). The genetic correlations between growth traits were positive and high (0.80 to 0.99) and so were the phenotypic correlations (0.34 to 76). Among the different methods used to estimate the heritability of harvest BW, ANOVA, REML, parametric bootstrap, asymptotic sampling, jackknife, and Bayesian posterior gave similar results (0.43-0.45), and non-parametric BLUP based bootstrap heritability was high (0.51). The rank correlations between the breeding values estimated by univariate and multivariate models were high (0.80 to 0.99). The high genetic correlation between BW at nine months and harvest by multi-trait model suggests a possibility of early age selection. A random regression model with heterogeneous residual variance gave the best fit for genetic evaluation of growth trajectories using a quadratic Legendre polynomial to estimate covariance functions. The results of genetic parameter estimates at fifty different ages suggested the high possibility to enhance growth in magur by applying selection on growth trajectories. The presence of high additive genetic variance in the base population of magur, suggests a possibility of developing a fast-growing high-performance strain of magur through genetic selection.

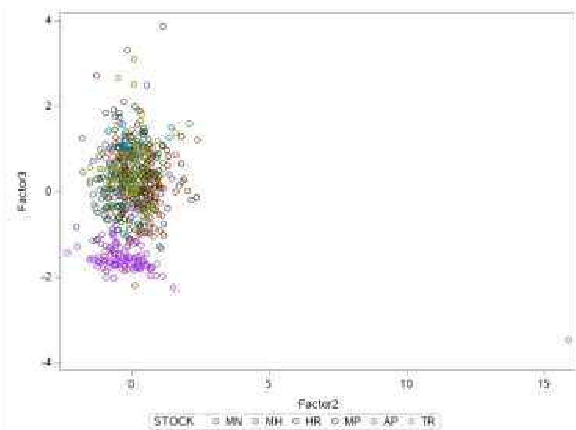
(CIFE/2015/FGB903/SR)

Assessment of Genetic Diversity in Selected Geographical Population of *Cyprinus carpio* (Linnaeus, 1758) using Morphometry and Mitochondrial D-Loop Marker

Lalramnunsanga

Major Advisor: Dr. Mujahid Khan Pathan

Cyprinus carpio (Linnaeus,1758) is a commercially important fish with global importance. It is an ideal species in aquaculture owing to numerous characteristics and its dissemination has been widely increased by human introduction. However, in India there are only four reported instances of introduction of common carp. The founding population was low in number and the genetic quality of stock was never maintained. Negative selection coupled with inbreeding has degraded the performance of stocks. Genetic selection programs need to be undertaken to improve the growth and performance traits. The basic necessity of such programs is to understand the standing genetic diversity of the population. In this background, the present study was undertaken to assess the genetic diversity of six geographical populations / stocks of common carp using morphometry and mitochondrial DNA D loop marker. A total number of 600 fish belonging to six geographical locations of India viz., Madhya Pradesh, Haryana, Tripura, Andhra Pradesh, Manipur and Maharashtra was measured for various traits. A truss network was constructed by interconnecting 15 landmarks to form a total of 39 distance variables extracted from digital images of samples using tps Dig2 and PAST software platforms.



The transformed truss measurements were subjected to factor analysis. Factor analysis for stock wise and sex wise showed meaningful loading of the middle portion, the head portion and the caudal portion on first, second and third factors respectively. Stock wise, the factor analysis revealed the existence of three major groupings among the six stocks viz., Andhra Pradesh-group1, Tripura- group 2 and rest other stocks- group 3. Sex wise, the male in Andhra Pradesh and Tripura stock separates noticeably with other stocks while only the female sex of Andhra Pradesh stock separates distinctly from the rest of other stocks. Mitochondrial D-loop sequences of common carp from five stocks viz., Manipur, Haryana, Tripura, Maharashtra and Madhya Pradesh were explored for genetic diversity. A total of 117 complete mtDNA D-loop sequences (1kb) were obtained by Sanger sequencing. About 47 variable sites and 17 haplotypes were identified. The average haplotype and nucleotide diversity were 0.3518 and 0.0019 respectively. H1 and H14 were the first and second major haplotypes representing populations at frequencies of 71.79% and 11.96%, respectively. The result suggested that Manipur and Tripura stocks form distinct groups with the rest of the population. The present study delineated shape and mitochondrial DNA D loop based genetic diversity among six populations of common carp. Further, the information generated will be useful for genetic selection and genetic management of common carp stocks.

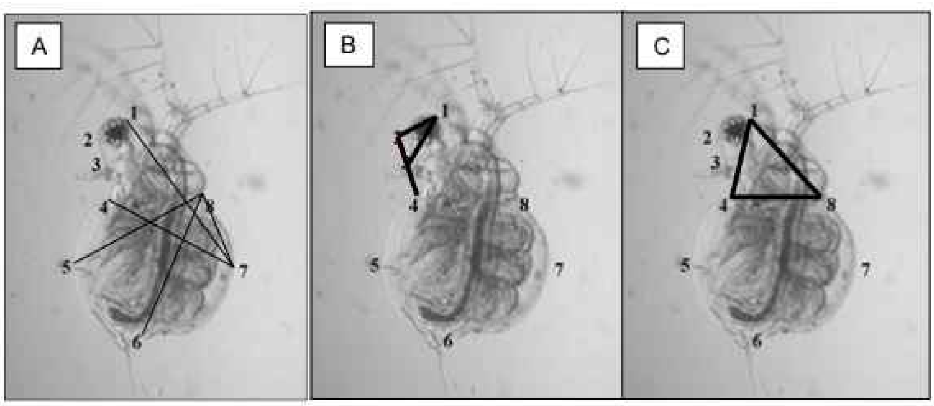
Genetic Characterization of Moina Species Different Geographical Locations of India

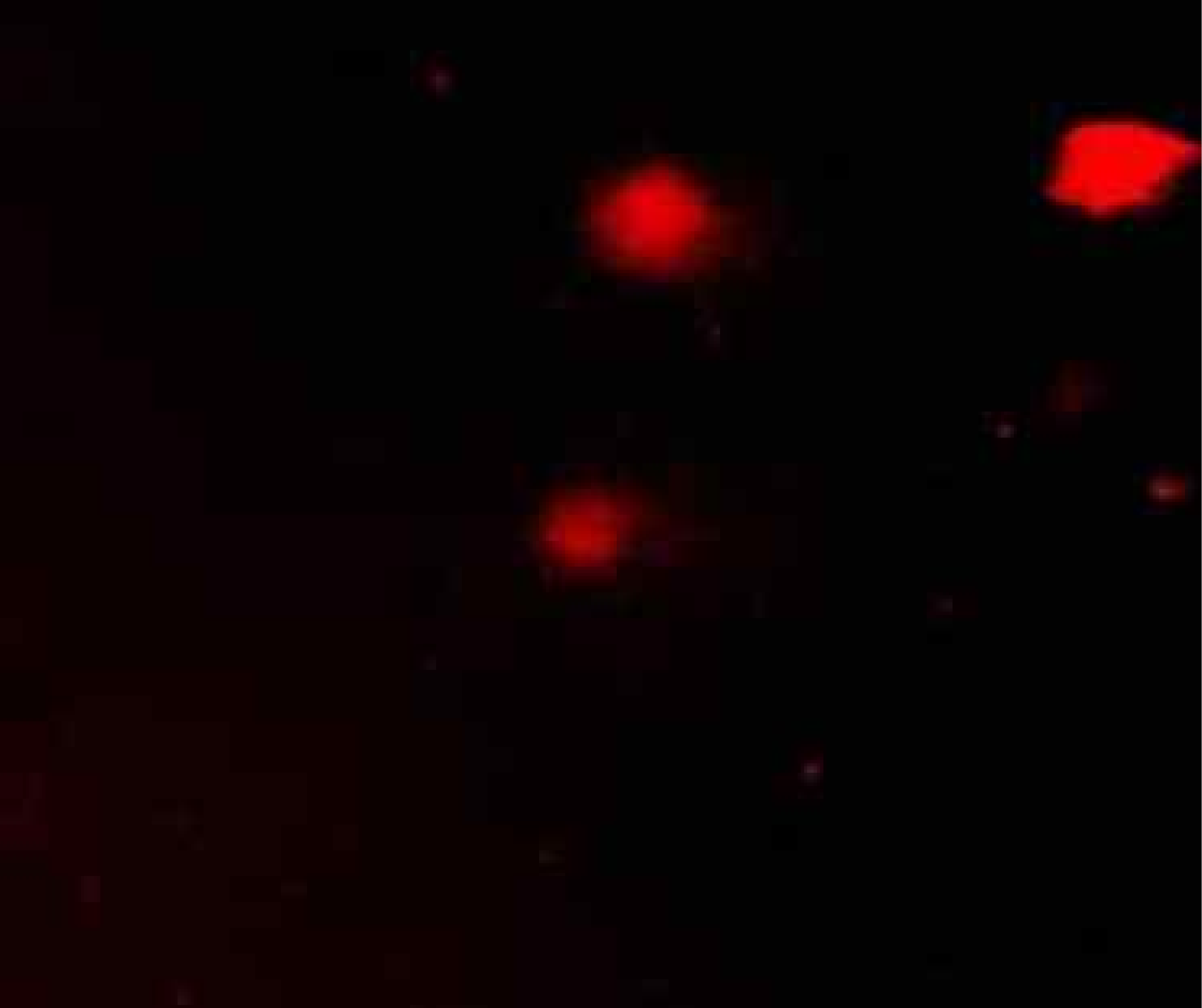
(CIFE/2015/FGB904/SR)

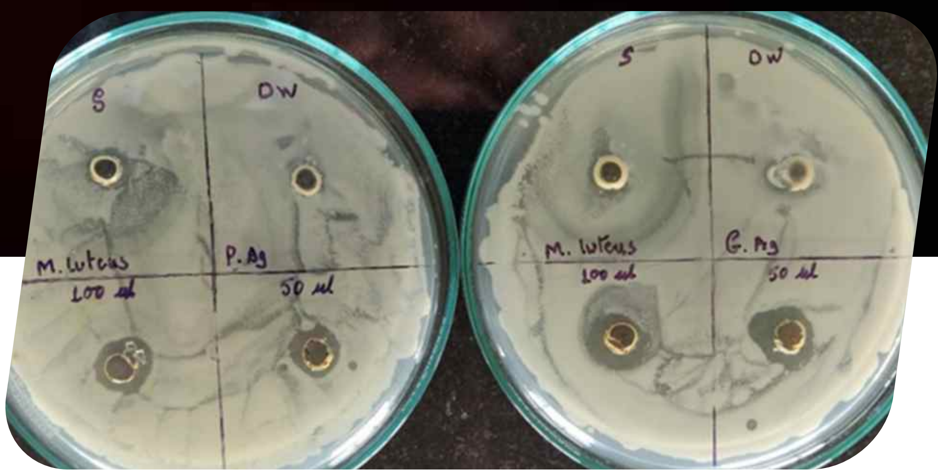
Nagaraja P.S.

Major Advisor: Dr. Sunil Kumar Nayak

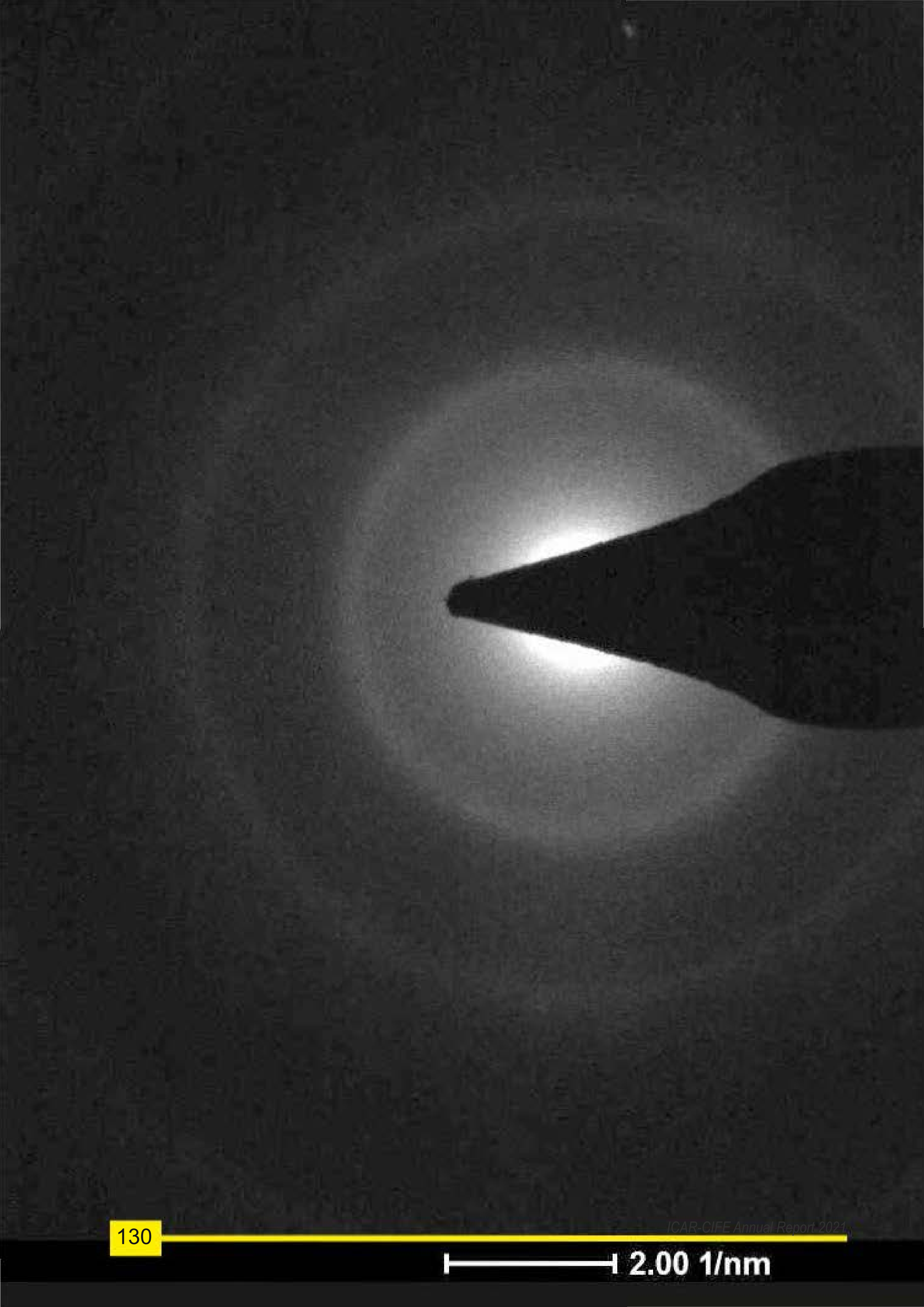
Live food organisms like Moina, Daphnia, Rotifers, Copepod, Artemia play a vital role in finfish and shellfish larvae culture. Among all the zooplankton, Moina species are promising in fish larvae and fry nutrition because of their ease to handle, high reproductive rate, short embryonic stage, easy to culture, smaller size, abundant energy storage, and short lifespan. There is limited information on the morphometric, meristic, and genetic diversity of the Moina population in general and India in particular. The present study was aimed to identify and quantify the important morphometric and meristic traits of Moina species and further genetically characterise them. A total of six stocks of Moina, three each from Haryana and Madhya Pradesh states, were collected. Individual Moina was identified using a compound microscope, and their images were captured with a camera mounted on the microscope. In the present study, seven morphometric and 21 truss measurements were retrieved from the captured image with the help of image J software. The genetic characterisation was performed using mt-COI gene for species confirmation. The average body length of *Moina micrura* from Madhya Pradesh stocks was 871.07±8.17 µm, and that of Haryana stocks was 811.39±9.16 µm. In the present study, there was no variation in the meristic traits, hence these three meristic traits were of little importance differentiating the Moina stocks. The average body length of the different stocks was significantly different from each other. The truss measurement analysis showed no significant difference in the stocks of Madhya Pradesh. The discriminant analysis based on the first three factors obtained from factor analysis gave a correct classification of 43.33, 65.00 and 58.89 %, for stock1, stock2 and stock3, respectively. The broad sense heritability of various morphometric traits ranged from 0 to 0.58. The mt-COI gene analysis using DNA barcoding confirmed that the species used in the present study is *Moina micrura*. The information generated from the present study will be helpful in the population diversity study of Moina species across different geographical locations using the truss morphometric traits.







Biotechnology & Nanotechnology


2.00 1/nm

Studies on Synthesis and Toxicity of Bioconjugated Carbon Nanotubes in Zebrafish Model

(CIFE/2019/3/IF)

Project duration: 2019- 2022

Principal Investigator
Dr. Rupam Sharma

Co-Principal Investigator
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Dr. Aparna Chaudhari
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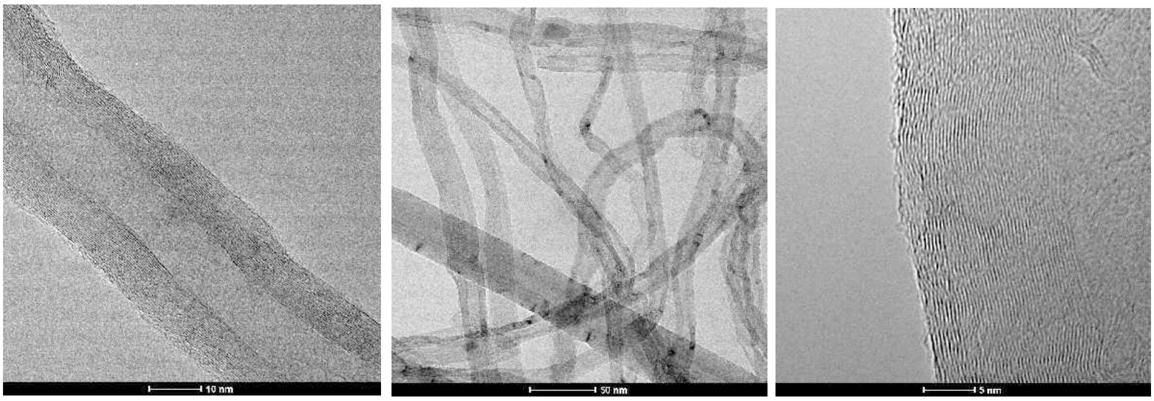
Technical Associate
Dr. Nalini Poojary

CNTs have potential applications in the field of biomedical science, nanomedicine, genetic engineering, biosensor, etc. because of their unique physical, chemical and biological properties such as high tensile strength, lightweight and higher chemical reactivity. It may easily permeate the cell membrane and enter the biological system due to its small size. Because of the presence of catalysts, CNTs are toxic to many biological systems. The severity of the harm caused by these materials is largely determined by their size, shape, dosages, and types. The lack of knowledge about toxicity, distribution and behaviour of carbon nanotubes in a biological system limited the use of these nanomaterials. CNTs are frequently functionalized with different substances to reduce toxicity and enhance dispersion. As a consequence, it's necessary to standardise the type and dosage of materials that can be considered safe and nontoxic for use in various biological systems.

As a result, the present study was carried out with the goal of determining the toxicity of MWCNTs in zebrafish. MWCNTs were synthesized using a chemical vapour deposition process. To remove carbonaceous and metal impurities from the nitric acid-treated MWCNTs, centrifugation procedure was applied. Morphology, size and zeta potential of pristine-MWCNTs, COOH-MWCNTs, and PEG-MWCNTs were investigated using HR-TEM and a zetasizer, and it was found that size and zeta potential varies among MWCNTs. The synthesised CNTs are multi-walled and hollow cylindrical in shape, as revealed by transmission electron microscopy. The surface deposition of polyethylene glycol on MWCNTs was confirmed by FTIR and HR-TEM. Zeta potential of P-MWCNTs, COOH-MWCNTs, PEG-MWCNTs was found to be -9.2 mV, –53.1mV and -14.9 mV, respectively. The diameter of multi-walled carbon nanotubes was found to be 7-13 nm (P-MWCNT), 12 nm (COOH-MWCNTs), and 23 nm (PEG-MWCNTs). The FTIR spectrum of MWCNTs showed a significant peak at 3411.12 cm^{-1}, which is assigned to the -OH stretching of the hydroxyl group in PEG. The peak at 2923.12 cm^{-1} was assigned to the C-H stretching of the methylene group in polyethylene glycol. Moreover, a new peak at wave number of 1096 cm is due to the C-O stretch of ester between oxide CNTs and PEG. This confirms that the MWCNTs are functionalized with PEG.

The adsorption of PEG on the surface of the CNTs was also revealed by TEM analysis. The formation of visible multi layers of carbon sheet over a hollow tube was confirmed by the study, demonstrating the formation of multi-walled CNTs. The carbon nanotubes were extended and bundled. This image showed nanotubes that are hollow and tubular in shape with many deflection sites. It can be clearly seen that PEG was uniformly deposited on the CNT surface. SAED pattern of PEG- MWCNTs showed single crystallinity which means the arrangement of particles in periodic manner is shown.



The toxicity of PEG-MWCNTs in zebrafish embryos was assessed after exposure of 96h. The LC50 and LC20 values were increased in a time-dependent manner.The LC50 values for PEG-MWCNTs were found to be 21.43 mg/L at 96h. The LC20 values for PEG-MWCNTs were found to be 75.37mg/L at 2.62 mg/L at 96h. Survival analysis of zebrafish embryos after exposure to PEG-MWCNTs showed a significant increase in mortality rate with increasing dose. Malformations like, pericardial edema, yolk sac edema, body deformities, tail bend and delayed hatching were observed after exposure to different concentrations of PEG-MWCNTs ranging from 0.64 to 10.24 mg/L. The comet assay tested at all concentrations and genotoxicity was observed at 1.28 mg/L, 2.56 mg/L. Histological investigation was conducted to understand toxicity and it showed disturbances like hypermia, notochord deterioration, somite disorganisation, tissue malformation, abnormal trunk, muscle fibre distortion, etc.

After all these studies, the safe dose of PEG-CNT was found to be 0.01-0.0.64mg/L. Because of their nanosize, biocompatible polymeric structure, and aqueous solubility, these particles can be used in a variety of in-vivo applications. These PEG-MWCNTs could be studied further for optimal drug loading, drug release, and appropriateness for different cell and pharmacological targets.

Protein Expression Profiling of *Labeo rohita* using Quantitative Proteomics

CIFE/2021/600/EF

Project duration: 2021- 2023

Principal Investigator
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Co-Principal Investigators
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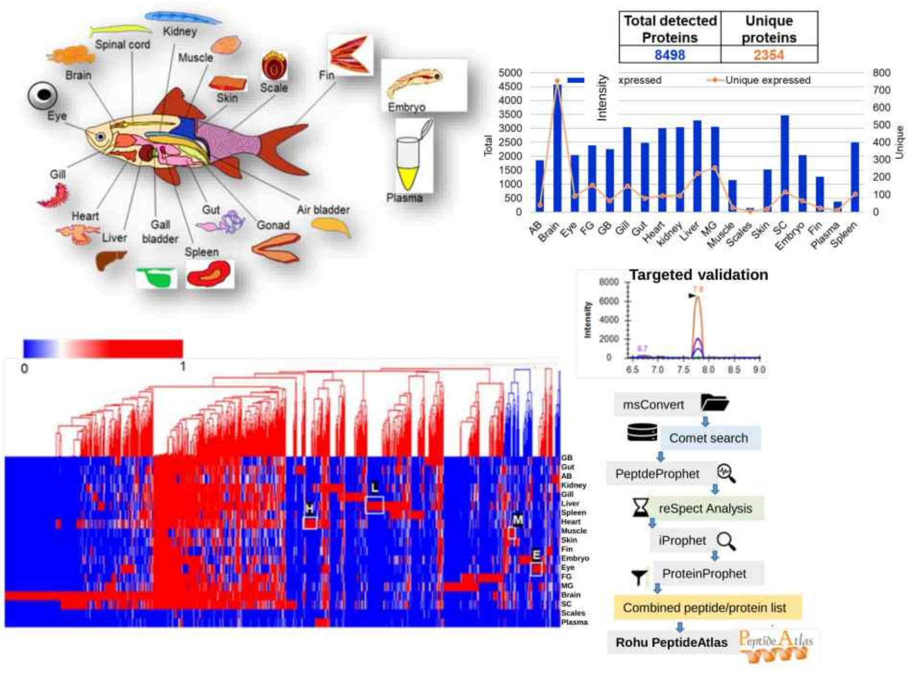
Budget
Rs. 100.546 lakhs

Funding Agency
DST-NANOMISSION, Govt. of India

The project came out with protein extraction methods and quantification assays which will be useful for carrying out proteomics studies in many fish species. Unsupervised-hierarchical clustering was performed to visualise the protein expression pattern across all the organs. These analyses revealed a large number of proteins showing a broad range of expression among tissues, while few proteins were found expressed only in one particular tissue. Deep proteomic profiling of 17 histologically normal tissues, blood plasma, and embryo of *Labeo rohita* provided mass-spectrometric evidence for 8498 proteins at 1% FDR that make up about 26% of the total annotated protein-coding sequences in *L. rohita*.

Fish Proteome Map (FPM) portal was developed to provide the protein expression information for all the studied sample types in *Labeo rohita*. It includes a search through which the expression pattern for one or multiple proteins can be visualized. The searched information is displayed in the form of a heat map along with some other information such as protein name, locus tag ID, number of unique peptides and status in peptide Atlas. Whole information can be downloaded in .csv format. FPM portal is made publicly available at www.fishprot.org.This comprehensive draft proteome map of *Labeo rohita* would advance basic and applied research in aquaculture to meet the most critical challenge, Global post-translational modifications (PTMs) in terms of acetylation (N-terminus and lysine), methylation (N-terminus, lysine, and arginine), and phosphorylation (serine, threonine, and tyrosine) have been identified to present a comprehensive



proteome resource. After analysing the high mass accuracy data-dependant analysis (DDA) mass spectrometry data using the PTMProphet tool (Shteynberg et al, 2019), we could detect 6870 acetylated peptides (1834 K acetyl, 3733 n Term acetyl and 1303 both K and nTerm), 3679 methylated peptides (1535 K methyl, 1180 R methyl, 471 n-Term methyl and 493 with 2-3 modified sites) and 826 phosphopeptides (524 S phospho, 138 T phospho, 41 Y phospho, 123 with 2-3 modified sites).In addition, a Peptide Atlas covering 140 K peptides has been made available for the scientific community. Targeted proteomic approaches e.g., Selected Reaction Monitoring (SRM) generally used for validating specific peptides for a particular target protein, was employed to validate the enriched expression of a set of forty-five proteins among nine organs including brain, embryo, eye, female gonad, heart, kidney, liver, male gonad and spinal cord. Differential protein expression profile of *Aeromonas hydrophia* and *Edwardsiella tarda* infected *L. rohita* was also made, which will be a useful biomarker for these bacterial diseases. Proteome analysis revealed important signalling pathways and protein-protein interaction networks.

Functional analysis of significant proteins in infected liver tissue revealed the dysregulation of several metabolic enzymes, cytoskeletal proteins and immune related proteins. This work has been recognised by the Journal of Proteome Research published by American Chemical Society.

Nanodelivery of Conspecific Kisspeptin to Enhance Sexual Maturity and Gonadal Development in *Catla catla*

CIFE/2021/601/EF

Project duration: 2020- 2023

Principal Investigator
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Dr. Gireesh Babu (ICAR-NRCM, Hyderabad)
Dr. Aparna Chaudhari

Funding Agency
DST-NANOMISSION, Govt. of India

Catla catla is the most key aquaculture species after rohu in India (FAO, 2009). It contributes about 50-60% to the total fish production from polyculture systems, fetching a high market price. However, for broodstock development and seed production, aquaculturists have to wait for more than three years. The species attains sexual maturity after three years of age compared to rohu and common carp, which takes two years and one year, respectively. In turn, the cost of production of broodstock is more compared to other carp species. To reduce this, intervention is required at molecular and hormonal level so that the age at maturity reduces and gonadal development takes place at early stages of life. Kisspeptin is one of such peptides which can be used for enhancing gonadal development. Kisspeptin plays an important role in the regulation of the Hypothalamic-Pituitary-Gonadal axis and is considered as key players in the neuroendocrine control of puberty and reproduction in mammals and lower vertebrates, including numerous fish. Kiss 1 and Kiss 2 gene has already been sequenced for *C. catla* by Rather et al., (2014) at Division of Fish Genetics and Biotechnology. The peptide sequence was deduced and synthesised the conspecific kisspeptin for further use. However, before that issue regarding toxicity needs to be studied. Accordingly, the experiment was set up at ICAR-CIFE, Powarkheda centre to study the toxicity of chitosan conjugated kisspeptin in *Catla catla*. Chitosan nanoparticles have been synthesized by the Ionic gelation method. Later these chitosan nanoparticles were conjugated with Kisspeptin (kiss 1 and kiss 2). The synthesised particles were characterized for size and zeta potential at FGB lab, ICAR- CIFE, Mumbai. The size of chitosan nanoparticles, CK1 and CK2 were found to be 126 nm, 224 nm, and 227 nm. The zeta potential of naked chitosan particles and CK1 and CK2 were 40.1 mV, 34.1 mV and 24.5 mV, respectively.

The entrapment efficiency was determined and found to be 70% for CK1 and 70.69% for CK2. To study the morphology of the synthesised particles, High Resolution Transmission Electron Microscopy (HR-TEM) was used for imaging and analysing. The result shows the shape of the particle as spherical uniform in dispersion. Size was found to be increased post conjugation process. To study the presence of functional groups in the particles, FTIR analysis was carried out.

For, toxicity study, an acute toxicity test was done with different doses in six different treatments of (PBS, Cyclophosphamide, kiss1, kiss2, CK1, and CK2) for a time period of 96 hr, in which LD_{50} was found to be much higher than the maximum dose of 1000 µg/kg.

Histology analysis was done to find out the effect of toxicity of different doses of treatments mentioned above. Hence, based on the acute toxicity test the suitable dose was found out which will be further evaluated for gonadal maturation in *C. catla.*

(CIFE/2019/FBT907/SR)

Toxicity of Chitosan Nanoparticle Conjugated Conspecific Kisspeptin in *Labeo catla* (Hamilton, 1822)

Yadvesh Ranvir Singh

Major Advisor: Dr. Rupam Sharma

Kisspeptin1 ($Kiss_1$) and Kisspeptin2 ($Kiss_2$) play an essential role in regulating the Hypothalamic-Pituitary-Gonadal axis of the *Labeo catla*. Kisspeptin is considered a key player in the neuroendocrine control of puberty and reproduction in mammals and lower vertebrates, including numerous fish. They are widely used for inducing maturation. The main limitation regarding the administration of Kisspeptin for regulation of reproduction is that they readily degraded on entry into the body by the reticuloendothelial system and enzymatic degradation. However, nanoencapsulation by chitosan nanoparticles increases their (Kisspeptin) shelf life by guarding them against the reticuloendothelial system and enzyme. However, the administration of nanopeptide in higher concentrations may cause adverse effects on the organism. There are limited studies about in vivo toxicity of nano conjugated Kisspeptin in *L. catla*. Hence, we evaluated the toxicity of Chitosan conjugated kisspeptin in *L. catla*. In this study, Chitosan nanoparticles were synthesized by the ionic gelation method and characterized for size and stability by zeta potential. Chitosan nanoparticles were further conjugated with Kisspeptin1 (Kiss1) and Kisspeptin2 (Kiss2). The size of chitosan nanoparticle and chitosan nanoparticle conjugated Kisspeptin1 (CK1) and Kisspeptin2 (CK2) were 126 nm, 224 nm, and 227 nm, respectively. The zeta potential of naked chitosan particle and chitosan conjugated Kiss1, and Kiss2 nanoparticles were 40.1 mV, 34.1 mV, and 24.5 mV, respectively. The drug loading efficiency for Chitosan-Kiss1 & Kiss2 nanoparticles were up to 70% and 70.69 %, respectively.

TEM image revealed the spherical structure of naked chitosan nanoparticles and chitosan nanoparticle conjugated Kisspeptin. FTIR study confirmed conjugation of chitosan nanoparticles and Kisspeptin. An acute toxicity test was performed with 125, 250, 500, and 1000 g/kg doses, and the LD_{50} value was determined at 96 hr, respectively. The LD_{50} value obtained for each treatment was 2336, 3736, 13006, 5456 µg/kg, respectively, significantly more than the highest dose (1000 µg/kg) administered in fish. Histology analysis was conducted to evaluate the in-vivo toxicity. At the highest dose of 1000 µg/kg, necrosis, leucocyte infiltration, massive degeneration, dilated sinusoids, detachment of hepatocytes, and hydropic degeneration were observed in the liver and brain showed massive degeneration, necrosis, hydropic degeneration, vacuolar degeneration, edema, and shrinkage of the granular layer, whereas, the dose of 250 µg/kg didn't cause any damage to the liver and brain of advanced fry of *L. catla*. Toxicity studies (acute toxicity test and histological analysis confirmed 250 µg/kg as a suitable dose for further evaluation in *L. catla*.

(CIFE/2019/AEM907/SR)

Algae Mediated Biogenic Metal Nanoparticles Production for Application as Anti-Algal and Antimicrobial Agents

Suchismita Jana

Major Advisor: Dr. S. P. Shukla

Biogenic silver nanoparticles were synthesized through a green process using live cells of cyanobacterium *Spirulina (Arthrospira) platensis* in an aqueous system where $AgNO_3$ was used as a precursor of the nanoparticles (1, 0.5, 0.1, 0.01 and 0.001M). The synthesized biogenic silver nanoparticles showed a peak at 415 nm in the UV-Vis spectrum, and brown colour was developed in the solution due to shift in plasmon resonance. The antialgal efficacy of synthesized nanoparticles was evaluated against green alga *C. vulgaris*. Seventy-two hour incubation of *C. vulgaris* culture treated with 1 to 5 % filtrates containing biogenic nanoparticles showed a decreasing growth rate of algal cells when compared to the control. The antimicrobial efficacy of synthesized silver nanoparticles was confirmed against multidrug resistance bacteria *Klebsiella pneumoniae* (KP_{53}) by employing a well diffusion method where 15 mm of inhibition zone was formed after silver nanoparticle exposure. In MIC and MBC tests, the bacterial growth inhibition was found at the concentration of 0.01M $AgNO_3$ treated algal suspension filtrates. The mechanism of bacterial growth inhibition was due to configurational changes in the beta-lactamase enzyme after exposure to silver nanoparticles. The absorption spectra of treated beta-lactamase with graded concentration of biogenic silver nanoparticles (0.001-0.1M) from 190-250 nm and 200-300 nm showed smoothening of peak indicating the gradual inactivation of the enzyme due to conformational changes induced by silver nanoparticle. An algal photobioreactor was also designed and developed for the continuous production of silver nanoparticles. *S. platensis* live cells were treated with 0.1M $AgNO_3$ solution, for the silver nanoparticles synthesis. The synthesized SNP had an average size of 167.8 nm where 99.9 % particles were 17.53 nm, and 0.1% particles were 80.77 nm, and the zeta potential was -24mV, which indicated moderate stability of the nanoparticles. The major findings of the study are: (1) Synthesis of biogenic silver nanoparticle can be upscaled through the newly designed photobioreactor (2) Biogenic nanoparticle produced in the bioreactor were effective in inhibiting the growth of alga *Chlorella* and the AMR strain of *Klebsiella pneumonia*. It is concluded that the process of biogenic nanoparticle production and its application for controlling the growth of the AMR strain can provide a solution for addressing the issues related to antibiotic resistance in pathogenic bacteria.

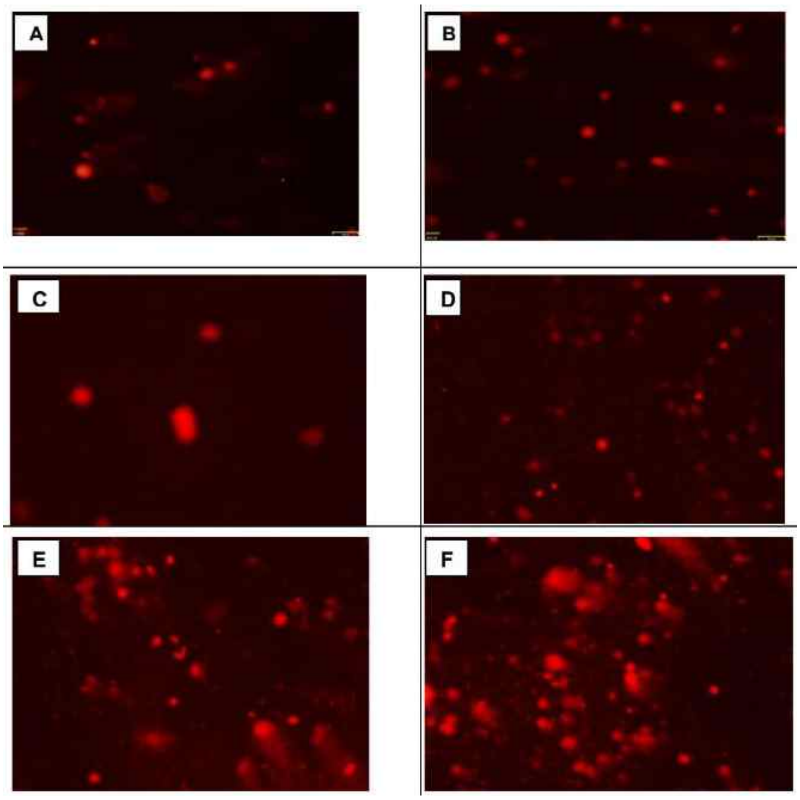
(CIFE/2019/FBT905/SR)

Toxicity and Biodistribution of Polyethylene Glycol (PEG) Functionalised Multi-walled Carbon Nanotubes in Zebrafish

Nikita Gurphale

Major Advisor: Dr. Rupam Sharma

Carbon nanotubes (CNTs) are carbon allotropes formed of graphite shaped into cylindrical tubes measuring a nanometer in diameter and many millimeters in length. CNTs have potential applications in biomedical science, nanomedicine, genetic engineering and biosensor because of their unique physical, chemical, and biological properties. However, a few concerns have been raised because of the scant solubility in biological media of non-derivatized CNTs



and their poor biological compatibility, possible toxicity, and scarce clearance. To mitigate this, CNTs are functionalized with different materials. Carbon nanotubes functionalized with polyethylene glycol (PEG–MWCNTs) are promising materials for biomedical applications, such as diagnostic devices and controlled drug-release systems. However, several questions about their toxicological profile remain unanswered. Thus, this study aimed to investigate the toxicity of PEG–MWCNTs at the cellular, genomic and morphological levels in zebrafish (*Danio rerio)* embryos. The MWCNT used in this study were synthesized by the chemical vapour deposition method, purified with nitric acid and then functionalized with PEG–6000. The characterisation was carried out with High transmission electron microscopy, Zeta sizer and FT–IR spectroscopy. PEG–MWCNTs with different doses were exposed to zebrafish embryos to study toxicity. The toxic effect of PEG–MWCNTs occurred only at a concentration of 1.28 mg L^{-1}, 2.56 mg L^{-1}, 5.12 mg L^{-1} and 10.24 mg L^{-1}. At the highest dose (10.24 mg L^{-1}), 37 % mortality was recorded after 96 hours of exposure. Body malformation rate in zebrafish embryos was increased with increasing the dose. The comet assay was for all the doses and revealed that genotoxicity occures at 1.28 mg L^{-1} and 2.56 mg L^{-1}. The histological investigation was conducted to understand toxicity which showed disturbances like hyperemia, notochord deterioration, somite disorganization. Functionalization increased dispersion stability of MWCNTs and toxicity of PEG-MWCNTs was increased with increasing dose. For better understanding of CNT toxicity in vivo, more research is needed through gene expression studies, bio persistence and biodistribution biochemical markers.

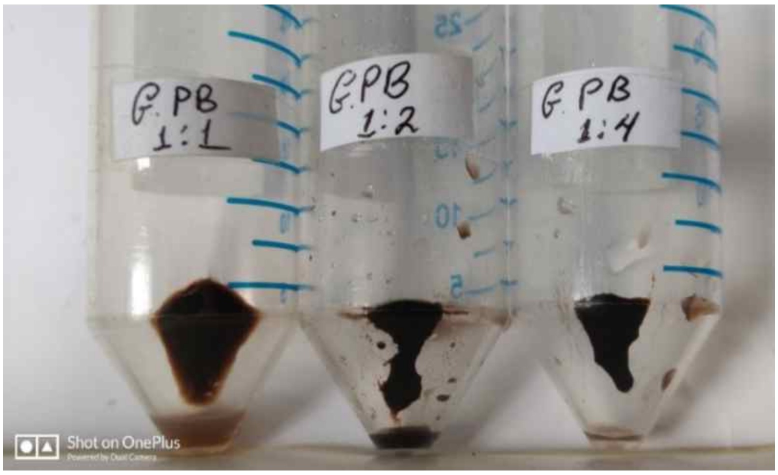
(CIFE/2019/AQC912/SR)

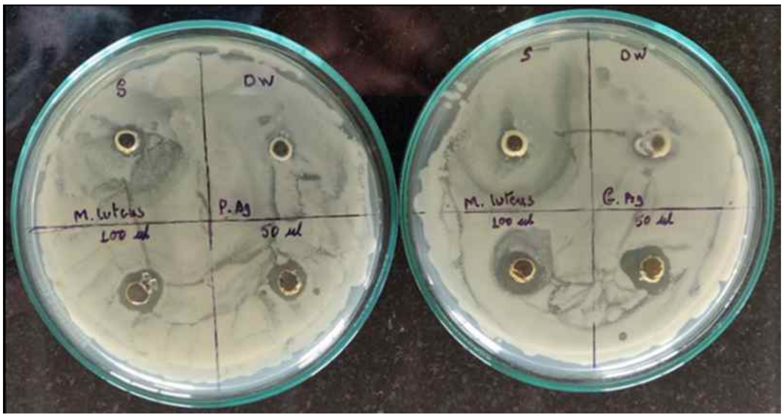
Synthesis, Characterization and Bactericidal Activity of Silver Nanoparticles Using Pig and Sheep Wastes for Exploring Potential Application in Aquaculture

Sowa O Lamare

Major Advisor: Mr. Harikrishna

The present study achieved the synthesis of silver nanoparticles (Ag-NPs) from the waste generated in pig and sheep slaughter houses, especially the intestine. This biosynthesis was carried out using silver nitrate as precursor incubated with extract from the waste of pig and sheep in the selected liquid medium. The characteristics of the synthesized Ag-NPs were obtained using High-Resolution Transmission Electron Microscope (HRTEM), Dynamic Light scattering (DLS) and UV-visible spectrophotometer. The size of the silver nanoparticles obtained using HRTEM was in the range of 5-100 nm, with the majority of NPs ranging between 5-30 nm. The surface plasmon resonance of the synthesized





Ag-NPs showed a maximum absorbance peak in the range of 405-410 nm. The synthesized Ag-NPs exhibited the zeta potential of -32 mV, which showed that biosynthesised Ag-NPs were highly stable. Effective bactericidal activity of these Ag-NPs was also observed against *Micrococcus luteus, Aeromonas hydrophila*, and *Edwardsiella tarda* based on the zone of inhibition. The chronic toxicity analysis of the synthesized Ag-NPs on *Pangasianodon hypophthalmus* was carried out by using stress biomarkers such as an antioxidant enzyme, AChE, and metabolic enzyme activity. Chronic toxicity of synthesized Ag-NPs was found to increase with increased sub-lethal ammonia concentration and temperature. The findings of this study revealed that biosynthesis of Ag-NPs can be undertaken by using pig and sheep wastes for its potential application in aquaculture based on the properties observed in characterisation and bactericidal activity.

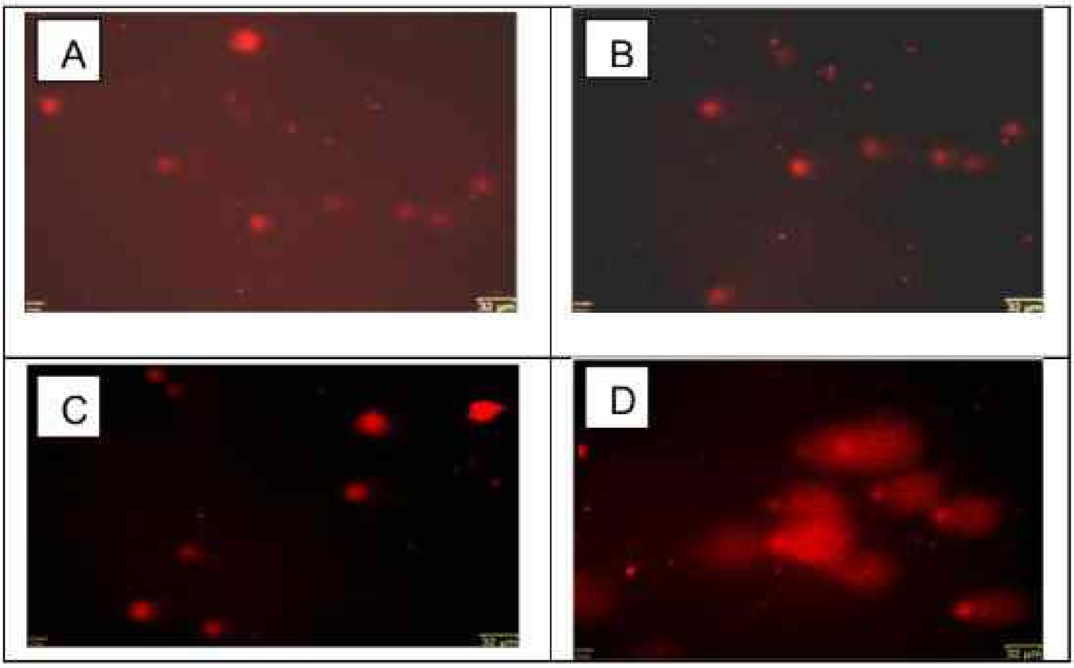
Evaluation of Teratogenicity and Genotoxicity of Mithi River Water in Zebrafish (*Danio rerio*)

(CIFE/2019/FBT902/SR)

Harshavarthini M.

Major Advisor: Dr. N. S. Nagpure

The Mithi river which expands from North latitude 19°00'15" to 19°15'00" and East longitude 72°45' to 73°01', rises from the hills east east of the Sanjay Gandhi National Park and gathers water from discharges of the Powai and Vihar lakes. The river drains at Mahim Bay and into the Arabia Sea and this area has been designated as a 'Salim Ali Bird Sanctuary,' where migratory birds come to nest. The Mithi river is a major water drain for Mumbai, with mangroves on both sides acting as a natural flood barrier. The Vihar Lake provides 3% of Mumbai's drinking water needs. The Mithi river in Mumbai is one of the most polluted bodies of water due to industrial and domestic discharges. Pollutant discharge has caused severe pollution of Mithi River over time, endangering its ecology and aesthetic aspects. A continuous monitoring of the quality of the water of river Mithi is required. The current study was carried out to determine the teratogenicity and genotoxicity of Mithi River water in zebrafish (*Danio rerio*). Water samples were taken from ten locations, viz. 1. Vihar Lake 2. Saki Vihar Road 3. Military Road Old Bridge 4. Andheri - Kurla Road 5. Near Airport 6. LalBahadhur Shastri Road 7. Taximens Colony Road 8. Chunabhatti - BKC Flyover 9. Sion-Bandra Link Rd 10. Near Mahim Causeway. At each sampling location, water samples were collected in duplicates with a distance of 10 meters apart and analyzed for physicochemical parameters. The range for physicochemical parameters viz., DO, hardness, TDS, BOD, COD and electric conductivity was 1.34 to 6 mg/l, 66 to 1804 mg/l, 15 to 1377 ppm, 17.75 to 342.2 mg/l, 26 to 511.15 mg/l & 0.19 to 2.12 mS/cm respectively. These values were found to be above



the permissible limits prescribed by BIS - IS: 10500:1991 and CPCB, 2009. To assess the toxicity of water samples, a zebrafish embryo toxicity test (ZFET) was performed with 8 different dilutions (0, 2, 4, 8, 16, 32 and 64 times) for each sampling site. A total of 30 embryos were exposed to each dilution, and after 120 hours, the highest mortality of 90% was observed in zebrafish embryos exposed to undiluted S5 (Airport site) water samples. Further dilutions of water samples from all sites were made at 0, 2, 4, 8, 16, 32, and 64 times to determine lethal dilution 50. The lowest and highest LD50 values of 0.233 & 4.122 were obtained for the S1 and S10 respectively. There was a significant difference in teratogenicity among various sites for endpoints such as egg coagulation, tail detachment, and mortality at 120 h. The comet assay (Single Cell Gel Electrophoresis) was used to assess DNA damage in zebrafish after 120 h of exposure to selected water samples. No significant difference in DNA damage was observed for zebrafish embryo cells exposed to S1 and control cells with OTM values 1.03±0.14 & 0.89 ±0.04 respectively. Whereas a significant DNA damage was observed in zebrafish embryo cells exposed to S_5 with OTM values 6.82 ± 0.09. The findings of the present investigation indicated that Mithi river samples (except Vihar Lake) were polluted and induced teratogenic and genotoxic effects in zebrafish embroys.

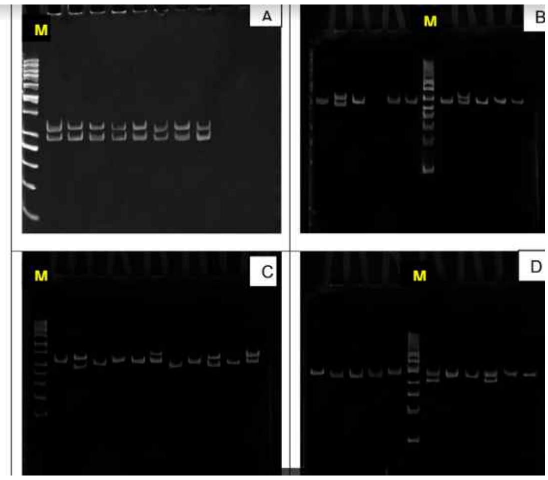
(CIFE/2019/FBT903/SR)

Mining and Characterization of SSRs from *Lamellidens marginalis* (Lamarck, 1819) Genome

Biswaranjan Mohapatra

Major Advisor: Dr. Annam Pavan Kumar

Lamellidens marginalis is an important freshwater pearl mussel in Southeast Asia. In India, this species has a wide distribution along the major riverine systems and provides livelihood to the local people. This is the most widely cultured mussel for pearl production. Because of distinct and different habitats (ecology) they colonize, *L. marginalis* would have diverse genetic stock across its distribution range. Further, the wild stocks of *L. marginalis* are facing threats due to anthropogenic factors. Knowledge of genetic diversity is necessary to formulate effective management and conservation measures. However, the genetic diversity of this species has not been studied much due to the lack of molecular markers. With this background, the present study is carried out



with objectives of mining the SSRs from the genome data of *Lamellidens marginalis* and to characterize the selected microsatellite loci of *L. marginalis*. A total of 1,88,615 SSRs representing mononucleotide (169,766) di- (10817), tri-(4563) and tetra-nucleotide repeats (3358) were mined from the secondary data. Within mono-nucleotide repeats, the repeat motif "A/T " was the most abundant motif with a frequency of 86%. Among the di-nucleotide repeats, "AC/GT " was more abundant than the other repeat motifs. The repeat motif "AAT/ATT " was the most prominent among the trinucleotide repeats. Within the tetranucleotide repeats, "ACAT/ATGT " are more in number than the other repeat motifs. Among the SSRs, the nucleotide motifs were repeated from 6 to 30 times. In most of the SSRs, the nucleotide motifs repeated 6 times. Out of 22 loci selected for characterization, 6 loci consisting of di-nucleotide (Lm 1191, Lm 1251), tri-nucleotide (Lm 39, Lm 547) and tetra-nucleotide (Lm 44, Lm 45) showed consistent amplification. Further studies are required to estimate the population genetic parameters with a large sample size. These markers are useful for characterizing the genetic stocks of *Lamellidens marginalis.*

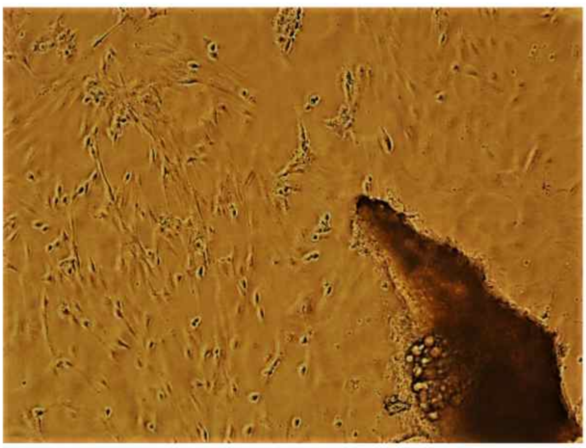
(CIFE/2019/FBT907/SR)

Development and Characterization of Muscle Cell Culture System from *Clarias magur*

Dhivyakumari S.

Major Advisor: Dr. Mukunda Goswami

Cell line has been used as a novel *in vitro* tool for performing various studies in life sciences. The current study was aimed to develop and characterize muscle cell culture system from *Clarias magur*. Explants prepared from the tissues of *C. magur* viz. caudal peduncle muscle and dorsal fin based muscle were used for the development of primary cultures. The primary cell cultures developed from caudal peduncle muscle were successfully subcultured up to 13 passages towards the development of a cell culture system. Cell culture system established from the caudal peduncle muscle was designated as CMM. CMM cell culture system was maintained in Leibovitz'-15 medium supplemented with 10% FBS (Fetal Bovine Serum) and 10ng/ml of bFGF (basic fibroblast growth factor). CMM cells exhibited maximum growth at temperature 28ºC. The maximum growth of muscle cells was recorded at L- 15 medium supplemented with 20% FBS. Relatively good growth was also observed at 10-15% FBS. Gene Sequences of mitochondrial cytochrome C oxidase subunit I (COI) derived from CMM cells was used for the confirmation of the species of origin. The cell culture system was successfully cryopreserved by a slow freezing procedure at -80ºC with a revival efficiency of 60%. Further characterization and maintenance of the CMM system would lead to a well characterized stable muscle cell line. The study revealed that the CMM cell culture system would be useful for visionary cell based fish meat production. In addition, the cell culture system would play an important role for carrying out *in vitro* aquaculture research.



Expression Profiling of Selected Reproductive Genes of *Clarias magur* (Hamilton,1822)

Diganta Dey

Major Advisor: Dr. Aparna Chaudhari

The culture of *Clarias magur* is limited due to the non-availability of quality seed and and feed. Commercially available inducing agents are used for breeding this fish, but still the males have to be sacrificed for milt collection. Researchers reported partial success with milt release on administration of oxytocin 12 h after GnRH administration. Similar approaches used by the FGB Division ICAR-CIFE have yielded similar results. Recently, gonad and brain transcriptomes of magur were sequenced by FGB Division, ICAR-CIFE. Several reproduction-related genes were characterized and expression profiles were generated at various stages of maturity to get a better understanding of the molecular mechanisms of the reproductive process and its regulation. That study hypothesized that peculiar neuro-endocrine regulation caused the magur testis to be held in a contracted state at 16 hpi. Based on these leads, this work was designed to analyze expression profiles of selected differentially expressed genes identified by RNASeq analysis. These genes *cyp8b1*, *gad67* & *gad65* (*glutamic acid decarboxylase-1*) & (*glutamic acid decarboxylase-2*), *th* (*tyrosine hydroxylase*), *gat1* & *gat3* (*sodium and chloride dependent GABA Transporter 1 & sodium and chloride dependent GABA Transporter 3*) and *cyp19a* & *cyp19b* (*p450 aromatase*) are involved in GABA, estrogen, cholic acid and dopamine synthesis /action. Magur adults (~200 g) were collected from Powarkheda farm of ICAR-CIFE and kept in 1000 L FRP tanks with aeration. 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 RNA was isolated and cDNA was prepared. PCR conditions for 7 selected genes were optimized and the purified PCR products were confirmed by Sanger sequencing. Real-time PCR of 2 genes showed significant up-regulation ($P<0.05$) in the gonadal tissues at 16 hpi in comparison to the mature group. *cyp8b1* shows 10-fold up-regulation in testis, while in the ovary *gat 3* is 3-fold up-regulated. *gad67* showed 3.5- and 3.0-fold higher expression in the male and female brains, respectively. The expression was 5- and 3-fold higher in the female and male brains, respectively. *cyp19b* showed 2.5-fold upregulation in male brain at 16 hpi. The expression profiles of 5 genes matched the

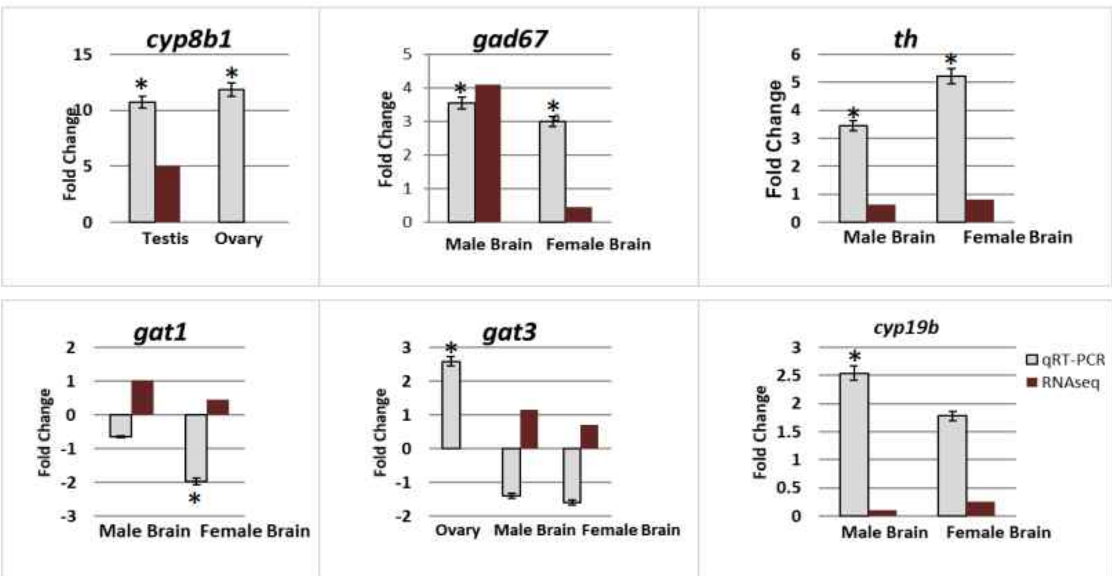


Fig. 17. Fold changes in the selected genes at 16 hpi compared to maturity stage. (Statistical significance at P<0.05. * Marks indicates significant differences).

RNASeq data of the previous study, while *gad65* and *gat1* differed. *gad65* was uniformly expressed and not significantly upregulated in the FB as predicted by RNASeq data, and *gat1* was seen to be 2-fold downregulated in the FB (unregulated in RNASeq data). This work confirms the hypothesis neuro-endocrine inhibition of milt release from magur males and can be used to develop an easy to use and effective induced breeding protocol for *Clarias magur* in future.

(CIFE/2019/FBT907/SR)

Mining of Antimicrobial Peptides from *Clarias magur* (Hamilton, 1822) Transcriptome

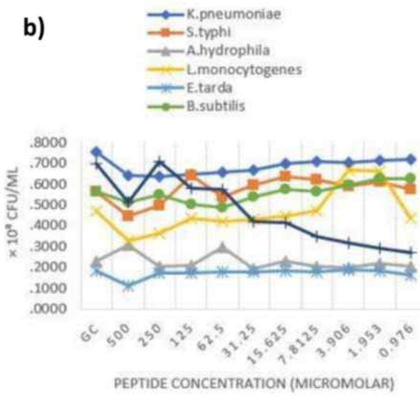
Subashini V

Major Advisor: Dr. Aparna Chaudhari

Antimicrobial peptides (AMPs) have emerged as promising alternatives to antibiotics due to their unique mechanism of action, making it less likely for pathogens to develop resistance. About 136 AMPs have been reported in fish species that live in a microbe-rich environment. The Indian catfish *Clarias magur* is a popular indigenous fish species with wide distribution. *C. magur* has a well-developed innate immune system and could be a good source of AMPs due to their preference for muddy waters. The transcriptome data of growth-selected *C. magur* available in the FGB Division, CIFE, was mined for AMPs. Homology search was conducted using Local BLAST to find matches for the 279 fish AMP sequences (retrieved from APD3 and NCBI databases) in the magur transcriptome comprising 52,237 contig sequences. 266 retrieved AMP sequences found hits in the *C. magur* contig set from which nine contigs were selected based on the lowest positive E-value. The selected contigs were analyzed for open reading frames (ORFs), and 7 ORFs with lengths of 12 to 40 amino acids were predicted to be AMPs by various prediction servers. *In silico* analysis of the putative AMPs was done based on various physicochemical parameters like charge, hydrophobicity, amphipathicity, etc.) and three putative AMPs - AMP1, AMP4, and AMP7 were chosen for molecular docking studies with 22 bacterial antigens of 7 pathogenic species for which 3D structures were available in the database AntigenDB. The 3D structure of the AMPs was predicted in the Pepfold server, and the quality of the structure was validated using the Ramachandran plot. All the three AMPs showed significant interactions with the antigens, and the least binding energy ranged from -8 to -12 Kcal/mol. The cluster size was also large, ranging from 170 to 250. AMP4 was commercially synthesized at 97.58% purity using Solid Phase Peptide Synthesis. The antimicrobial activity of the AMP4 was validated using broth microdilution assay against gram-positive *Staphylococcus aureus, Bacillus subtilis, Listeria monocytogenes*, and gram-negative *Aeromonas hydrophila, Edwardsiella tarda, Klebsiella pneumoniae, Salmonella typhi* with IBSC approval for handling human pathogens. The assay was conducted as per the CLSI guidelines at peptide concentrations ranging from 500µM to 0.976µM. It was found that AMP4 inhibited *Aeromonas hydrophila* with Minimum Inhibitory Concentration between 15.625 µM to 31.25 µM. CFU/ ml reduced to 56% and 41% of the positive control at these concentrations. Higher concentrations of AMP4 did not further reduce the cell count, which could be due to the limited efficacy of the peptide. AMP4 had no antimicrobial activity against other pathogens at the

a)	APD3	CAMP	iAMP pred	ANTI BP2	ADAM	MACREL
AMP1	AMP	AMP	0.94	AMP	0.69	0.614/ H
AMP2	AMP	AMP	0.52	NAMP	0.29	0.82/ H
AMP3	AMP	AMP	0.92	AMP	0.56	0.6629/ NH
AMP4	AMP	AMP	0.96	AMP	0.76	0.693/ H
AMP5	AMP	AMP	0.98	AMP	0.89	0.653/ H
AMP6	AMP	AMP	0.79	NAMP	0.9	No
AMP7	AMP	NAMP	NAMP	NAMP	NAMP	0.574/ H

b)



peptide concentrations tested. These results will be reconfirmed in the future. It is concluded that AMP enriched magur transcriptome could be a better source of AMPs, and AMP4 could be a promising therapeutic agent for aquaculture to treat hemorrhagic septicemia caused by *Aeromonas hydrophila* and other pathogenic species of the genus.

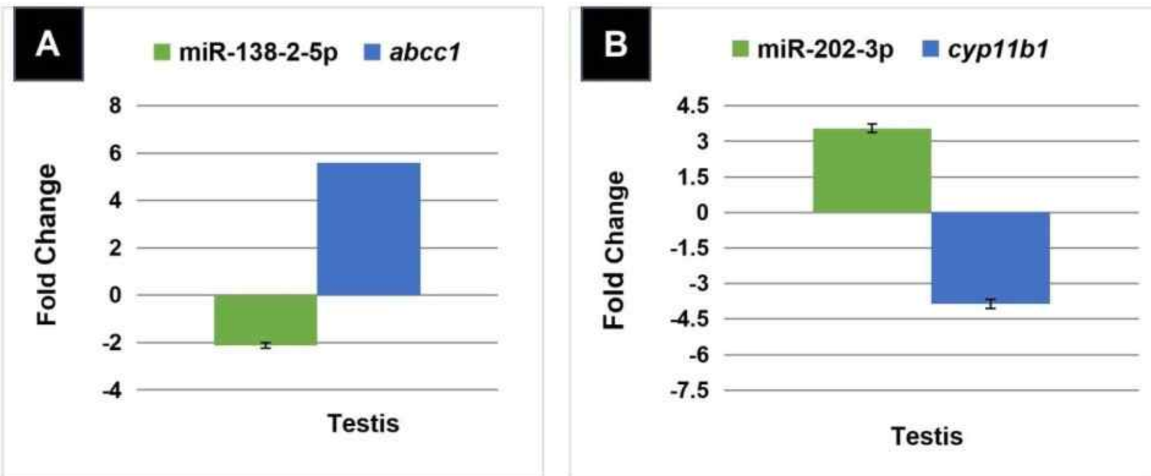
(CIFE/2019/FBT908/SR)

Experimental Validation of MicroRNAs (miRNAs) in *Clarias magur* (Hamilton, 1822)

Shasti Risha K.

Major Advisor: Dhalongsiah Reang

Understanding the mechanisms behind reproduction and disease resistance can make molecular interventions possible in improving the induced breeding of *Clarias magur* in captivity. MicroRNAs (miRNAs) are naturally occurring short non-coding RNAs that regulate gene expression of about 30% protein coding genes. Previous studies in FGB Division, ICAR-CIFE on *in silico* miRNA prediction from the existing magur transcriptome data identified candidate microRNAs that show regulation of their corresponding target genes . The transcriptome data consisted of 39738 contigs of magur male and female brain and gonads at 4 reproductive stages: Premature-P, Mature- M, 6 h and 16 h post Ovatide injection. The present study aimed to validate the putative miRNAs and to examine the gene expression profiles of predicted miRNA-target gene pairs. The target genes selected were those involved in reproduction, immunity and metabolic regulation. Magur adults (~200 g) were collected from ICAR-CIFE Powarkheda Centre. Two groups of 3 males and 3 females each were made. Brain and gonad tissues were collected from non-injected mature fish and 16 h post GONOPRO-FH™ injection that was administered @ 0.5 mL Kg^{-1}B.W. to females and 0.3 mL Kg^{-1} B.W. to males. Total RNA was isolated and cDNA was prepared. Small-RNA was enriched by following mirRICH protocol, and specific stem-loop primers were used to prepare the first strand cDNA. The quality of cDNA was checked by PCR amplifying beta-actin and U6 genes for mRNA and miRNA, respectively. PCR optimization was been done for two reproductive microRNAs (cma-mir-202-3p and cma-mir-10622-5p), one regulatory (cma-mir-30-e-3p) and two immune-related microRNAs (cma-mir-202-5p and cma-138-2-5p) and their target genes, *cyp11b1* (steroid 11-beta hydroxylase), *cyp19* (cytochrome P450 aromatase), *dhcr7* (7-dehydrocholesterol reductase), *rfx7* (DNA-binding protein RFX7), *abcc1* (multidrug resistance protein 1-like isoform X1), *prkc* (PRKC apoptosis WT1 regulator protein). Out of the seven *in silico* predictions of target gene regulation made by the earlier study, expression profiling by real-time PCR confirmed the regulation of only five, including *cyp11b1* in testis, *abcc1* in female brain, *dhcr7* in female brain *and rfx7* in male brain. Of these five, only two target genes show reciprocal regulation with respect to their predicted miRNAs. These were *cyp11b1* & miR-202-3p (in all tissues), and *abcc1* & miR-138-2-5p at 16 hpi. Two target genes, *prkc*, *cyp19b* were not regulated in the same direction as was predicted. Thus out of the seven predictions of miRNA regulation, only two could be validated (28% prediction efficiency), but a total of 12 inversely regulated



miRNA-target gene instances were observed, at least in one tissue for each pair and in all 4 tissues in case of *cyp11b1*, which is a reproductive gene that plays a significant role in spermatogenesis by catalysing the synthesis of 11-hydroxytestosterone (precursor of 11-ketotestosterone). It is also related to stress response as it is involved in glucocorticoid synthesis. MiRNA regulation can be confirmed only by use of anti-MiRNAs, which could be done in future.

(CIFE/2017/FBT904/SR)

Identification and Functional Characterization of MicroRNAs Associated with Carbohydrates Metabolism in Rohu, *Labeo rohita* (Hamilton, 1822)

Kiran Dashrath Rasal

Major Advisor: Dr. J. K. Sundaray

Rohu, (*Labeo rohita*, Hamilton, 1822) is one of the important carp species in aquaculture in Asian countries. Recently farming of rohu is facing challenges due to increased input feed cost. Rohu is omnivorous in nature and supposed to be a better carbohydrate utilizer. However, the physiological and molecular basis of this apparent glucose intolerance in rohu is not fully understood. The role of microRNA (non-coding RNAs, 19-21 nucleotides) in post-transcriptional gene regulation associated with glucose metabolism has been revealed in several organisms including fish. Thus, the present study was performed to investigate miRNAs role by small RNA and mRNA sequencing in the liver of rohu fed with different proportions of carbohydrate diet (20% (control), 40% and 60% carbohydrate). Illumina-NextSeq500 technology yielded a total of 80.2 million reads and computational analysis identified 138 conserved and 161 novel miRNAs. A total of 18 up-regulated miRNAs were identified in the liver tissues of rohu fed with 40% carbohydrate, while 11 upregulated miRNAs were identified in the liver of rohu fed with 60% carbohydrate (Log2FC >1.5). Target prediction and gene ontology (GO) study suggested that miR-29, miR-21, miR-375, miR-365, miR-202, miR-193, miR-10, miR-133, miR-375, miR-459, miR-454, and miR-124 showed association with regulatory transcripts of metabolic functions in the liver of rohu. Liver transcriptome sequencing revealed that transcripts associated with glucose metabolism such as *hexokinase, glycogen synthase, g6pca,* and *UDP- Pyrophosporylase, ACS, and PPARγ* were up-regulated in liver of fish fed with high carbohydrate as compared to control, that indicated enrichment of glycogenesis and *de novo* lipid synthesis. Randomly selected miRNAs and transcripts linked with carbohydrate metabolism were validated by RT-qPCR and the results indicated that their expressions were consistent with the RNASeq data. The co-expression analysis of miRNA-targeted genes showed correlated actions and a total of 44 targeted transcripts associated with liver metabolic functions showed a decrease in their expression level significantly ($P<0.05$) in the liver of rohu when fed with high carbohydrate. Further analysis depicted mature miRNA and their predicted target sites in genes were involved in developmental biology, cellular activities, transportation, etc. This work indicated the modulation in the insulin signalling pathway for maintaining glucose homeostasis in the liver of rohu. The present study revealed atypical regulation transcripts and a few set of miRNAs role associated with glucose metabolism and *de novo* lipogenesis in the liver of rohu due to inclusion of high carbohydrate in the diet. This is the first report of the miRNAs in the liver tissue of rohu and their comparative profile linked with metabolism will serve as a vital biomarker resource. Overall, the findings from the present study will rationalize the way for *in vivo* studies on the role of miRNAs in farmed carps.

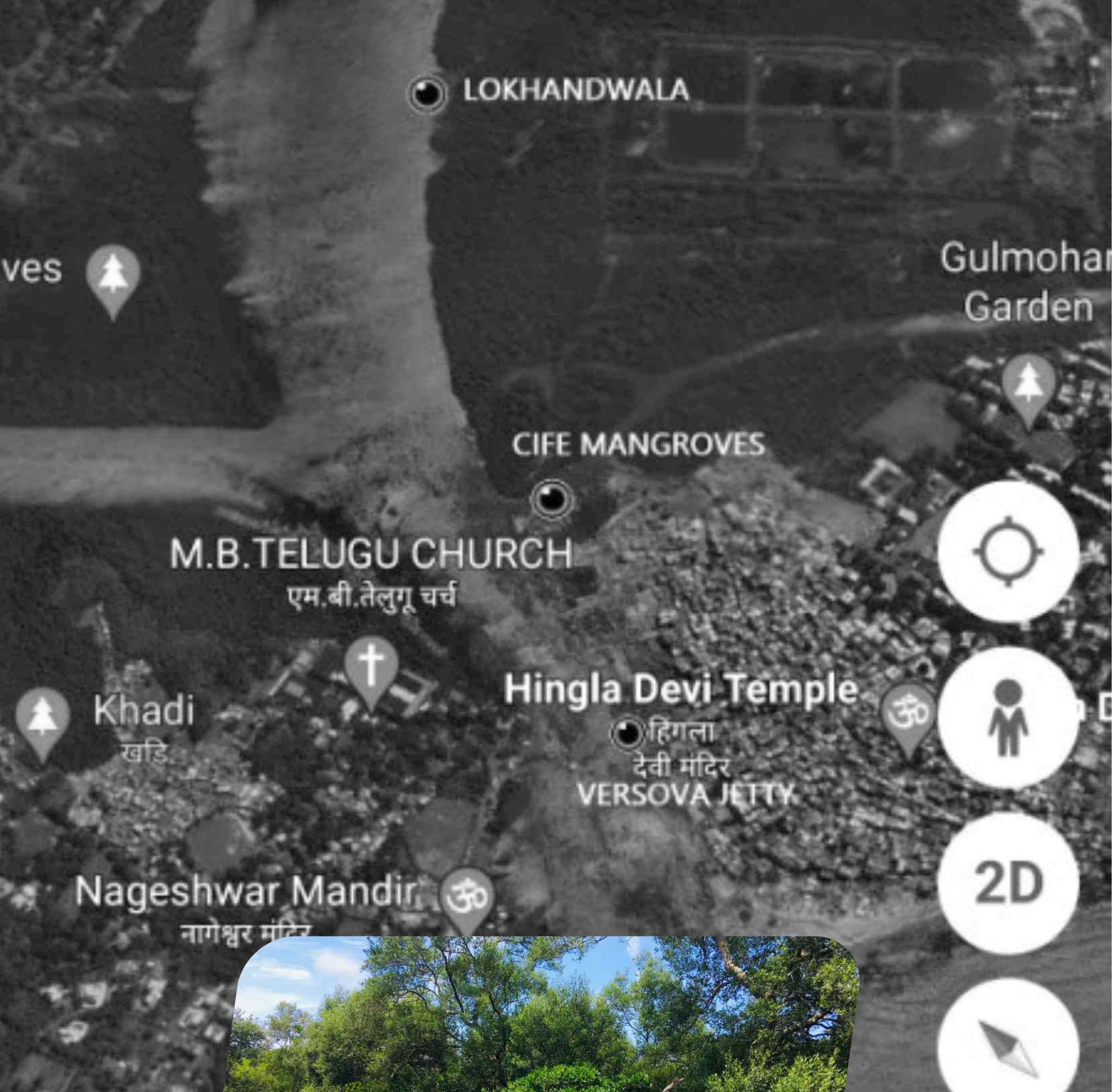
(CIFE/2019/AQC906/SR)

Role of miRNAs, their Expression, Profiling and Identification in Gonadal Development of *Channa striata* (Bloch,1793)

Gitanjali Behera

Major Advisor: Dr. J. K. Sundaray

MicroRNAs are small non-coding RNAs about 22 nucleotides long and are important post-transcriptional regulators of gene expression. They are found in almost all the eukaryotes and show conserved nature across species. miRNAs are involved in almost all biological processes including gonad development and reproduction. To understand their role and expression during different stages of gonadal development, this study was carried out at pre-spawning stage, spawning and post-spawning stage taking *Channa striata* as the experimental fish. *Channa striata* is one of the most important candidate species for freshwater aquaculture and important for climate- resilient aquaculture owing to its capacity to grow in adverse water conditions. We identified 6 miRNAs in the gonad, liver and brain of both male and female *Channa striata* which are miR-34a, miR-202-5p, miR-21, miR-133b, miR-22 & miR-200. Their relative expression was checked at pre-spawning, spawning and post-spawning stages to determine the role played by these miRNAs in the gonadal development of *C. striata*. Very high relative expression was found in male gonads in case of miR-202-5p and miR-21 during the spawning stage. Both miR-202-5p and miR-21 targets genes which play an important role in spermatogenesis and sperm maturation. miR-202-5p is up-regulated 12 times in male gonads which are involved in sperm maturation and expressed in sertoli cells. miR-34a was seen to be down-regulated during spawning season in male gonads and upregulate the activity of gsk3a gene which is involved in sperm motility. The higher expression of miR-22 in both male and female gonad during spawning stage might regulate the maturation of gametes in the respective sex organs. miR-200 had higher expression in both male and female brains during the spawning stage which suggests it might control the synthesis of luteinizing hormone in the pituitary as observed in mice.



Aquatic Environment Management

Low-Cost Adsorbents for the Removal of Phosphate, Nitrate and Heavy Metals from Sewage Fed Aquaculture

(CIFE/2021/3/IF)

Project duration: 2021- 2023

Principal Investigator
Dr. Suman Manna

Co-Principal Investigators
Dr. Shubhendu Datta
Mrs. Sweta Pradhan
Dr. G. H. Pailan

Technical Associates
Mr. P. K. Behera

Significant achievement

- Nitrate and phosphate loads are present in the sewage fed pond water as evident from the chemical characterization and need to rectify by employing suitable adsorbent.
- Synthetic poly-acrylate composites were prepared as adsorbent materials to treat the water sample.

Analysis and characterization of sewage water/sewage fed aquaculture pond water

Water was collected from sewage fed aquaculture situated in the Nalban sewage fed fishery, Govt of West Bengal. Water samples were collected from two different points, one from source point and one from sewage fed pond. The water sample was analyzed for their chemical composition which is given in Table 1. The nutrient loads in terms of nitrate, phosphate and soluble iron content is higher in source point than the pond water.

Table1: Characterization of water sample from sewage fed pond

Parameter	Water from source point to pond	Water from sewage fed pond
pH	8.0	6.5
Dissolved oxygen (mg L-1)	6.5	7.5
Salinity	2	1
Ammonia (mg L-1)	0.05	<0.05
Nitrate (mg L-1)	10	5
Phosphate (mg L-1)	5	0.25
Soluble iron (mg L-1)	0.3	0.1

Natural as well as synthetic adsorbents are used for removal of toxicants from water in general. Here we have collected some locally available natural adsorbents like rice straw, rice husk, rice husk ash, ashes etc.

Synthesis of adsorbents for the removal of toxicant

Some synthetic adsorbents are synthesized by interfacial polymerization at 60 °C for 12 hrs. The synthetic adsorbents are categorized as polyacrylate crosslinked hydrogels. Polyacrylate crosslinked hydrogels of six different compositions by varying the crosslinker, initiator and filler content was synthesized for the experimental purpose. Wood ash was used as filler materials for better adsorbing capacity. The solid gel mass was hydrolyzed with 1 (N) NaOH solution (half of the volume and full volume of the gel mass) at 50 °C for 12 hrs. Different volumes of alkali were taken to check the hydrolyzing ability and subsequent adsorption capacity. After hydrolysis the adsorbents were neutralized with 10% acetic acid (CH_3COOH) to bring down the pH 7.0. Then they were treated with acetone for quick drying. After that they were kept in the oven for complete drying. After drying the mass was powdered for adsorption experiment with sewage fed pond water.

Fig. Different polyacrylate adsorbents synthesized for the study

Assessment and Management of Priority Abiotic and Biotic Stresses in Aquaculture Production Systems of Selected Districts of Bihar and Jharkhand

(CIFE/2020/5/IF)

Project duration: 2021- 2023

Principal Investigator
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Co-Principal Investigators
Dr. Md Aklakur
Dr Saurav Kumar
Dr. Kapil Sukhdhane
Dr. Swadesh Prakash
Dr. Arpita Sharma (From November 2022)

Technical Associates
Mr. Narendra Aglave
Dr. Parmanand (From November 2021)

Interactions with State Fisheries Directorate, Bihar and Jharkhand, hatchery operators and ICAR Institutes (NIBSM, Ranchi, ICAR-RCER, Patna and Mahatma Gandhi Integrated Farming Research Institute, East Champaran) were held. Various villages of Muzaffarpur and Samastipur districts of Bihar were visited on 16-19 November 2021 and selected 12-fish farms/ponds/farming clusters, based on the stocking density/intensification (extensive / semi-intensive / intensive culture system), cultured fish species, existing farming practices (diversification) with prevalence of pathogens, productivity, and accessibility for sample collection. Composite samples were collected and analyses showed that these parameters were found to be within the reference ranges and suitable for freshwater aquaculture.

Group meetings with farmers were organized in various villages of Muzaffarpur and Samastipur districts and advisories on improved technology interventions, BMPs and water quality management, bagasse assisted bioremediation, use of water analysis kit were provided to aqua-farmers. During the group meetings, prevailing packages of practices were collected for evaluating and comparing economic viability.

Advisories for reference ranges of water quality parameters optimum for freshwater, inland saline and brackishwater aquaculture systems have been prepared. Progress has been made for fabrication of Kit technology for measurement of critical water quality parameters such as pH, dissolved oxygen, ammonia, and nitrite for on farm demonstration. Research work has also been initiated on the development of medicinal plant based products for mitigation of priority abiotic and biotic stresses in aquaculture.

Organization of brain-storming sessions

A brainstorming session on the project theme was organized virtually on 6th November 2021. Based on the recommendations and valuable inputs provided by the experts, activities are being implemented for smooth running of the project.

Study on the Occurrence, Impact on Biotic Communities and Development of Integrated Technologies for Remediation of Emerging Pollutant Triclosan

(CIFE/2021/700/EF)

Project duration: 2021- 2024

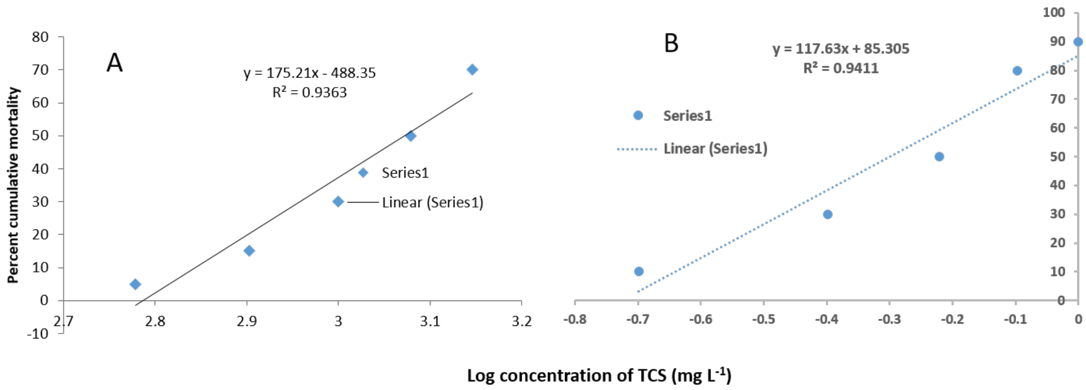
Principal Investigator
Dr. Kundan Kumar

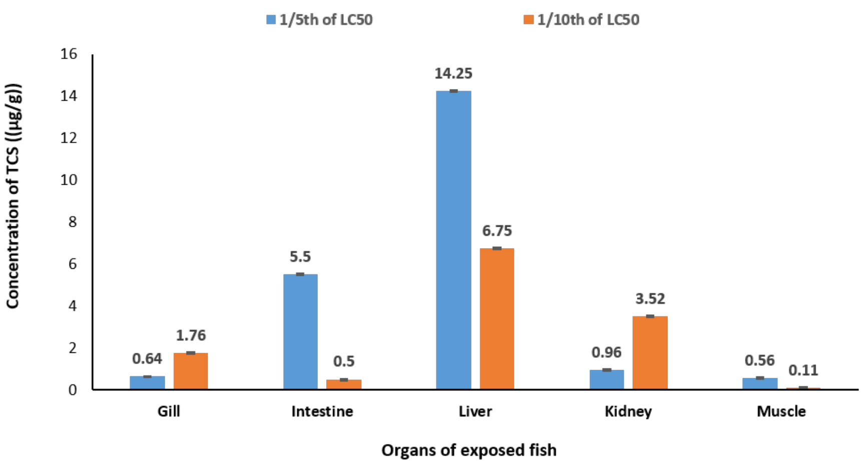
Co-Principal Investigators
Dr. S.P.Shukla
Dr. Saurav Kumar

Budget: 64.22 Lakhs

Funding agency
Department of Science and Technology, New Delhi

Triclosan (TCS) is a broad spectrum antimicrobial agent generally used in Pharmaceutical and Personal Care Products (PCPs). Its frequent use over recent decades have raised its concentration in the aquatic environment, with detectable levels found along the food chain from aquatic organisms to humans. TCS has been detected in different environmental matrices including terrestrial, aquatic and biosolids resulting from WWTPs. TCS and its derivatives are already present in measurable quantities, which may potentially affect water quality, impact on ecosystem and human health. Taking into consideration, the impact of TCS on aquatic organisms and environment, comprehensive research on their distribution and fate in various environmental compartments, in particular, wastewater treatment plants and coastal waters which are the final sinks is the need of hour along with appropriate treatment.





Sediment and water samples were collected from five different sites (A) Versova Jetty; (B) CIFE mangrove; (C) Lokhandwala creek; (D) Goregoan I and (E) Goregaon II along Versova creek of Mumbai, India. Concentrations of triclosan were estimated in the water and sediment samples using high performance liquid chromatography (HPLC, Analytical 3000Plus, India) fitted with C18 column having temperature 35° C with UV detector at 280 nm. Triclosan concentration was detected in the range from 0.063 to 1.859 mg L^{-1} in water samples whereas 0.08 to 1.439 mg kg^{-1} in sediments of five different sampling stations along the Versova creek, Mumbai. The highest concentration of TCS was noticed in water and sediment samples of Versova jetty and Goregoan creek (table 1).

The acute toxicity test of TCS on *P. hypophthalmus* and *L. rohita* were carried out according to US Environmental Protection Agency (EPA) (2002) and United Nation Environmental Programme (UNEP) (1989) in a static renewal system. Five experimental concentrations of TCS *viz.* 0.6, 0.8, 1.0, 1.2 and 1.4 mg L^{-1} were used for performing acute toxicity tests using *P. hypophthalmus*. In case of *L. rohita*, 0.2, 0.4, 0.6, 0.8 and 1.0 mg L^{-1} of TCS concentrations are used. One group was exposed to only de-chlorinated tap water and NaOH (solvent used for TCS solution) which served as control. The values of 96 h LC_{50} of TCS for *P. hypophthalmus* and *L. rohita* were 1.18 and 0.645 mg L^{-1} using linear equations Y= 175.21x – 488.35 and Y= 117.63x + 85.305 respectively(figure 2A & B). Subsequently, chronic toxicity study of TCS in *L. rohita* was performed at 1/5th and 1/10th concentrations of the estimated LC_{50} 0.128 and 0.064 mg L^{-1} respectively, for 14 days to determine the Bioconcentration Factor (BCF) in different tissues *viz*. gills, liver, muscle, kidney and intestine. The results showed that the BCF of TCS was highest in liver tissue in both the concentrations and least bioconcentration was found in muscle of *L. rohita* after 14 days of exposure.

With the objective to map the potential bioremediation bacteria, screening of TCS tolerant bacteria from water and sediment samples collected from sewage treatment plant, Lokhandwala, Maharashtra, India. A cumulative of seven TCS tolerant bacteria from water and soil sediment were isolated and identified. Among the all bacterial species screened, *Pseudomonas putida* was non-infectious and found to be tolerant against 100 mg L^{-1} TCS which can be used further for bioremediation of triclosan.

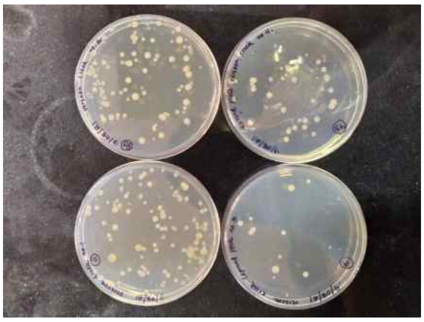
(CIFE/2019/AEM906/SR)

Isolation and Characterization of Triclosan – Degrading Bacteria from Versova Creek

Sakshi Patil

Major Advisor: Dr. Kundan Kumar

The current study screened and characterized 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, SS14 were able to tolerate as well as 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 are non-pathogenic and capable of degrading TCS. Moreover, *Pseudomonas putida* is commonly found in wastewater. Thus, the present study suggests that this bacteria could be used as a good candidate for bioremediation of triclosan in WWTPs. Further studies could be carried out to understand the biodegradation mechanism towards the TCS and also the environmental factors affecting the degradation.

(CIFE/2019/AQC907/SR)

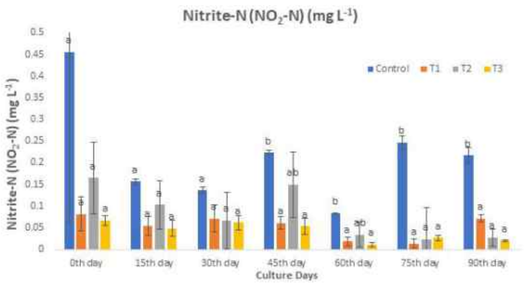
Effect of Phytoremediation and Zooremediation on Growth and Water Quality Dynamics in *Labeo rohita* (Ham. 1822) Grow-out Culture System

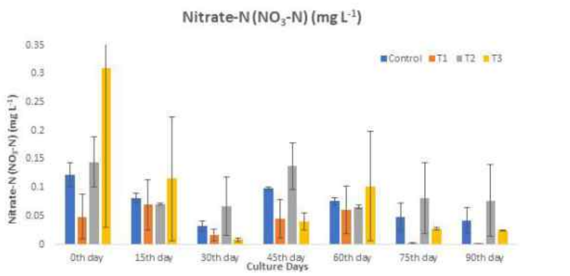
Hariharan M.

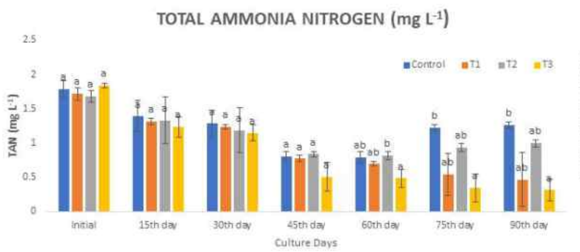
Major Advisor: Dr. Syamala K.R.

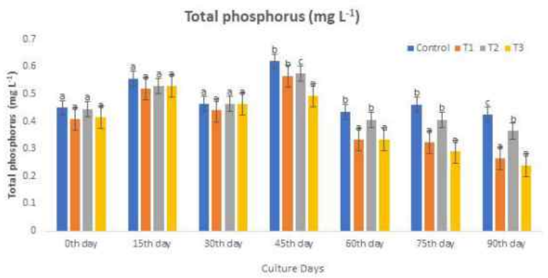
Decomposition and recycling of these nitrogenous compounds are essential in aquaculture systems to minimize the toxicity of ammonia and nitrite and the possibility of hyper eutrophication of the environment by nitrate. The bioremediation technique is an alternative for removing non-treated wastewater during fish culture. A 90-day experiment was conducted to assess the nutrient removal efficiency of different bioremediation methods using plant and animal in an earthen pond-based rohu fish culture. The study consisted of one control and three treatment groups namely, rohu culture without spinach and snails ©- control), rohu fish culture with spinach (T1 - Phyto-remediation), rohu fish culture with snails (T2 - Zoo-remediation) and rohu fish culture combined with spinach and snail (T3 - combination of Phyto and Zoo-remediation) which were randomly distributed in eight uniform-sized earthen ponds (each 200 m^2 area).

At the end of the experiment, the study found significantly higher nutrient removal efficiency in the T3 group (Combination of Phyto and Zoo-remediation) as 95.5%, 83.01%, and 57.5% of Nitrite-nitrogen, Total ammonia nitrogen (TAN), Total phosphorus (TP), were removed respectively than T1 (85.2%, 73.3%, 46%) and T2 (94.1%, 40.6%, 36.5%). In terms of fish growth performance, significantly higher growth was obtained in T3 (275.9±1.79) followed by T2 (238±1.57) and T1 (221.9±1.00) and the lowest was recorded in the control group (201.7±1.24). Fish reared in the T3 group recorded significantly higher survival rate (97.63%) and growth performance, including final weight gain (189.5±2.45), weight gain% (219±4.0), specific growth rate (0.55±0.00), feed conversion ratio (2.79±0.06), feed efficiency ratio (FER) (0.355±0.00), and protein efficiency ratio (PER) (1.33±0.02). The results of the present study indicated that using spinach (*Spinacia oleracea*) and freshwater snail (*Pila globosa*) could be considered an effective biological method for nutrient management in freshwater rohu culture to improve the growth performance of fish.









(CIFE/2019/AEM902/SR)

Assessment of Selected Azo Dye Bioremediation Potential of *Chlorella vulgaris*

Bhautik D. Savaliya

Major Advisor: Dr. Rathi Bhuvaneswari

The present study was conducted to investigate the toxicity and decolorization of the azo dye, Reactive Black 5 (RB 5), which is widely used in printing, pharmaceuticals, textiles, pulp mills, paper, and food industries. The acute toxicity (96h) of RB 5 on the freshwater alga *Chlorella vulgaris* was determined by examining growth, pigments, protein content and the activities of oxidative stress enzymes. The 96h median inhibitory concentration (96h LC_{50}) was found to be 25.23 mg L^{-1}. The growth of the algal cells were conspicuously inhibited by RB 5 exposure. A significant reduction in growth rate, pigments (*chl a*, *chl b* & carotenoid) and protein content were observed in a dose-dependent manner when exposed to various concentrations of RB 5 ranging from 1 to 50 mg L^{-1}. The algal growth inhibition was accompanied by increased activity of antioxidant enzymes such as catalase and peroxidase, indicating oxidative stress. Algal growth inhibition may be produced by damage to the algal structure.

Our findings revealed that RB 5 could be potentially toxic to the freshwater algae in aquatic ecosystems. The efficiency of *C. vulgaris* was investigated for the bioremediation of the synthetic azo dye, RB 5. In the bioremediation study, the effect of algal inoculum density, pH and temperature on RB 5 decolization was studied and the optimum values are found to be 95 lakh cells mL^{-1} algal cell density, pH 8, and temperature 35°C respectively. The effect of the initial dye concentration on the decolorization ability of microalgae was evaluated in a batch culture system. The decolorization experiment was conducted for 21 days with six different concentrations of RB 5 below IC_{50} value (0.1, 1, 5, 10, 20 and 25 mg L^{-1}). RB 5 decolorization was assessed by UV–Vis spectrophotometer at 597nm (λmax). *C. vulgaris* effectively decolorized 0.1, 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 after 21 days with the highest decolorization at lowest concentration (0.1 mg L^{-1}). The contact time and initial dye concentrations were found to be the important factors involved in decolorization. The results revealed that the biological decolorization efficiency decreased with an increase in RB 5 concentration. The findings of this study provide scientific evidence for the toxicity of RB 5 on photoautotrophic organisms in general and algae in particular. 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.

Fig. The morphology of algal cells after 96h exposure to different concentrations of RB-5. (A): Control; (B) 25.23 mg L^{-1} treatment and (C) 50 mg L^{-1} treatment

After 96h of exposure to RB 5 (25.23 mg L^{-1}), some cells appeared depressed or shrunk (Fig). Furthermore, as the treatment concentration increased from 25.23 to 50 mg L^{-1}, numerous algal cells showed more clearly deflated surfaces.

Aquatic Weed Assisted Bioremediation of Priority Pollutants under Controlled Condition

Aalia Bashir

Major Advisor: Dr. Kishore Kumar Krishnani

The evolution of aquaculture operations from traditional to semi-intensive and intensive culture operations including finfish and shellfish farming results in increased aquaculture production levels with metabolic waste generation. The toxicity of nitrogenous and metallic toxicants has adverse effects on shrimp and fish growth and may lead to mortality in extreme cases. TAN (Total ammonia nitrogen) and Nitrite-N are the most prevalent toxicants in intensive culture systems. The other class of pollutants is heavy metals that pose a severe threat to aquatic life. Thus, it becomes necessary to remove these toxicants to maintain a healthy aquaculture operation. Plants are considered to possess a natural ability to remove inorganic pollutants from water in an eco-friendly and low-cost process called plant-assisted bioremediation. The present study aims to determine the phytoremediation efficiency of the product developed from aquatic weeds (Hydrilla and Ceratophyllum) collected from Dal Lake (Jammu and Kashmir), for TAN and Nitrite-N removal from varieties of aquaculture water (pond, aquaponics and ornamental) and biosorption of lead (Lead) and chromium (VI) under controlled conditions. The experiments were conducted under lab conditions and after getting successful results large scale experiments were conducted for TAN removal following a completely randomized design. The experimental results showed that removal of TAN and Nitrite-N was effective at pH 7.5 whereas chromium (VI) removal was observed at pH 2 at 100 and 200 mg/l respectively. The average lead biosorption observed was 14 and 16mg/g respectively. The removal efficiency observed for TAN was 60-65%, for Nitrite-N 50%, for Cr (IV) 99% and 90% removal for lead, respectively. Hence, these aquatic weeds also have the potential for uptake and removal of heavy metals like lead and chromium (VI). In conclusion, Dal Lake aquatic weeds are effective in the removal of TAN, Nitrite-N, lead and chromium (VI) from the varieties of aquaculture waters, which can be attributed to functional moieties and alkali metals and alkaline earth metals present in the aquatic weeds, which are responsible for adsorption and ion exchange of priority pollutants onto aquatic weeds. This will have future potential application in circular economy based bioresource utilization of aquatic weeds for aquaculture application.

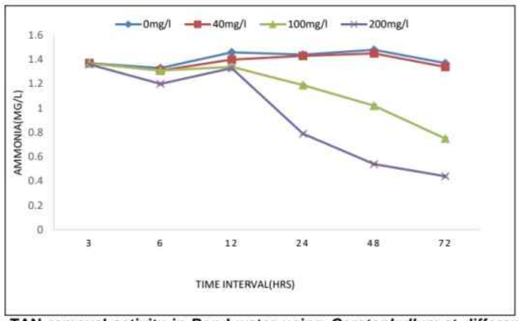


Fig.2. TAN removal activity in Pond water using *Ceratophyllum* at different time interval

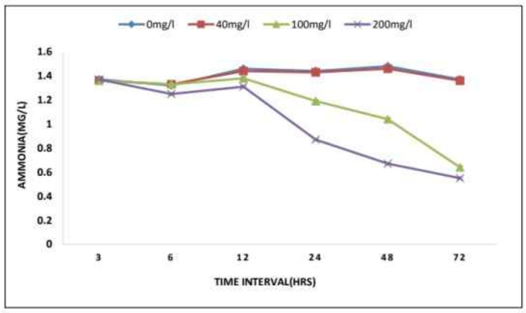


Fig.3. TAN removal activity in Pond water using *Hydrilla* at different time interval

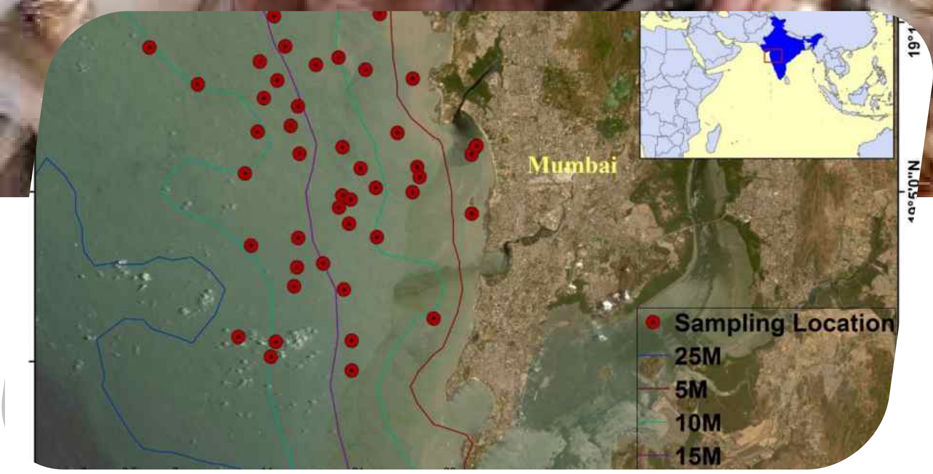
(CIFE/2019/AQC905/SR)

Plant Assisted Bioremediation of Nitrogenous Waste and Bacterial Contaminants

Gajanan Uddhav Kate

Major Advisor: Dr. Kishore Kumar Krishnani

The present investigation was carried out to evaluate the removal efficiency of plant based products for nitrogenous waste viz. Total Ammonia Nitrogen (TAN) and nitrite-N, their bactericidal properties against *Escherichia coli, Aeromonas Hydrophilla, Micrococcus luteus* and *Edwardsiella tarda* and effects of these herbal products on growth performance, antistress activity and survival in *Pangasianodon hypophthalmus*, when exposed for acute and chronic duration. Experiment was carried out to evaluate the TAN and Nitrite-N removal efficiency of different plant based products like aloe vera, banana stem, mint, bagasse, coat buttons (*Tridax procrumbens)* and Indian beech *(Pongamia pinnatum).* An effective dose of mint and bagasse based products also carried out for reducing TAN and nitrite level. Two separate experiments were conducted over a period of 24h and 45 days to evaluate the growth and antistress ability of herbal based product derived from mint and agro-waste product derived from bagasse. Present study indicated that banana stem, bagasse and mint leaves based products at 30 ppm are effective in lowering TAN and nitrite level from Aquaponics water. Another experiment on bactericidal activities showed that ethanol extract was more effective than aqueous extract showing moderate zone of inhibition against bacterial strains like *A.hydrophilla, E.coli, E.tarda,* and *M.luteus.* Physiological study of *P. hypophthalmus* exposed to ammonia showed that herbal based product derived from mint and agro-waste product derived from bagasse possess better antistress property and reduced ammonia stress. It also helped to maintain homeostasis as indicated by reduced serum hormones like ALT, AST and tissue biochemical indices compared to control and group exposed to only ammonia. Growth study showed *P. hypophthalmus* exposed to bagasse and mint leaves based product significantly improves the growth performance in terms of increase in % body weight gain, SGR and decrease in FCR. In conclusion, several medicinal herbs and agricultural wastes based product have the ability to bioremediate nitrogenous waste in aquaponics water and may have future application in aquaculture systems.



Biodiversity and Sustainable Fisheries Management

A Study on Taxonomy of Selected Families of Marine Fishes and Indigenous Freshwater Ornamental Fishes of Maharashtra

(CIFE/2019/3/IF)

Project duration: 2020- 2023

Principal Investigator
Dr. A.K. Jaiswar

Co-Principal Investigators
Dr. A. Pavan Kumar
Dr. Karankumar K. Ramteke
Mr. Dayal Devdas
Dr. Shobha Rawat

Technical Associate
Dr. Pawan Kumar

A total of 29 species of marine fishes belonging to family Sciaenidae, Synodontidae and Carangidae from different parts of India and 26 species of freshwater fishes belonging to families *Anabantidae, Nandidae, Channidae, Heteropneustidae, Bagridae, Cyprinidae, Mastacembelidae, Belonidae, Ambassidae,* collected from Maharashtra, were identified. After identification, the fish samples are being processed for barcoding for confirmation of identification. Barcodes for 14 fishes have been submitted to GeneBank.

Fig. 1 (a): Nematolosa nasus

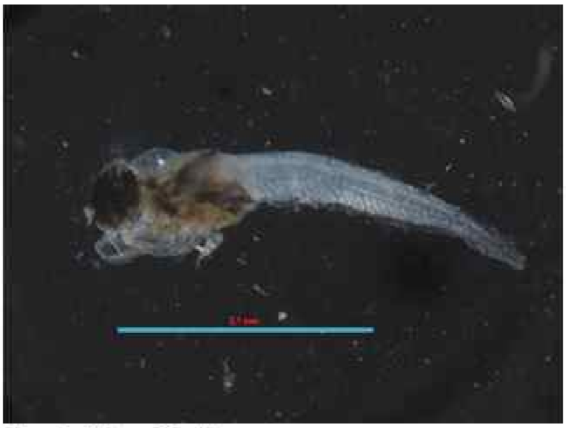


Fig. 1 (b): Mullet sp.

Fig. 1 (c): Nematolosa nasus

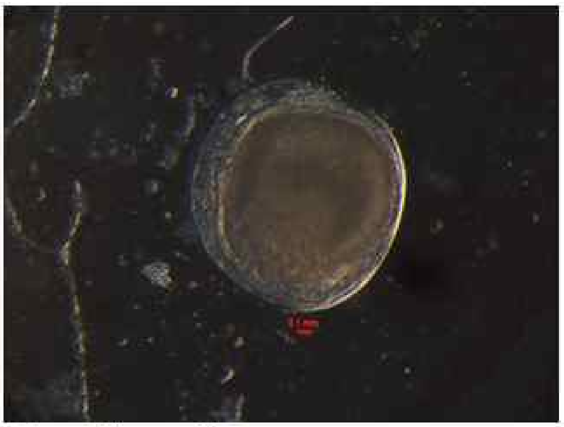


Fig. 1 (d): Mullet sp.

A Study on Species Diversity in Family Sciaenidae From Mumbai Waters

(CIFE/2019/FRM905/SR)

Geenita K.

Major Advisor: A. K. Jaiswar

During the study on species diversity of Sciaenidae along the Mumbai coast of Maharashtra, nine species belonging to 3 genera could be collected from landing centres along the Mumbai coast. There may be many more species along the coast that could not be collected due to pandemic lockdown. However, a comparative taxonomic study, based on morphology, morphometric and meristic traits were conducted on the nine species collected during study viz., *Johnius macrorhynus, Johnius borneensis, Johnius elongatus, Johnius dussumeiri, Johnius glaucus, Johnius belangerii, Otolithes cuvieri, Otolithes ruber* and *Otolithoides biauritus* from Mumbai waters. A total of 31 morphometric and 14 meristic traits were measured and subjected to statistical analysis. Descriptive statistics revealed significant differences among the species. Discriminant Function Analysis could correctly classify the species with 100% success. Principal Component Analysis (PCA) revealed that pre-pectoral length, preanal length, anal fin base length, and inter-orbital length are the important characters that can be used in differentiating these species. Multivariate analysis of variance also showed significant differences among the species. The number of gill rakers on the upper and lower gill arch and the total number of gill rakers showed clear variations among the species. DNA barcoding was also attempted for the collected species; however, sequencing results for a few species could be obtained. It is suggested to conduct a detailed study to assess the diversity of Sciaenids.

Assessment of Elasmobranchs Diversity Along the Kerala Coast

(CIFE/2019/FRM908/SR)

Sneha Satheesh K

Major Advisor: A. K. Jaiswar

A study was conducted to assess the diversity of elasmobranchs in the landing centres across Kerala, from December 2020 to May 2021. Fifteen fish landing centres of Kerala, Madakkara, Azheekkal, Maplabay, Thalayi, Chombala, Puthiyappa, Beypore, Munambam, Kalamukku, Cochin Fisheries Harbour, Sakthikulangara, Kayamkulam, Neendakara, Shakthikulankara, Pozhikkara, and Vizhinjam were selected for the study. Elasmobranchs are landed by trawls and gill nets as bycatch. Thirty-two species of elasmobranchs belonging to twenty-nine genera, nineteen families, and ten orders were recorded during the study period. Batoids (numbfishes, electric rays, skates, stingrays, and manta rays) formed 56%, sharks 41% (13 species), and chimeras 3% (one species) of the total chondrichthyans landings. Shark species *Carcharhinus falciformes* contributed maximum to the catch. Among rays, *Maculabatis gerrardi* contributed maximum. Sakthikulangara harbor shows the maximum species diversity. Landings of non-commercial species, juveniles, sub-adults, and a few adults have been recorded. Regarding the gear-wise composition of elasmobranchs, trawl net contributed maximum (74%) followed by gill net (26%). The observed length classes indicate that juveniles and sub-adults are relatively higher in bycatch, and fully mature adults' occurrence is very less. IUCN status of 32 species was compared using www.iucnredlist.org, and it was found that 64 % of species in the landings are threatened. Similarity dendrogram was used to analyze species' presence-absence in different landing centers where gill net, trawl net, and a combination of both were used. The similarity observed might be because of the same type of fishing gears used in similar operational depths. The market structure of elasmobranchs of Kerala and their utilization pattern were documented. The utilization and trade revealed that elasmobranchs meat, skin, bone, and teeth were marketed and traded.

Mapping Ecosystem Valuation and Modelling for Simulating Sustainability Fisheries Management Scenario in Selected Reservoirs of India

(CIFE/2021/8/IF)

Project duration: 2021-2024

Principal Investigator
Dr. Vinod Kumar Yadav

Co-Principal Investigators
Dr. S.N. Ojha
Dr. Arpita Sharma
Dr. Karan Rameteke

Systematic attempt has been made to study and understand the trophic dynamics of the aquatic systems of the Dimbe reservoir, Pune by monthly sampling. Sample which was collected during December 2021 indicated that the water temperature of the reservoir is 20.56 degree centigrade. The depth recorded is 25.87 m with transparency 203.00cm. Dissolved oxygen (5.57 mg/m^3) and Chlorophyll-a (7.39 mg/m^3). The gut content study of selected fish species revealed that there were 11 major food items preferred by different fishes. The food items were divided into different percentage compositions based on their abundance and frequency of occurrence for each fish group. The major diet compositions of selected fish species were fed in the Ecopath with Ecosim software to evaluate their trophic level in the present reservoir ecosystem. Most of the fishes were observed to be omnivorous. The information acquired during the study and other secondary sources, hinted that there were many local indigenous fishes which existed in the waters of Dimbhe reservoir but slowly lost their place in the catch. Remote sensed images were downloaded from Landsat-8 for finding the Land Use Land Cover (LULC) Change detection, change in Water spread area, changes from one resources area to other resources area.

Taxonomical, Biochemical Evaluation and Utilization of Order Dictyotales-Brown Algal Species

(CIFE/2021/1/IF)

Project duration: 2021-2024

Principal Investigator
Dr. Geetanjali Deshmukhe

Co-Principal Investigators
Dr. A. K. Balange
Dr.Pavan Kumar
Dr. Layana P.

Samples of *Padina, Dictyota, Dilophus, Stoechospemum Spatoglossum* (family Dictyotaceae) were collected from Tiruchendur, Mandapam, Andaman (East coast) and Ratnagiri, Malvan from the west coast of India. *Colpomenta* (Scytosiphonales) was collected from Ratnagiri and Malvan coast. Morphological and anatomical studies for *Padina* and *Dictyota* are being carried out.

Identification and Characterization of Recruitment Ground of Commercially Important Small Pelagic Fishes along Maharashtra Coast

(CIFE/2020/4/IF)

Project duration: 2020-2024

Principal Investigator
Dr. B. B. Nayak

Co-Principal Investigators
Dr. Karan Kumar Ramteke
Dr. Shashi Bhushan
Dr. A. Pavan kumar
Dr. Geetanjali Deshmukhe
Dr. A. K. Jaiswar

Technical Associate
Dr. Pawan Kumar

Samples were collected from Manori Creek (2 stations) at an average depth of 5-6 m and from Karanja estuary (3 stations) at an average depth of 7-10 m. During high tide and low tide samples were collected for testing water quality parameters, ichthyoplankton, phytoplankton, primary productivity and fish samples. Larvae and eggs were collected for the morphometric and molecular identification. Methodology for the analysis was standardised and primers were designed for molecular identification.

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Table: Water quality readings observed during January, 2022 from Karanja estuary

Sl No.	Parameters	Site 1	Site 2	Site 3
1	Location	18⁰50'48"N 72⁰58'29"E	72⁰56'29"E 18⁰47'35"N	18⁰48'48"N 72⁰58'84"E
2	Air temperature	21⁰C	24⁰C	22⁰C
3	Water Temperature	26⁰C	25⁰C	25⁰C
4	pH	7.6	7.6	7.4
5	Salinity(ppt)	29	25	22
6	Transparency(cm)	92.5	71	82.5
7	DO (mg/l)	4.79	4.3	3.82
9	Alkalinity (ppm)	155.5	148	130
10	Primary Productivity (mg/C/m³/day)	Yet to calculate	Yet to calculate	Yet to calculate
12	NH_3-N (mg/l)	OD recorded	OD recorded	OD recorded
13	NO_3-N (mg/l)	OD recorded	OD recorded	OD recorded
14	NO_2-N (mg/l)	OD recorded	OD recorded	OD recorded
15	Silicate (mg/l)	OD recorded	OD recorded	OD recorded
16	Phosphate (mg/l)	OD recorded	OD recorded	OD recorded
17	Chlorophyll-a (mg/m³)	OD recorded	OD recorded	OD recorded

(CIFE/2014/FRM406/SR)

Spatial Mapping and Management of the Indian Squid *Uroteuthis* (Photololigo) *duvaucelii* (d'Orbigny, 1835) along Maharashtra Coast, India

Bhendekar Santosh Nagnath

Major Advisor: Dr. K. Sunil Mohammad

In the present study, spatio-temporal distribution, biology and habitat suitability of the Indian squid *Uroteuthis (Photololigo) duvaucelii* along the Maharashtra coast have been investigated. The annual latitudinal variability in the trawl fisheries for Indian squid from April 2017 to April 2019 revealed three different fishing patterns. After monsoon fishing ban (June-July), in August, fishers target Indian squid in 17° N to 16° N latitudinal range with the fishing fleet concentrating in 20-40 m depth range catching on an average 43 (± 30) kg per hour of the Indian squid. In September, the fishing fleet moves further down from 16° N to 15° N in 40-60 m depth with an average catch per hour of 49 (± 24) kg hr^{-1}. As the season advances the trawl fishing fleet for Indian squid is more scattered moving towards the north in the latitudinal range of 17° N to 20° N. The monthly and seasonal maps of the Indian squid distribution were prepared on GIS platform. The ontogenetic distribution pattern showed the dominance of juveniles and sub-adult down 16° N latitude. Owing to the short life-cycles and fast growth rates of the Indian squid, its stock may be highly volatile, both highly susceptible to recruitment overfishing and, conversely, capable of rapid recovery. So, it is important to study biology, determine the appropriate level of fishing and stock abundance on an annual basis. The present work based on 1462 specimens (45-330 mm DML) revealed the negative allometric growth for the Indian squid.

The exponent (b) of length-weight relationships estimated for pooled males and females were 2.29, 2.228 and 2.434 respectively. The overall male-dominant sex ratio (M:F, 1:0.59) of the Indian squid was found along the Maharashtra coast, which significantly differs from the 1:1 (M:F) ratio. The length at 50% maturity (L50) for females was estimated at 92.1 mm DML. The spawning season of the species was protracted with peak GSI observed from October to December. The estimated fecundity was in the range of 1653 -13741 oocytes with a mean ± SD of 5965 ± 3947 oocytes per ovary. The diet analysis revealed species was carnivorous and cannibalistic with fishes as the preferential food item (% IRI; 64.2) followed by crustaceans (30.53) as secondary food item (5.25) and cephalopods (0.02) as accessory food. The mean vacuity index (70.5%) indicates the dominance of empty stomachs and slackness in feeding especially in larger individuals. The estimated growth parameters based on pooled length-frequency data from 2017-18 were $L\infty$ = 392.84 mm DML and K = 1.67 yr^{-1}. The instantaneous natural mortality (M), total mortality (Z), fishing mortality (F) and exploitation ratio (E) of the Indian squid were estimated at 1.788 yr^{-1}, 10.4 yr^{-1}, 8.612 yr^{-1} and 0.83 respectively. The current exploitation ratio (E; 0.83) was higher than the reference exploitation ratio (EMSY; 0.79) indicating overexploitation of species and precautionary approach should be followed in the near future by maintaining the exploitation ratio at 0.61 (E0.5). The MSY was estimated at 13.2 thousand t using the Catch-MSY method. The factors influencing suitable habitats of Indian squid were assessed using a generalized additive model (GAM). The model result indicates higher probabilities occurrence of Indian squid were attributed to SSH with ± 0.2 to 0.4 m, salinity 34.5 to 35 ppt, PAR > 40 Einstein m^{-2}day-1, combined with SST in range of 27.5 to 29.5° C, the current speed of >0.3 m s^{-1} and Chl-a > 2 mg m^{-3}. The model successfully predicts the known areas of high abundance of the Indian squid along the Maharashtra coast. Such habitat suitability studies are important for assessing the distribution and abundance of fish resources on a synoptic scale for sustainable fisheries management.

(CIFE/2019/FRM909/SR)

Spatial Variability of *Sepia pharaonis* Ehrenberg, 1831 and its Assemblage in Relation to the Environment Variables along Maharashtra Coast

Sonam Angmo

Major Advisor: Dr. Zeba J. Abidi

The Pharaoh cuttlefish (*Sepia pharaonis*) is one of the most important cephalopod species along the Maharashtra coast. It is one of the most important revenue earners after shrimps in the state, fetching high prices as an exportable commodity. No studies have attempted to know spatio-temporal distribution and its potential assemblage in relation to environmental variables along the Maharashtra coast. In the present study, abundance of Pharaoh cuttlefish has been recorded between 16.5° and 17.3° N latitude and 72.6° and 73.4° E longitudes based on geolocation data collected from commercially operating trawlers along Maharashtra coast during September 2020 to February 2021. The average Catch per Hour (CPH) of Pharaoh cuttlefish has been estimated to be 10.3 kg/hr during the study period The highest abundance of *Sepia pharaonis* along the coast of Maharashtra has been observed from the coastal water of Ratnagiri during the study period. An ensemble modelling approach in the biomod2 package in R-software was used to examine the potential assemblage of *Sepia pharaonis* in relation to environmental variables (i.e., SST, BST, SSH, SSS, Chl-a and PAR) along the Maharashtra coast. The correlation matrix indicates each environmental variable has an additive effect on the assemblage pattern of Pharaoh cuttlefish in the Maharashtra waters. The eight different models (GLM, GAM, MARS, CTA, ANN, SRE, FDA and RF) were fitted with 3-fold cross-validation for each model. The ensemble model were prepared by combining individual models (i.e., RF, CTA, GAM and MARS) having TSS value >0.7. The potential assemblages of *S. pharaonis* were found between 16.5°N to 17.5°N and 72.6°E to 73.4°E along the coast of Maharashtra. The performance of the ensemble modelling approach was better than single-algorithm models for predicting species distribution patterns. The use of the ensemble model gives better and more reliable mapping of potential zones for fishery application and will help manage resources by implementing restrictions on breeding grounds and fishing season.

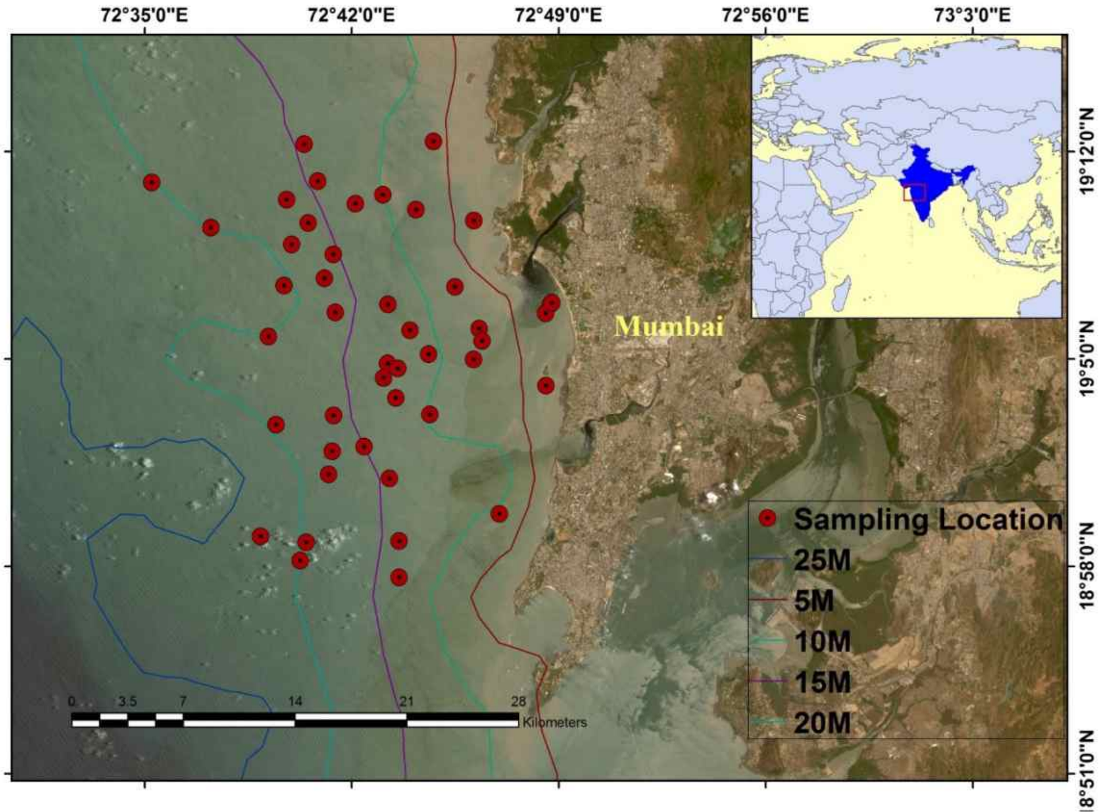
(CIFE/2016/FRM610/SR)

Integrated Approach to Studies on Trawl Fisheries using Sea-Truth and Remote Sensing Information off Mumbai Coast

Karan Kumar K. Ramteke

Major Advisor : Dr. Latha Shenoy

A study was conducted during Septemper 2017 - May 2019 to study the pattern of catch composition and their spatio-temporal distribution and to assess and correlate the quality of satellite-derived environmental parameters using in-situ trawl fish catch data. Experimental fishing was carried out fortnightly between 18°57'N to 19°12'N latitude and 72°40' E to 72°43' E longitude in the depth range 6-21m using ICAR-CIFE's vessel having 35 m bottom shrimp trawl and 35 mm mesh size cod end. The catch composition revealed a dominance of bycatch (79.43%) over commercial catch (20.12%) with marine debris forming the remaining 0.45%.The estimated bycatch ranged from 3.44-61.34 kg/h and commercial catch from 3.80kg/h - 57.25kg /h. Composition of trawl catch revealed that 93 species comprised the fish community off Mumbai coast. The species were categorized into finfishes (53), shrimps (13), gastropods (11), crabs (4), cephalopods (4), stomatopods (3), elasmobranch (3), lobster (1) and hermit crab (1). Sciaenids (37%), shrimps (21%) and coilia (17%) comprised the majority of commercial catch. Bycatch consisted of mainly squilla (28 %), juveniles of sciaenids (13 %) and shrimps (11%). Analysis of



variations in spatial distribution of trawl resources revealed that the maximum number of species (69) was recorded at 12-15m depth strata.

The quality assessment of three satellite-derived parameters i.e. Chlorophyll-a, Sea surface temperature and Salinity (SST & SSS) with the in-situ observations (n=190) was statistically evaluated by applying strict match-up in view of complexity and variability of coastal water. The R^2 values observed for the three chlorophyll-a regression equations were not so strong, but showed a significant relationship for MODIS (R^2 = 0.36; $p<0.001$), OCM2 (R^2 = 0.32; $p<0.001$) and VISSR (R^2 = 0.19; $p<0.001$) with evident overestimation (MODIS and VIIRS) and in tune (OCM2) with the satellite-derived datasets. Comparison of retrieved chlorophyll-a with in-situ products showed lowest root mean square error (RMSE) of 0.32 for OCM2. In case of Sea surface temperature, R^2 values for both the regression equations in comparison with in-situ observation showed strong association and significant variability (0.75 for MODIS and 0.76 for SNPP VIIRS at $p<0.001$).

The significant RMSE observed for the MODIS (1.05) and SNPP-VIIRS (1.0) showed that satellite-derived SST agreed well with in- situ observations. Comparison of SMAP satellite retrieved salinity products with in-situ data showed R^2 value of 0.4; $p<0.001$ and a root mean square error (RMSE) of 2.04. The comparative study highlighted the need for further development of algorithms for Chlorophyll-a and Salinity measurement from satellite observations. Canonical correspondence analysis (CCA) and Generalized additive modeling (GAM) analysis identified the set of most important environmental parameters namely, Chlorophyll, SST,SSS, Sea surface height and current speed have more influence on fish catch. These parameters correlated well with the in-situ catch.

Assessment of Sedimentation and its Impacts on Fisheries in Navegaonbandh Reservoir using Remote Sensing

Komal Nandagawali

Major Advisor: Dr. Karan Kumar Ramteke

Reservoir sedimentation generates several interconnected issues. Aside from capacity loss, increased flood risks, hydropower production interruptions, and downstream river bed degradation, other issues like water quality degradation, increased complexity in reservoir operation and maintenance, and downstream river bed degradation all contribute to increased costs. Water storage capacity is reduced as sedimentation raises turbidity and limits primary production. Reservoirs successfully capture suspended solids. Our knowledge of reservoirs and ability to predict its impacts is inadequate. Due to the scarcity of such data, investigations were carried out by adopting combination of satellite-based observation and on field sampling was carried out from July 2020 to February 2021 to fulfill the following objectives: (1) To assess the sedimentation rate of Navegaonbandh Reservoir (2) To monitor the impacts of altered habitat on fish catch. It is observed that the original storage capacity of the reservoir was estimated to be 29.93 Mm³ while 26.65 Mm³ of derived reservoir capacity was estimated from the remote sensing data. This reveals the loss of 3.28 Mm³ (11%) from the live storage capacity due to sedimentation between 276.33 m and 277.45 m elevation of the reservoir from 1967 to 2019-20. Thus, the average rate of loss of capacity is computed to be 0.062 Mm³ (0.20%) per year during 1967 to 2019-20. Present study observed 41 fish species in the Navegaonbandh reservoir belonging to seven orders, 16 families, and 30 genera. Fish catch data for the years 1998 and 2021 were compared in this study to observe the change in fish catch composition. In 1998, 52.27% of the catch came from the Indigenous (Minor) group, 6.23% of the catch came from the Indigenous (Major) group, and 41.50% of the catch from the Non-Indigenous group. In 2021, the Catch from Indigenous (Minor) group is 1.76%, which is reduced drastically compared with the year 1998, Catch from Indigenous (Major) group is 3.55%, which is half of the year 1998, and Non-Indigenous group is contributing 94.68% in catch. Sedimentation reduces the breeding ground quality for Indigenous minor group fishes. Present study recommends that strategic planning should be implemented to reduce the sedimentation rate. Additionally, the breeding grounds for Indigenous minor group fishes should be protected so that they can coexist peacefully with other fish groups.

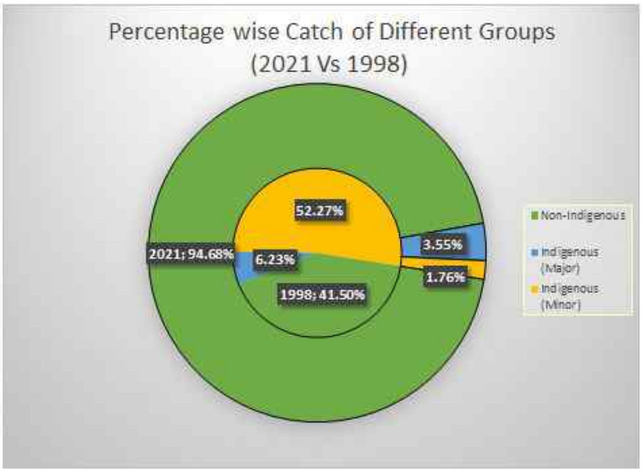


Fig. : Percentage wise Catch of Different Groups (2021 Vs 1998) in Navegaonbandh Reservoir showing changes in catch composition.

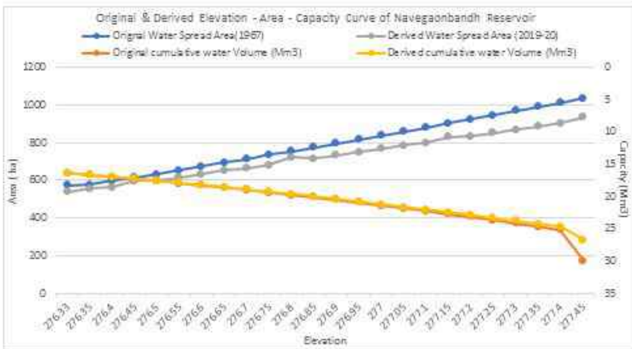


Fig. : Original & Derived Elevation - Area - Capacity Curve of Navegaonbandh Reservoir, showing , the average rate of loss of capacity is computed to be 0.062 Mm3 (0.20%) per year during 1967 to 2019-20.

(CIFE/2014/FRM403/SR)

Application of Remote Sensing and GIS to *Trichiurus lepturus* fishery in the North-West Coast of India: A Management Approach

Abdul Azeez P.

Major Advisor: Dr. Latha Shenoy

Ribbonfish (*Trichiurus lepturus*) is one of the major fishery resources of the North-West Coast of India (NWCI) having significance from commercial as well as ecological point of view. Information on spatio-temporal variations of ribbonfish and bycatches made by mid-water trawlers, as well as environmental preferences of ribbonfish are sparse, limiting precise prediction of the fishing grounds for efficient harvest and management of the resource. The present study examined fishery data from mid-water trawlers targeting ribbonfish in NWCI. The bycatch included 123 species and was estimated to comprise 56.92% of total catch by weight. Teleosts dominated the bycatch with a share of 62.09% followed by cephalopods (35.88%), crustaceans (1.47%) and elasmobranchs (0.56%). Discards formed 6.32% of total catch and consisted of 62 species belonging to 29 families. The bycatch per hour of fishing differed significantly between the seasons with the lowest being in summer and highest in post-monsoon. Lower bycatch rates were observed in the offshore waters than inshore waters. The spatio-temporal distribution of ribbonfish juveniles indicated that their grounds were along inshore waters (<50 m depth) whereas subadult and adults were distributed in relatively offshore waters (>50 m depth). The spatio-temporal distribution of bycatch was influenced by ribbonfish abundance and indicated trophic competition. The ribbon fish catch rate in the region were influenced by both north-east and south-west monsoon. 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 (Zue) between 35 m and 57 m, Sea Surface Height anomaly (SSHa) less than 0.1 m and depth between 55 m and 135 m. Machine learning approach of the Boosted Regression Tree (BRT) model performed better in predicting the ability of fishing grounds than the Generalized Linear Model (GLM) and Generalized Additive Model (GAM). Spatial variation of ribbonfish over the months modelled from BRT model indicated potential fishing grounds were strongly linked with the biophysical environment of the fish. Field demonstration of the model analysis indicated the model to be in good agreement with the catch data and reliable for prediction of spatio-temporal variation in potential fishing grounds of ribbon fish in the NWCI.

(CIFE/2017/FRM705/SR)

Stock Characterization of *Nemipterus randalli* Russel, 1986 and *Saurida tumbil* (Bloch, 1795) along the Indian Coast

Sri Hari M.

Major Advisor: Dr. Zeba J. Abidi

Nemipterus randalli Russell 1986 and *Saurida tumbil* (Bloch, 1795) are the important demersal fisheries resources along the Indian coast, subjected to overexploitation. Thus, it is essential to understand the stock structure of the species for designing approximate management strategies. Samples of *N. randalli* and *S. tumbil* were collected across its distributional range along the Indian coast between September 2018 - November 2018. A multidisciplinary approach comprised of traditional morphometric, truss network, meristics, otolith shape, otolith microchemistry, and mtDNA D-loop region were used to elucidate the stock structure of these species. A total of 19 morphometrics traits, 23 truss variables and nine meristic traits were used for the analysis of *N. randalli*. Whereas, 20 morphometric traits, 23 truss variables, six meristic traits were extracted from *S. tumbil.* Six shape indices and four elemental signatures (Ca, Sr, Li and Mn) of otolith were used to identify the stocks of both species. Morphometric analysis revealed that traits like eye diameter, head length, post-orbital length and caudal peduncle depth were helpful in differentiating the stocks of *N. randalli*. On the other hand, stocks of *S. tumbil* were delineated based on pre-dorsal fin length, pre-adipose fin length, pre-anal fin length, dorsal fin base length and pectoral fin length. Truss network analysis of *N. randalli* revealed the presence of different stocks based on the variations in the caudal peduncle, head and mid-body region. On the other hand, truss distances contributed significantly to the variation of stocks of *S. tumbil* were based on the anterior-body, head and caudal peduncle region. Meristic traits failed to differentiate the stocks of both species. Otolith shape analysis showed regional differences in shape indices of both species, suggesting the existence of different stock units along the Indian coast. The spatial differences of *N. randalli* and *S. tumbil* stocks were mainly driven by concentrations of Li:Ca and Mn:Ca. However, the population genetic structure analysis of mtDNA D-loop region indicated low genetic structuring and panmixia of *N. randalli* and *S. tumbil* populations along the Indian coast, respectively. The study also revealed the overall population genetic structure of *N. randalli* in its native (Indian coast, Red Sea) and invasive regions (Mediterranean Sea). Analysis of mtDNA D-loop region identified a distinct population of *N. randalli* from Visakhapatnam, with a possible deep genetic divergence. In summary, the phenotypic stocks of these two species exist due to their adaptation to the site-specific environmental conditions. Based on the different morphological methods used to identify the stocks, the present study identified discrete phenotypic stock units of *N. randalli* and *S. tumbil* along the Indian coast, indicating the need to assess and manage these distinct stocks separately. To conserve genetic integrity, special attention and detailed studies are needed on the Visakhapatnam population of *N. randalli*.

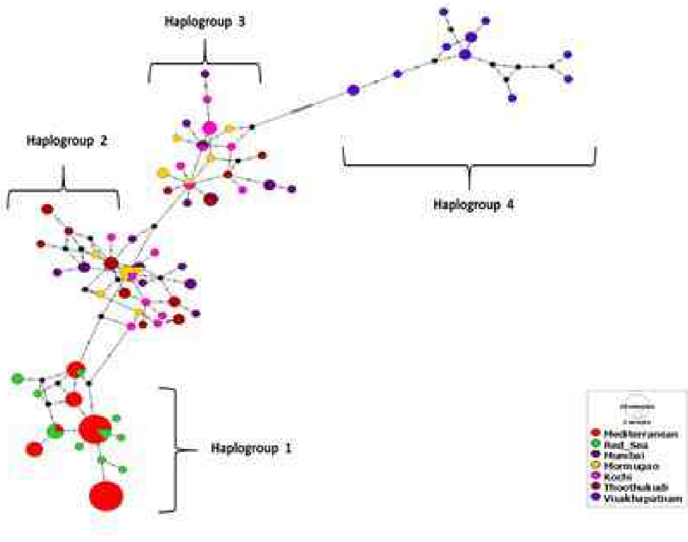


Fig: Haplotype network for mtDNA D-loop region of *N. randalli*

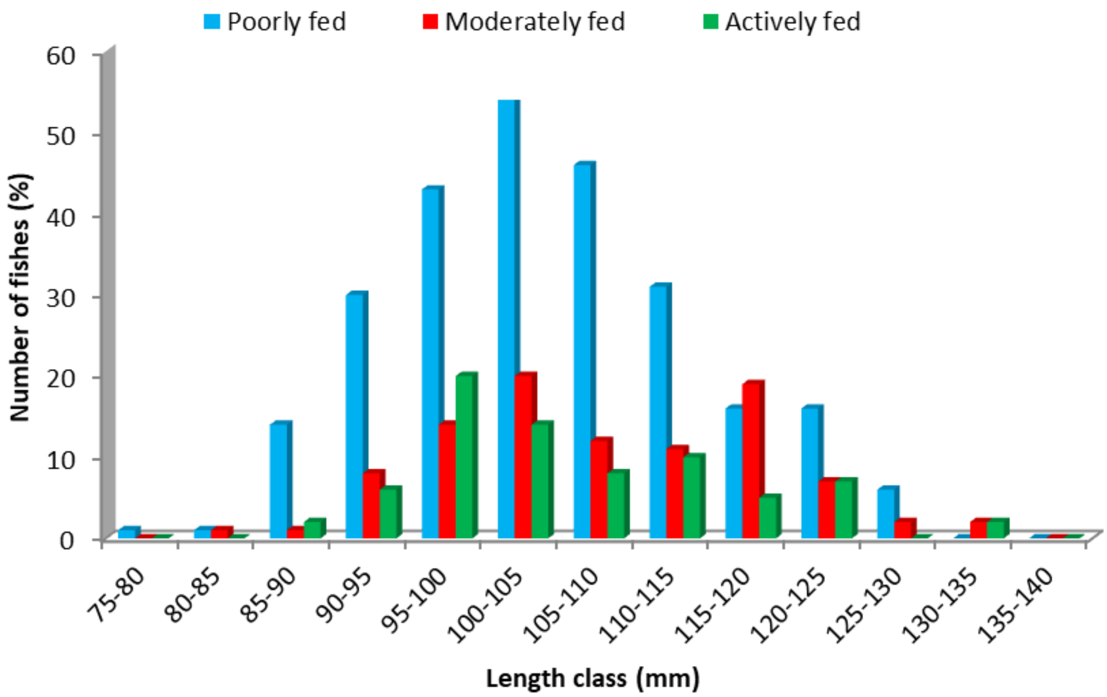
(CIFE/2013/AEM301/SR)

Studies on Biology and Stock Assessment of Leiognathidae and Relationship of the Fishery with Selected Environmental Parameters in Mandapam Waters

Remya L.

Major Advisor: Dr. P.U. Zacharia

The biology and stock assessment of silverbellies of Mandapam waters, Tamil Nadu, India was studied along with the relationship of fishery with selected environmental parameters. The species which contributed to the total catch of silver bellies at Rameswaram fish landing centre during the study period was *Eubleekeria jonesi* (64.65%), at Mandapam Palk Bay was *Nuchequula gerreoides* (45.47%) and at Mandapam Gulf of Mannar and Pamban Therkuvadi was *K. dussumieri* (45.38% and 39.16% respectively). LINKTREE analysis between silverbellies catch and the environmental parameters shows that three months, from July to September 2017 are specialized with more silverbelly catch and the favorable environmental parameters are more silicate, phosphate, wind speed, nitrate and salinity in Station I and dissolved oxygen phosphate, silicate, zooplankton, humidity and salinity in Station II. Similarly season wise LINKTREE analysis reveals zooplankton, air temperature, SST, net primary productivity, and Chl-a have



direct impact on the silverbellies catch at Station I and except rainfall all other environmental parameters have direct impact on the silverbellies catch at Station II. The food and feeding study revealed that planktonic crustaceans (>25%) were the preferential as well as dominant food items of *E. jonesi*, *N. gerreoides* and *K. dussumieri*, whereas *G. minuta* consumed 59% fishes in their diets. The size at maturity (Lm50) for *E. jonesi*, *N. gerreoides*, *K. dussumieri* and *G. minuta* was 85 mm, 87.5 mm, 99.2 mm and 102.3 mm respectively. All the species were continuous breeders and the peak spawning occurred during January to April. The growth parameters viz., L∞, K and to were estimated as 136 mm, 1.4 yr-1, and -0.103yr respectively for *E. jonesi*, 141.75 mm, 1.5 yr-1 and -0.0114yr respectively for *N. gerreoides*, 168 mm, 1.4 yr-1 and -0.0143 yr respectively for K. dussumieri and 189 mm, 1.5 yr-1 and -0.0172 yr respectively for G. minuta. The maximum sustainable yield (MSY) was calculated as 221.63 t, 253.31 t, 240.48 t and 325.1 t for *E. jonesi*, *N. gerreoides*, *K. dussumieri* and *G. minuta* respectively. Therefore, any further increase in fishing effort will not help in augmenting the production of silverbellies in Mandapam waters as the present level yield is found to be on or above optimum catch.

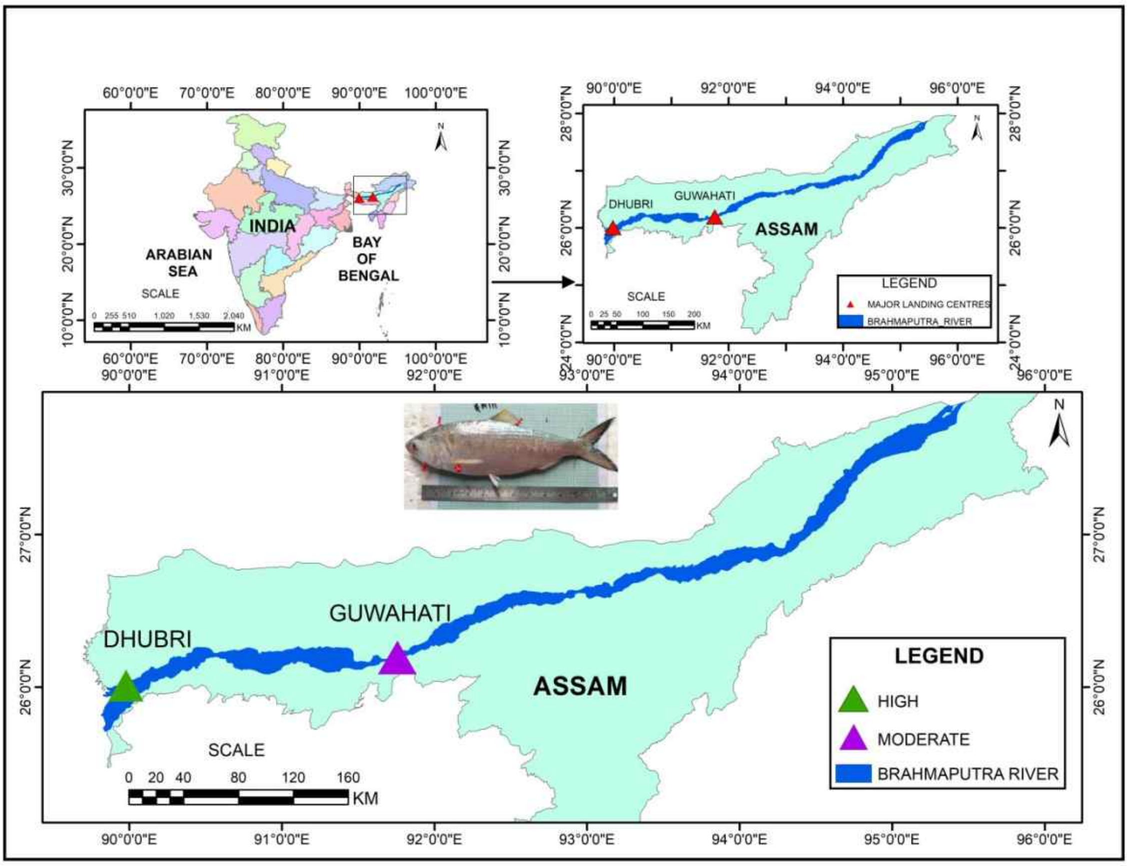
(CIFE/2013/FRM306/SR)

Fishery, Biology and Stock Characterization of *Tenualosa ilisha* (Hamilton, 1822) in Brahmaputra River, Assam, India

Simanku Borah

Major Advisor: Dr. B. K. Das

The present study on fishery, biology and stock characterization of *Tenualosa ilisha* (Hamilton, 1822) from Brahmaputra River, Assam was carried out to assess the catch structure, population characteristics, food and feeding habits and reproductive biology and characterize the stock of *T. ilisha* from Brahmaputra River, Assam, India. The study revealed dominance of smaller size group (150-200 mm) in Hilsa landings at Dhubri landing center of River Brahmaputra. Growth parameters estimated with the help of von Bertalanffy growth formula revealed that L∞ as 451 mm; K as 0.51 year-1; to as -0.49 year and growth performance index (ϕ) as 3.016. The natural mortality rate (M) was found to be 0.51 year-1, total mortality (Z) 1.59 year-1 and fishing mortality rate (F) 1.08 year-1. The present study showed lower values of gastro-somatic index, hepato-somatic index and index of fullness during spawning season. Relative gut length of the species was found to be high and ranged



from 1.098 to 2.0 with a mean relative gut length of 1.336±0.013. A total of 57 different types of food items were observed in gut of *T. ilisha*, while index of preponderance as well as index of relative importance indicates zooplankton as the preferred item of the species. Assessment of gonado-somatic index (GSI) of *T. ilisha* revealed higher values of gonado-somatic index value during the months from October to February. Absolute fecundity was found to range from 103,164 to 583,456 ova for fishes in the size range of 229-403 mm with an average of 250,532 ova per female. Relative fecundity was found to range from 306 to 1096 ova per gram body weight with an average of 791 ova per gram body weight. Ova diameter ranged from 414.6 µm to 738.2 µm. Mean ova diameter was found to be 546.73 ± 7.18 µm. Percentage frequency distribution of mature ova indicated a distinct single peak, which also indicates that the species spawn only once in a year in Brahmaputra River. Sex ratio (Male: Female) was found to be 1:0.87 with dominance of males in smaller size groups. Bivariate plot shows that in general the differences in otolith micro-chemistry were more pronounced on a spatial scale as compared to the temporal differences. Analysis of Molecular Variance (AMOVA) revealed 7.76% of total variation between groups. Analysis revealed the presence of a single Hilsa stock in Brahmaputra river in the stretch studied.

(CIFE/2019/FRM907/SR)

Productivity Susceptibility Analysis (PSA) Ecological Framework for Assessment of Marine Fishery

Muzammal Hoque

Major Advisor: Dr. Zeba J. Abidi

Semi-quantitative risk assessment frameworks, such as the productivity susceptibility analysis (PSA), are widely used to assess the relative vulnerability of species to the overfishing or other fishing activities in data constrained regions and prioritize management, research and conservation efforts among different species. In the present study, PSA

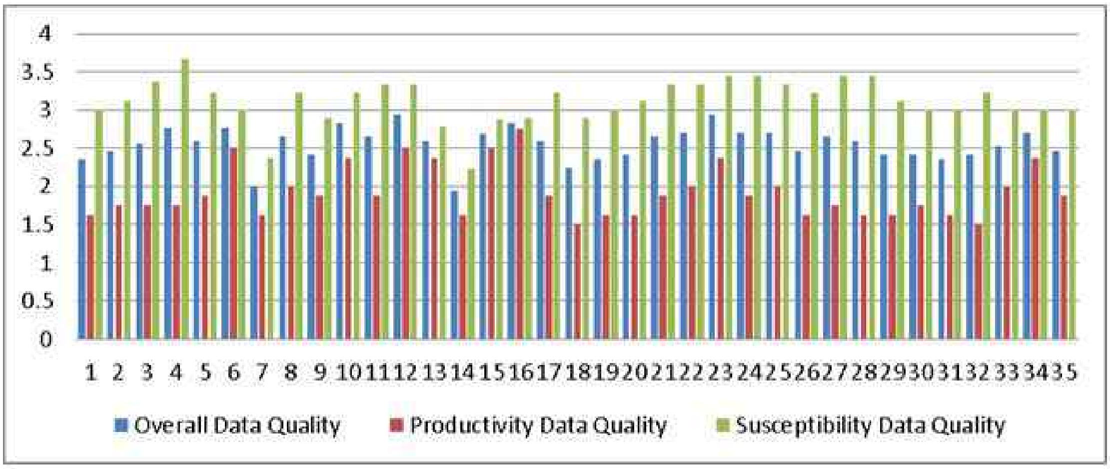


Fig. : Data quality graph of 35 pelagic fishes along the N-W coast of India.

evaluated the vulnerability of commercially important 70 species, including 35 pelagic species and 35 demersal species from the North-West coast of India. It was also assessed in which gear which species is more vulnerable along the North-West coast of India. For the demersal species, the vulnerability score varied from 0.9 to 2. The spotted eagle ray *Aetobatus narinari* was found highest vulnerable species among selected demersal species with a vulnerability score of 2, and Black pomfret *Parastromateus niger* showed the lowest vulnerability with a score of 0.9. Four species (11.42 %) were classified as moderate vulnerability categories with a score ranging 1.8 to 1.9, and thirty species (85.71 %) were classified as low vulnerability with a scoring range of 0.9 to 1.7 among the demersal species. For the 35 pelagic fishes, the vulnerability score ranged 0.9 to 1.9. The lowest vulnerability score, i.e. 0.9, showed Indian oil sardine *Sardinella longiceps* and Commerson's anchovy *Stolephorus commersoni*. On the other hand, the Great barracuda showed the highest vulnerability score, i.e., 1.9 among 35 pelagic fishes from the North-West coast of India. Among 35 pelagic fishes, six species (17.14%) showed moderate vulnerability and great barracuda *Sphyraena barracuda* showed very high vulnerability with a score 2.2 in trawl net. Eight (22.8%) species showed moderate vulnerability, and only the Diamond trevally *Alectis indica* showed high vulnerability with a score of 2.1 in purse seine among the pelagic species. In dol net for the pelagic fishes, the vulnerability score varied 1.4 to 2.2. From 35 demersal fishes, 10.42 % species showed high vulnerability and 11.42 % species showed moderate vulnerability in the trawl net. The majority of the demersal fishes in purse seine showed low vulnerability with a score ranging 1.0 to 1.9. About 17.14% of total demersal fishes showed moderate vulnerability in dol net, 11.42% stocks showed high vulnerability, and 68.57% stocks showed low vulnerability in dol net. The susceptibility data quality for the majority species is low. So, it indicates the need for improved data collection on life-history traits of particular species.

Spatio-temporal and Environmental Drivers of Fish Community Structure of Dhansiri River, Nagaland, India

(CIFE/2019/FRM912/SR)

Shamyung O. Ongh

Major Advisor: Dr. Asha Landge

Ichthyo-faunal diversity and its assemblage pattern were evaluated and compared among the four selected sites, within the longitudinal gradient of the river Dhansiri. A total of 71 fish species belonging to 47- Genera under 17- Families from 8- Orders was recorded with Cyprinidae Family dominating the catch composition. Multivariate analysis such as Canonical Correspondence Analysis (CCA), Bray- Curtis Similarity Index (cluster), and K- Dominance Plot, Taxonomic Distinctness Index, and Correlation study and species diversity indices were calculated using statistical tools

PAST, PRIMER 6 and Correlation matrix. CCA identified environmental parameters such as DO, pH, CO_2, TDS, Conductivity, Temperature and Depth as the significant variables that affect the occurrence and distribution of fish assemblage. A remarkable variation in fish assemblage was also observed between the habitats of the upper stretch and lower stretch of the river. Species richness and diversity were at their peak during pre-monsoon and monsoon seasons. The results of Rank Based Quotient (RBQ) species vulnerability assessment revealed the impacts of climate change like rising in water temperature and change in rainfall pattern compounded by anthropogenic activities such as the use of destructive fishing methods, pollution, abstraction of sand and gravels as the prime factors that leads to decline in aquatic resources. The study form the baseline for further research and the findings can be used for sustainable management and conservation of resources. The environmental variables were found within the acceptable range for aquatic organism survival and served as a driving force of the Dhansiri River ecosystem.

Table 1 Spatial Diversity Indices of Dhansiri River

	Site 1	Site 2	Site 3	Site 4
Taxa_S	58	45	43	41
Individuals	934	808	851	806
Simpson_1-D	0.975	0.9646	0.9657	0.965
Shannon_H	3.817	3.555	3.532	3.509
Evenness_e^H/S	0.7977	0.7779	0.7955	0.8152
Margalef	8.188	6.572	6.226	5.977
ACE	58	45	43	41

Table 2 Temporal Diversity Indices of Dhansiri River

	POST MONSOON	PRE MONSOON	MONSOON
Taxa_S	54	69	68
Individuals	370	533	723
Simpson_1-D	0.9711	0.9729	0.9767
Shannon_H	3.726	3.855	3.938
Evenness_e^H/S	0.7685	0.6848	0.7549
Margalef	8.963	10.83	10.18
ACE	61	84	73

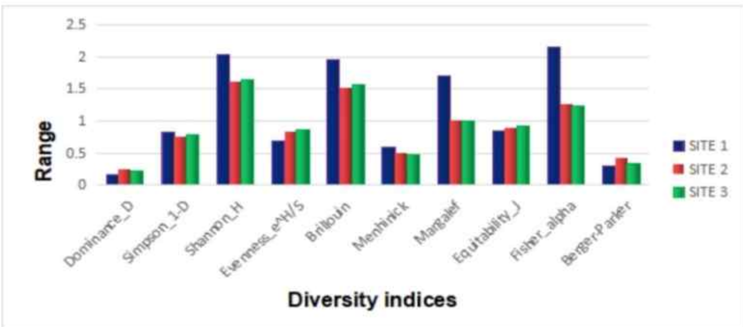
(CIFE/2019/FRM903/SR)

Spatio Temporal and Environmental Drivers of Fish Community Structure in the River Vasishtha Godavari, AP, India

Kollati Bharathi

Major Advisor: Dr. Asha Langde

The current study was aimed to study the fish diversity and fish assemblage pattern in relation to environmental parameters and the fish species vulnerability using stakeholder approach in Vasishtha Godavari river located in West Godavari and East Godavari district, Andhra Pradesh, India. Sampling was carried using a standard methodology from December 2020 to April 2021 and July to August 2021 on a monthly basis. The diversity of fish species was represented by 53 fish species belonging to 43 genera, 32 families and 14 orders. Among the orders listed from the study area, Perciformes was the most dominant order regarding the number of species. Biodiversity indices of fish species have revealed that some of the fish species had dominated the fish diversity of the study area. Almost all the environmental parameters



Site wise diversity indices in Vasishta Godavari river were within the favourable range to support fish growth and health. Canonical Corresponding Analysis (CCA) showed that the transparency, salinity, DO, and pH had played a significant role in the abundance, distribution and assemblage pattern of fish species. The correlation matrix further revealed that temperature, alkalinity and pH were negatively correlated with DO and pH was positively correlated with the alkalinity. Taxonomic distinctness index (Δ^{+}) results showed that the diversity in the Antharvedi Palem was below the expected range; at Dowleswaram, it was in the predicted range, and it was more than the expected range at Koderu Lanka. As per the Rank Based Quotient (RQB) analysis, the pollution and industrial effluent were the most important constraint regarding the sustainability and changes in reproductive behavior of fish species. Hence, conservation and management of the study area by following suitable management measures will help sustain the fish diversity and their reproductive behaviour.

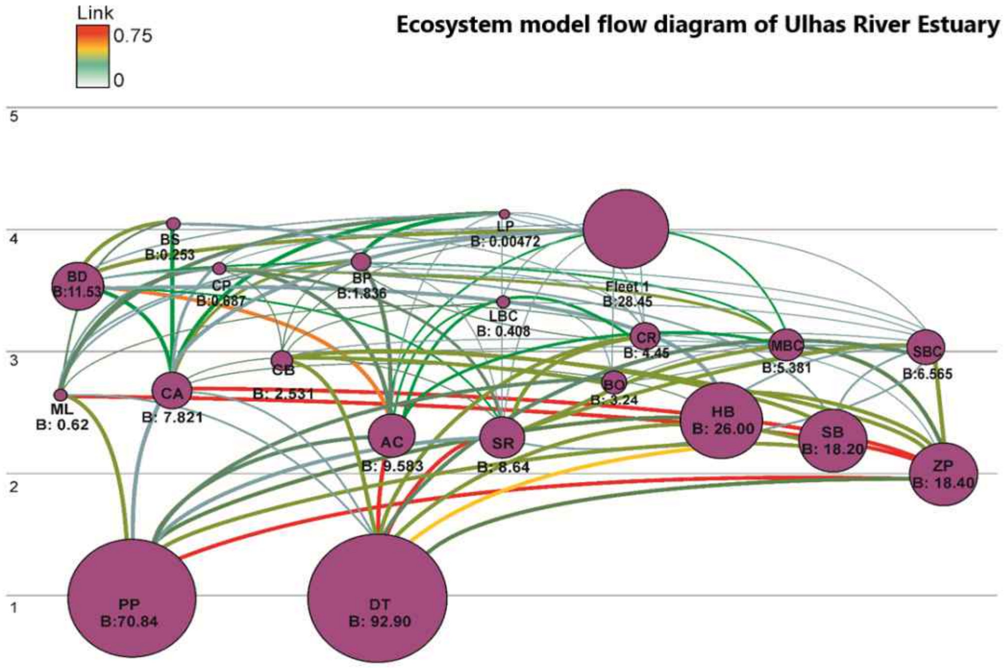
(CIFE/2016/FRM602/SR)

A Study on the Trophic Structure of Ulhas River Estuary, Maharashtra

Dhanya M. Lal

Major Advisor: Dr. Zeba J. Abidi

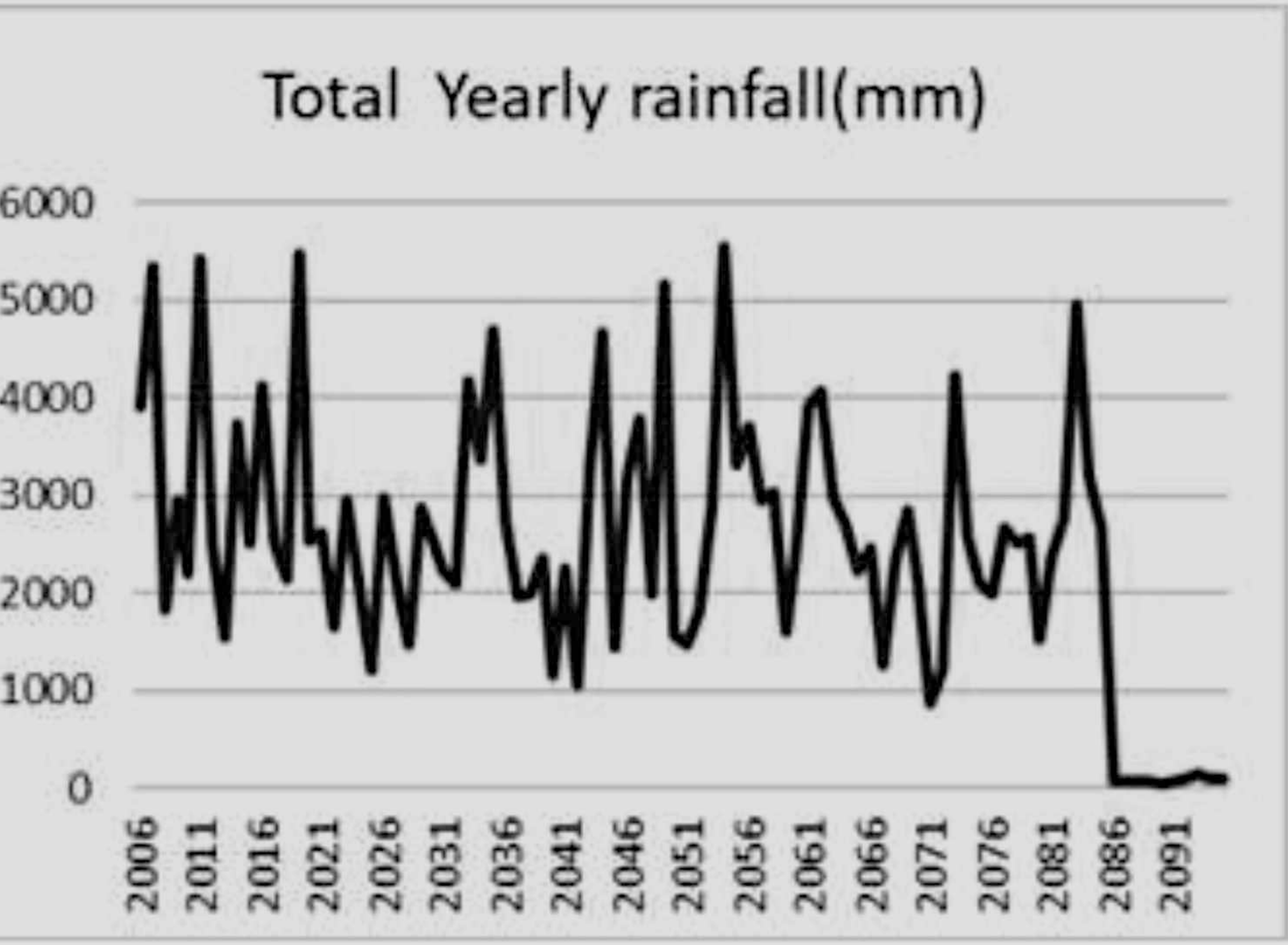
This study analyzed the trophic structure of a highly disturbed tropical estuarine ecosystem, the Ulhas River Estuary(URE) located near the Mumbai city, Maharashtra in terms of the seasonal variations in fish diversity and community structure, source consumer relationships in the food web, trophic flows between components and the ecosystem health status indicators during the period of 2017-2019. A total of 105 species, belonging to 4 classes, 19 orders, 44 families and 75 genera were recorded from the estuary. Based on the Relative Importance Index (RII), *Escualosa thoracata* and *Acetes indicus* were the most dominant fish species, whereas *Harpadon nehereus also* formed remarkable dominance and hence fishery, but showed seasonal occurrences. The trophic guild, Omnivores (OM) constituted the major proportion in terms of the total number of species (30%) followed by Mid Level carnivores (MLC:29%) and High-level Carnivores (HLC:24%). The exceptional seasonal abundance of the two species *H. nehereus* and *A. indicus* were found to be the most important attribute for the clear shift of trophic guild structure in the Estuary between seasons. The isotopic mixing model using R-package (SIMMR) developed using three basal carbon sources and eight consumer groups clearly indicated a phytoplankton based pelagic food chain and detritus based benthic food chain. The δ^{13}C varied from -19.67‰ to -24.61‰ between species, whereas δ^{15}N ranged from 6.31‰ to 15.39‰ for the primary consumer to the top predator species. The δ^{13}C values in the omnivore, *A indicus* (-24.38‰), demonstrated close values with the detritus δ^{13}C signature (-25.4‰). Based on the δ^{15}N

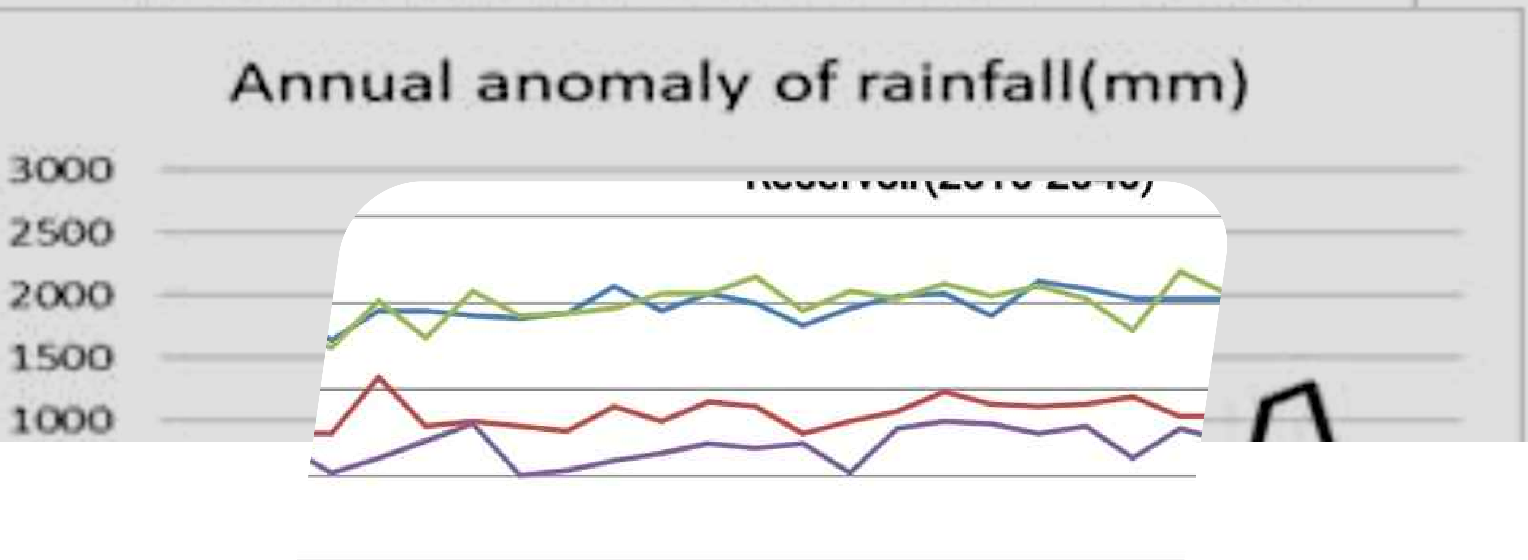


signatures of dominant consumer species, the food chain length is estimated as 3.75 signify a food web structure with at least four trophic guilds.

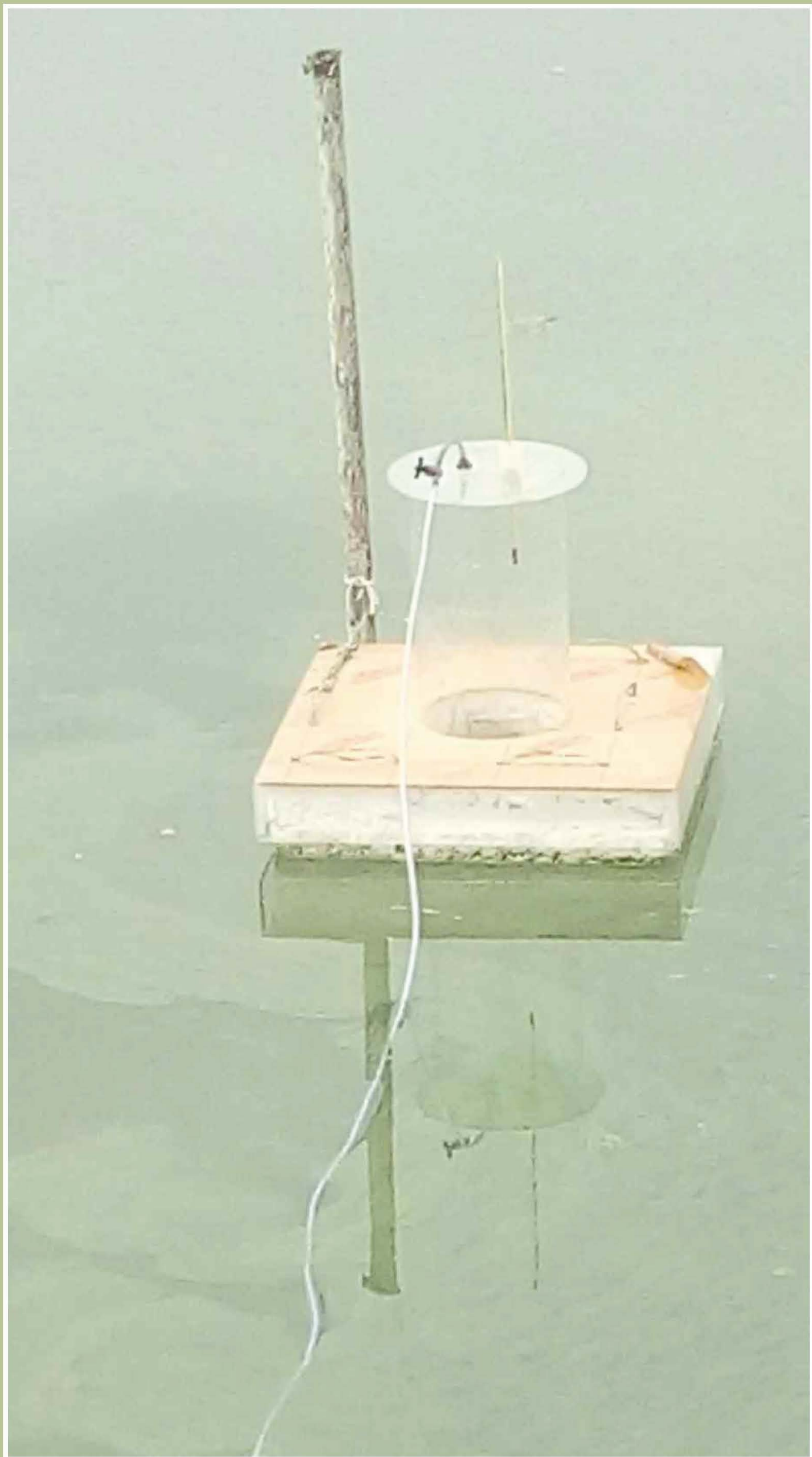
An ecosystem model of the URE depicted the trophic flows in 20 ecological compartments using ECOPATH modelling approach. The highest Ecotrophic efficiency (EE) values were observed for groups such as Clupeids and Anchovies (0.95), Acetes (0.92), Shrimps (0.90) and Small benthic carnivores (0.95). Cephalopods were the most important keystone species in the system. Higher magnitudes of ecotrophic efficiency of the detritus (0.61) and flow towards the detritus (3647 t km ^{2}year^{-1}) indicated the importance of detrital pathways in URE. The total system throughput (TST) was 16736.20 to km ^{2}year^{-1} and the mean trophic level of catches were obtained as 3.01. The moderate dimensions of the net system production (NSP = 1398.78 t km ^{2}year^{-1}) and total primary productivity/ total biomass (TPP/TB =25.17) and lower level of total biomass/ total system throughput (TB/ TST =0.01) indicated the immature status of the URE. The Finns Cycling Index (FCI) and System Omnivory Index (SOI) were 13.94% and 0.32 respectively. The value of the Estuarine Fish community Index Matric EFCI was obtained as 38. All the ecological stress indicators point towards a medium to high level of impact in URE due to anthropogenic activities. The annotated checklist developed including the taxonomic, functional and conservation aspects of the fish fauna revealed 51.42 % Marine migrants and 21.9% Amphidromous species in the estuary, signifying the use of this ecosystem for the nursery function of commercially important marine fisheries resources. Based on the IUCN Red List of Threatened Species, one species was listed as Vulnerable (*Tenualosa Toli*) and 2 species as Near threatened (*Harpadon nehereus* and *Chilocilium grecium*). Increased proportion of "Not Evaluated" (53%) and "Data Deficient"(8%) categories in the context of high level of anthropogenic stress demands for more updated documentation of the biodiversity and dynamics of the ecological structure for formulating and implementing effective ecosystem-based management programs for URE.

The obtained results also supported by Prasanta et a





Climate Change and Vulnerability



Documentation, Inventorization and Bioprospecting of Micro-Algae of Freshwater Habitats of Maharashtra for Atmospheric Carbon Sequestration

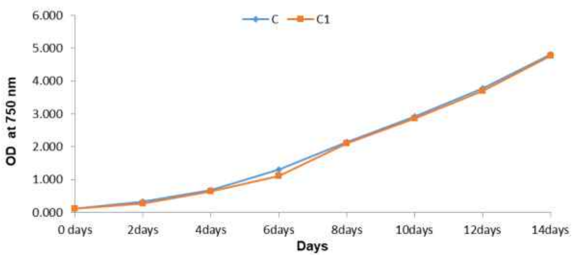
(CIFE/2019/14-B/IF)

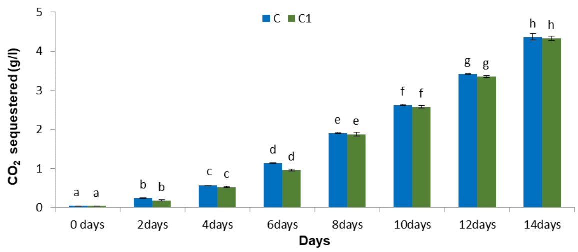
Project duration: 2019- 2022

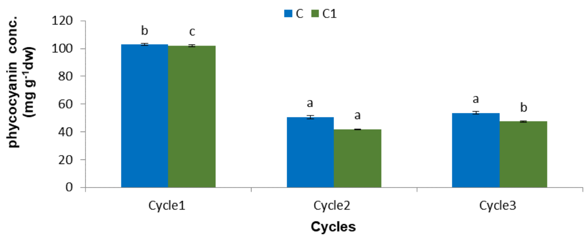
Principal Investigator
Dr. S P Shukla

Co-Principal Investigators
Dr. G R Bhuvanesvari
Dr. Saurav Kumar
Dr. Kundan Kumar

The design and trial of cemented raceways with submerged culture mixing assembly was completed. The yield of biomass in outdoor culture systems has been calculated. Carbon content in the biomass estimated using CHNS analyser and corresponding carbon dioxide sequestered was calculated. C/N ratio and protein content of the biomass was estimated to evaluate the quality. The biomass produced was utilized for colorant grade phycocyanin extraction using a simple protocol.







Assessing Carbon Sequestration Capacity and GHG Emission Potential and its Mitigation under Different Aquaculture Systems

(CIFE/2019/14-A/IF)

Project duration: 2019-2022

Principal Investigator
Dr. Vidya Shree Bharti

Co-Principal Investigators
Dr. Gayatri Tripathi
Mr. Hari Krishna
Dr. Sunil Kumar Nayak
Dr. G. Rathi Bhuvaneswari

A study was conducted to assess the carbon sequestration potential of new ponds and 6-7 years cultured ponds. It was observed that the carbon sequestration is higher in cultured ponds as compared to new ponds. We also studied the effect of stocking density and related management practices on carbon sequestration and GHGs emission. The carbon sequestration is increasing with increasing stocking density but the significant increase was observed at SD of 45no/m^2 as compared to 60nos/m^2. Whereas the emission of the GHGs emission measured using a manufactured device particularly nitrous oxide is higher with higher stocking density i.e. SD 60/m^2 in Inland saline shrimp culture ponds.

The soil carbon sequestration rate varied from 530 ± 120 kg $hr^{-1}yr^{-1}$ in control ponds to 1297 ± 124 kg $hr^{-1}yr^{-1}$ in cultured ponds and sequestration rate increased almost two times in all treatment ponds over 6 to 7 yrs of the culture period compared to control ponds. Different forms of the carbon eg. total carbon, organic and inorganic carbon was studied and it was observed that out of these carbon forms organic carbon is

N_2O (ppb/m^2/day)	DAY 1	DAY15	DAY30	DAY45	DAY60	DAY75	DAY90	DAY105	AV
SD30	-57±17	61±13	220±133	207±13	8.7±12	580±98	-102±10	98±10	122±38
SD45	-38±27	146±2	507±179	715±65	449±108	558±110	475±169	588±23	425±85
SD60	49±10	183±2.2	509±186	837±69	618±259	1045±134	116±3.9	161±10	**440±84**

significantly affected by the management practices and stocking density. Among the organic fractions, the less labile form of the carbon is significantly affected by the management practices. Change in stocking densities of shrimp in the culture system has no effects on the flux of CO_2 and CH_4 wherever it has a direct effect on N_2O emission. The average fluxes of N_2O in shrimp culture ponds of SD-30, SD-45, SD-60 were 122±38, 425±85, 440±84 ppbm^{-2}day^{-1}, respectively.

In the second experiment in the freshwater system it was observed that the organic carbon content is significantly higher whenever the bottom sediment is not removed as compared to the ponds where bottom sediment is removed at regular intervals. Carbon sequestration potential of freshwater aquaculture ponds is relatively higher as compared to degraded Inland saline system. In the third experiment biochar was added in the shrimp culture system and it was observed that there is significant increase in organic carbon as compared to the control. Work on application of biochar in pond condition is under progress in Inland saline aquaculture and freshwater systems to study the effect on c-sequestration and GHGs emission. We have designed and fabricated the drum kiln for biochar production with locally available discarded metal drums of petrol/ chemical for production of biochar at farm level and are operating at CIFE, Mumbai; Rohtak Center and Powarkheda Center. The soil carbon sequestration rate varied from 530 ± 120 kg hr^{-1} yr^{-1} in control ponds to 1297 ± 124 kg hr-1 yr-1 in cultured ponds and sequestration rate increased almost two times in all treatment ponds over 6 to 7yrs of the culture period compared to control ponds. The average fluxes of N2O in shrimp culture ponds of SD-30, SD-45, SD-60 were 122±38, 425±85, 440±84 ppbm^{-2}day^{-1}, respectively

Predictive Modelling Approach for Inland Fisheries Management Under Climate Change Scenario

(CIFE/2018/1/IF)

Project duration: 2018- 2021

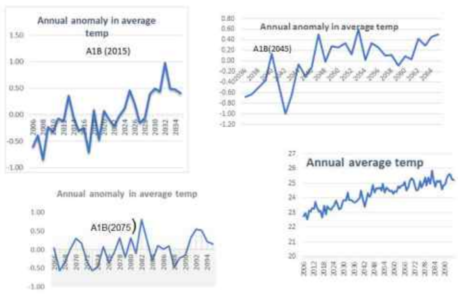
Principal Investigator
Dr. Vinod Kumar Yadav

Co-Principal Investigator
Dr. S.N. Ojha

Climate change has emerged as one of the most multifaceted manifestations of global change of our time. It is obviously clear that climate change has an impact on the fisheries sector, so it's better to know how simulating future values of climate parameters relevant to inland fisheries affect inland fisheries and also how vulnerable the fishing communities are to changing climate. Annual and seasonal trends in future time series of temperature and rainfall (2006-2095) generated for A1B scenario using a statistical downscaling method has been carried out for the periods (2006-2035, 2036-2065, and 2066-95) for complete Maharashtra state and also Dimbe and Bhavanisagar reservoir of Maharashtra(MH) and Tamil Nadu (TN) respectively. The seasonal trend of temperature analysis of MH shows an increasing trend in pre-monsoon and no trend in monsoon and post-monsoon seasons. There is significant decreasing trend of rainfall in pre-monsoon and monsoon seasons and increasing trend in post-monsoon data. The seasonal trend analysis reveals rising trend in temperature for Dimbe reservoir during all three seasons (pre-monsoon, monsoon, and post-monsoon), while there is no trend of rainfall during pre-monsoon.

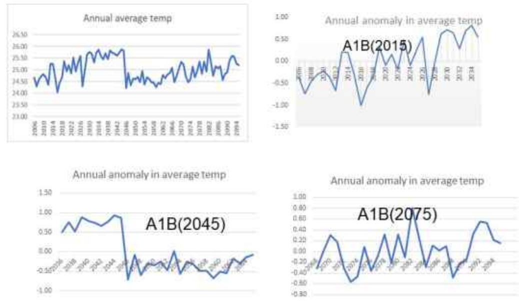
The seasonal trend analysis revealed a decreasing trend in temperature for Bhavanisagar reservoir during pre-monsoon and monsoon seasons but an increasing trend in post-monsoon. In the case of Dimbe reservoir, the average yearly rainfall for the periods (2006-2035, 2036-2065, and 2066-95) is likely to decrease, whereas in the case of Bhavanisagar reservoir, it is likely to increase. The present study simulated

Future trend of Temperature (Dimbe Reservoir)



Average tmp for 2006-2035(2015) is 23.35 degree centigrade, average tmp for 2036-2065(2045) is 24.35 degree centigrade , average tmp for 2066-2095(2075) is 25.04 degree centigrade

Future trend of Temperature (Bhavanisagar Reservoir)



Average temperature for 2006-2035(2015) is 25.03 degree centigrade (average increase /year is 0.04 degree centigrade).Average temperature for 2036-2065(2045) is 24.94 degree centigrade(average increase /year is 0.57 degree centigrade).Average temperature for 2066-2095(2075) is 25.04 degree centigrade

the total fish production potential for Maharashtra state and different reservoirs of Maharashtra and Tamil Nadu with respect of changes of 0-1 % in two significant variables (temperature and rainfall). The study found that varying vulnerability levels among fishing communities of Dimbe (high) and Bhavanisagar (low) reservoirs. Ambegaon block (Dimbe Reservoir) has relatively higher vulnerability because of high sensitivity (high SC/ST population) resulting from presence of tribal communities. Bhavanisagar have least vulnerability and the fish production is relatively higher than other reservoirs because of effective management of reservoir through TNFDC (Tamil Nadu fisheries development corporation). The predicted future scenarios of climatic parameters and their impact on fisheries and socio-economic vulnerability can help draw appropriate management strategies.

(CIFE/2019/FEC903/SR)

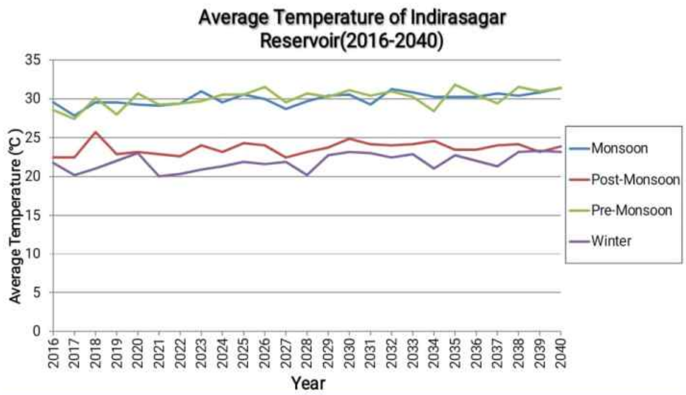
Assessing Vulnerability and Effect of Climatic Variables on Inland Fisheries in Selected Reservoirs of Madhya Pradesh

Mondeep Saikia

Major Advisor: Dr. Vinod Kumar yadav

Inland fisheries are seen as a positive means of achieving food security and providing employment, income, recreation, and cultural enrichment to increasing global human population. In India, Inland fisheries contributed 73.65% of India's total fisheries production, accounting for 14.16 million tons in 2019-2020. Climate change has had a major historical influence on global biodiversity and will continue to impact the structure and function of natural ecosystems, including the provision of natural services such as fisheries. A study was conducted in selected reservoirs of Madhya Pradesh on socio-economic vulnerability and the effect of climatic variables on fish yield. The climatic data of Madhya Pradesh were collected from IMD. Temperature and rainfall data under A1B scenario were processed using Linux based Ferret software, chlorophyll-a and water surface temperature data were retrieved from Landsat-8 imagery using SNAP and ARCGIS software. The secondary data for finding socio-economic vulnerability index (SEVI) was obtained from the census of India 2011 and 2001 and various government departmental websites formed data sources. Annual anomaly analysis for average temperature and rainfall showed warming in annual temperature at Indirasagar reservoir under A1B scenarios during 1991-2015, 2016-2040 and 2041-2065. While rainfall decreased between (1991-2015) and (2016-2040) but increased during (2041-2065). Similar case results were witnessed in case of Gandhi Sagar reservoir.

Seasonal trend analysis was done using Mann-Kendall(M-K) test which showed an increasing trend for average temperature in post-monsoon and winter, while decreasing trend in Monsoon and Pre-Monsoon in Indirasagar reservoir. There is a significantly decreasing trend for rainfall in all the 3 seasons except Monsoon. In case of Gandhisagar reservoir, average temperature showed an increasing trend in all the seasons while rainfall showed a significantly decreasing trend in all the seasons except Post-Monsoon. Forecasting of reservoir fish production was done using Auto-Regressive Integrated Moving Average (ARIMA) and Auto-Regressive Integrated Moving Average with exogenous variables (ARIMAX). It was witnessed that ARIMAX performed better with lower Mean Absolute error and higher R^2 value. Mean Maximum Temperature, Mean Minimum Temperature and Mean Wind Speed were significant variables in predicting fish production. Fishing villages of Indirasagar reservoir are comparatively more vulnerable than the fishing villages of Gandhi Sagar reservoir due to higher Sensitivity (0.605) and lower adaptive capacity (0.434). Analysis of Mann-Whitney U test showed that 4 indicators varied across fishing and non-fishing villages of Indirasagar and 1 indicator varied in case of Gandhisagar. The present study will provide useful insight to devise a better strategy for the management of water resources in the Indirasagar and Gandhisagar Reservoir. Influences of climate change on fish catch will give the roadmap to facilitate the management strategies for enhancing sustainable fisheries and adaptation strategy for climate change.



Seasonal variation of Average temperature can be observed, **Pre-Monsoon(March, April, May)** being the **highest** and **Winter(January, February)** being the lowest in terms of Average Temperature.

Socio-Economic Vulnerability and Fisheries Development: Transformation Pathways for an Aspirational District in Andhra Pradesh

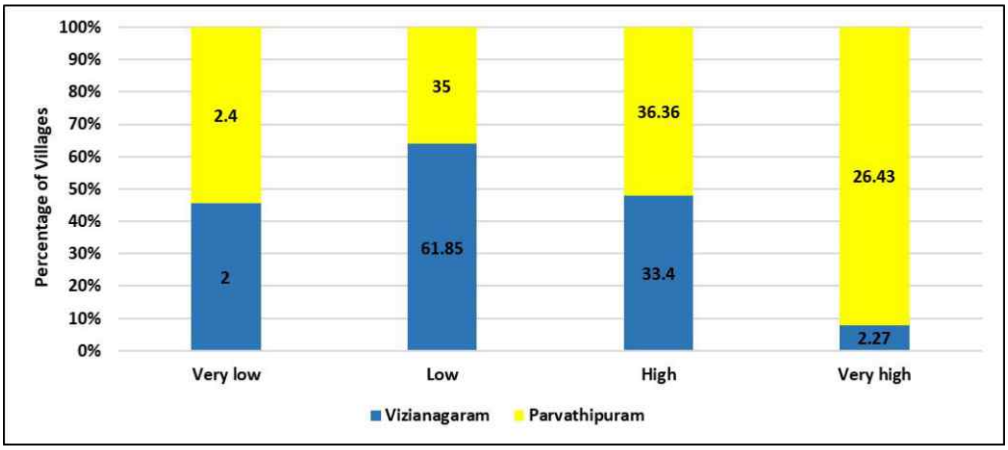
(CIFE/2019/FBT907/SR)

Sathya G

Major Advisor. Dr. Neha W. Qureshi

Socio-economic vulnerability assessment involves assessing a region's vulnerability to a hazard based only on its social and economic status. Owing to India's massive coastline of 7516 km and a vast network of rivers, fisheries development will help the communities to increase their adaptive capacity to the hazards they face. The purpose of this study is to investigate the socio-economic vulnerability status of the most developed district (East Godavari) and aspirational district (Vizianagaram) of Andhra Pradesh. The SEVI methodological framework was used to assess the vulnerability status of the districts at the division/tehsil/village level. The overall SEVI value of East Godavari-0.31 and Vizianagaram-0.33 was found to be very low. As per the SEVI analysis, the highest number of high to very high vulnerable villages were found in Vizianagaram, i.e., 1139 villages (78.4%) out of 1452 villages and in East Godavari, out of 1312 villages, 688 villages (52.4%) were identified as high to very high vulnerable villages.

The tehsil wise SEVI values indicated that Gummalakshmipuram tehsil in Vizianagaram and Maredumilli tehsil in East Godavari tops the index value with 0.45 and 0.46, respectively. While Vizianagaram tehsil (0.23) in Vizianagaram and Rajahmundry tehsil (0.24) in East Godavari are the least vulnerable tehsils. The study also identified fisheries development indicators that measure the fisheries' potential, fisher's human development and institutional arrangements for suggesting strategies to enhance the overall development of the selected aspirational district. The aspirational district Vizianagaram lags behind East Godavari in every aspect of the fisheries development. The major constraints prevailing in the Vizianagaram district are lack of technical guidance, inadequate infrastructure facilities for seed production, post-harvest, and poor domestic market development. By deepening the capital subsidy for infrastructure construction, offering



training packages on advanced technologies, promoting women participation and setting up of retail markets can narrow down the increasing development gap between the aspirational and better-performing districts. In order to reduce vulnerability in the identified vulnerable villages and tehsils, specific mitigation and adaptation plans need to be prepared by Panchayat Raj Institution's with the help of experts and civil society.

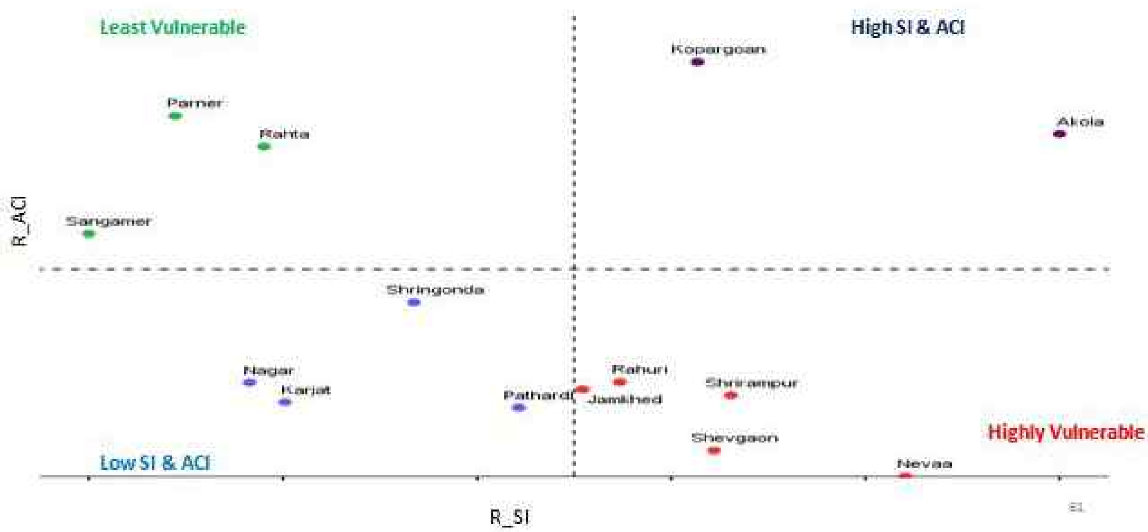
Socio-economic Vulnerability and Fisheries Development: Transformation Pathways for an Aspirational District in Maharashtra

(CIFE/2019/FEC905/SR)

Seenivasan P.

Major Advisor: Dr. Ananthan P. S.

Vulnerability assessment is vital to devise suitable adaptation measures for enhancing community resilience. This study attempts to assess the social and economic vulnerability of Nandurbar district, the most backward district as per NITI Aayog, and Ahmednagar district, the agriculturally most progressive district in the same region, in Maharashtra. Studies have focused largely on physical aspects of hazards and vulnerability, and very few on the social and economic dimensions at the community/village/tehsil level. Using novel methodological frameworks namely SEVI and the Fisheries Development Indicators (FDI), this study



covered 930 villages in Nandurbar and 1582 villages in Ahmednagar using the Census of India (2011) data and other secondary data. It was found that 480 villages (52%) in Nandurbar and 615 villages (39%) in Ahmednagar were found to be *highly vulnerable* as per SEVI analysis. While the social sensitivity of Ahmednagar (0.28) was low, it was *high* in Nandurbar (0.58). Due to this, the overall SEVI value is higher in Nandurbar (0.41) than Ahmednagar (0.30), though it falls under low (0.25 to 0.5) category.

The independent t-test revealed statistically significant differences in SEVI values across villages in both Nandurbar and Ahmednagar districts, with mean values differing for 18 out of 22 indicators. This indicates the usefulness of the SEVI framework for micro-level assessment as well as for planning customized development interventions at the village level. Reservoirs and tanks are the major fisheries resources in both districts. Fish productivity was found to be higher in Nandurbar (256 kg/ha/yr) compared to Ahmednagar (84 kg/ha/yr) raising questions about the criteria used for labeling districts as 'backward' and 'progressive' in relation to agriculture, fisheries and socio-economic development. The study also found a significant gap between the districts' potential and actual fish production due to various factors including inadequate infrastructure and poor extension services. Comparative analysis of SEVI and FDI for Nandurbar and Ahmednagar provided important insights: contrary to assumptions, though the socio-economic vulnerability was higher in Nandurbar, fish yield and share of fisheries in the district GDP were found to be higher in Nandurbar. The national program PMMSY offers opportunities to strengthen fisheries development, and hence effectively made use of. In order to reduce sensitivity and increase the adaptive capacity, especially in identified vulnerable villages and tehsils, specific mitigation and adaptation plans need to be prepared by panchayati raj institutions with the help of experts and civil society.

Socio-Economic Vulnerability and Fisheries Development: Transformation Pathways for an Aspirational District in Madhya Pradesh

(CIFE/2019/FEC906/SR)

Talib Mohammad

Major Advisor: Dr. Ananthan P. S.

Socio-economic vulnerability assessment involves assessing a region's vulnerability to a hazard based only on social and economic status of people living therein. India has immense potential for fisheries development that will help the communities to increase their adaptive capacity. This study assesses the social and economic vulnerability of Barwani district, the most backward district as per NITI Aayog, and Sagar district, agriculturally most progressive district in the same region, in Madhya Pradesh. The Socio-Economic Vulnerability Index (SEVI) framework relying on census and other secondary data was used to assess the vulnerability status at the district/tehsil/village level covering 680 villages in Barwani and 1869 villages in

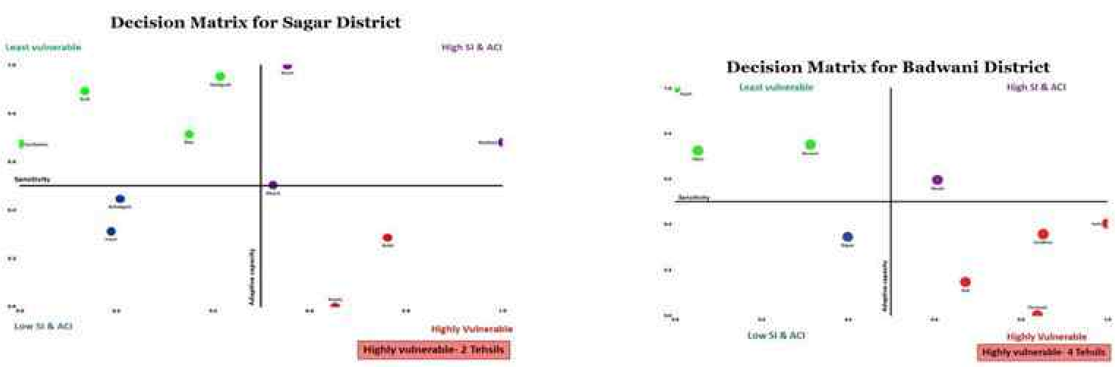


Fig. Vulnerable tehsils of Sagar and Barwani (aspirational district) based on Socio-economic vulnerability index (SEVI)

Sagar. It was found that 302 villages (44%) in Barwani and 1395 villages (75%) in Sagar were found to be highly vulnerable as per SEVI analysis. While the social sensitivity of Sagar (0.37) was low, it was high in Barwani (0.58). Due to this, the overall SEVI value was low but slightly higher in Barwani (0.40) than Sagar (0.36). One-way ANOVA test, at 0.05% level of significance, revealed that the socio-economic vulnerability of villages differed significantly from each other across all tehsil in both district for 15-18 (out of 22) indicators.

The independent t-test also revealed statistically significant differences in SEVI values across villages in both Barwani and Sagar districts, with mean values differing for all the 22 indicators. This indicates the usefulness of the SEVI framework for micro-level assessment as well as for planning customised development interventions at village level. The study also identified fisheries development indicators that measure the fisheries' potential, fishers' human development and institutional arrangements for suggesting strategies to enhance the overall development of the selected aspirational district. Comparative analysis of SEVI and FDI for Barwani and Sagar provided important insights: contrary to assumptions, though the socio-economic vulnerability was higher in Barwani, fish productivity was found to be higher in Barwani. The study also found a large gap between the districts' potential and actual fish production due to various factors including inadequate infrastructure and inadequate extension services. The national program PMMSY offers opportunities to strengthen fisheries development not only in the study districts but across the state. Using SEVI, key drivers for high sensitivity and lower adaptive capacity were identified, and appropriate development interventions are suggested identified vulnerable villages and tehsils. Specific mitigation and adaptation plans need to be prepared by Panchayat Raj institutions with the help of experts and civil society.

(CIFE/2019/FEX907/SR)

Socio-Economic Vulnerability and Fisheries Development: Transformation Pathways for an Aspirational District in Tamil Nadu

Suvetha V.

Major Advisor: Dr. Ananthan P. S.

Focused interventions in the districts with relatively poor socio-economic development can improve the overall human development. NITI Aayog's Transformation of Aspirational Districts initiative aims to address this. Socio-economic vulnerability assessment can aid in this process. Most studies lay the focus on physical hazards and vulnerability and ignore the social and economic dimensions of vulnerability at the village/tehsil level. This study assesses socio-economic vulnerability as well as fisheries development of an identified aspirational district (Ramanathapuram) and compares with a better performing district (Nagapattinam) in Tamil Nadu using a novel methodological framework of SEVI using secondary data. Results have shown that the SEVI values of villages in Nagapattinam district (overall SEVI: 0.27) ranged from very low to low with Vadakkupogainallur village in Nagapattinam tehsil being least vulnerable (0.13) and Okkur village of Kilvelur tehsil being the most vulnerable (0.37). SEVI scores of villages in Ramanathapuram district (overall SEVI: 0.26) also ranged from very low to low with Muthuramalingapattinam village in Thiruvadanai tehsil being least vulnerable (0.14) and Thattanendal village of Mudukulathur tehsil being the most vulnerable (0.49). Out of 426 villages in Nagapattinam, 126 villages (30%) were highly vulnerable, while only 18% (69 out of 383 villages) were highly vulnerable in Ramanathapuram.

The highly vulnerable villages were located in 3 tehsils namely, Kuthalam (45%) and Tharangambadi (45%) tehsils in Nagapattinam and Ramanathapuram tehsil (30%) in Ramanathapuram. One-way ANOVA test revealed significant differences among tehsils in 15-16 out of 22 vulnerability indicators in both districts. A graphical 2D decision matrix and identification of drivers and buffers provide a snapshot of the vulnerability status for each village based on sensitivity and adaptive capacity threshold values. Indicators of fisheries development underscored the existence of a potential for fisheries based livelihood development but also the gaps that require to be bridged. Key drivers for high sensitivity and lower adaptive capacity were identified, along with appropriate development interventions. The study findings would aid in the preparation of detailed village specific socio-economic development/adaptation plans for reducing vulnerability in villages of Nagapattinam and Ramanathapuram districts.

(CIFE/2019/FEX908/SR)

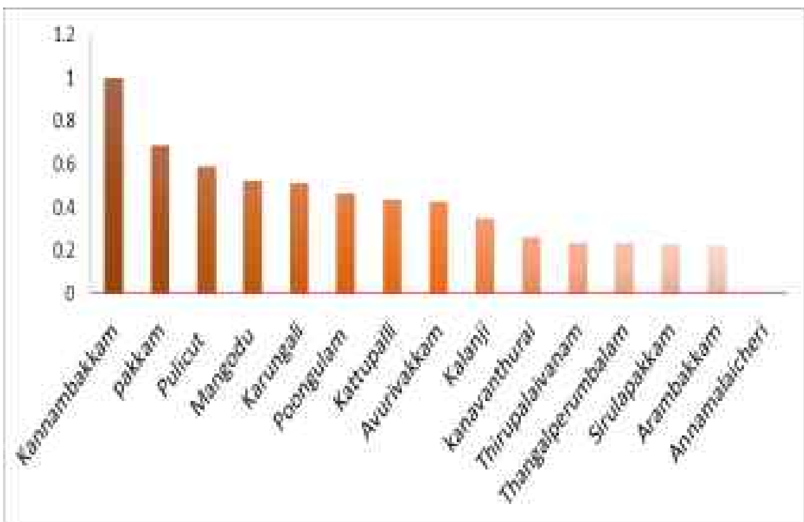
Community-Based Fisheries Management and Fishers' Vulnerability in Pulicat Lake,Tamil Nadu

Krishnaveni K. N.

Major Advisor: Dr. Swadesh Prakash

Pulicat Lake is the second largest brackish water Lake situated along the East coast of India, extending both in Andhra Pradesh (84%) and Tamil Nadu (16%). *Padu* is a traditional Community-based fisheries management system practiced by fishermen of Pulicat Lake with no government intervention. Around 162 *padu* fishing grounds and different types of fishing gear are being practiced in Pulicat. The fishing grounds were categorized into six groups and nine clusters. The hierarchy level of the *padu* system starts from Fisherman to Union President, playing a vital role in assessing and managing the system such as constituting schedules for fishing based on the rotational basis .However, several regulations are modified in the existing system to increase the lake's productivity and ensure equality in sharing the fishery resources of the Pulicat Lake. The system evolved due to the limited resources utilized by more populations. This study attempts to assess the social and economic vulnerability of fishing villages around Pulicat Lake. The study was conducted to find the difference in the vulnerability status of fishing and non-fishing villages in Minjur and Gummidipondi block.

Comparative study shows fishing villages have high economic sensitivity of 0.53 due to the impudence of relatively more distance to urban areas and medical services. Among all fishing villages, the vulnerability of Kannambakkam (1) village is 5 times highly vulnerable than Annamalacheri (0.2). The study found the vulnerability difference between both blocks in terms of both fishing and non-fishing villages and the result shows ranges from low to very low vulnerability. Mann-Whitney U test revealed statistically significant differences in SEVI values across fishing and non- fishing villages in both Minjur and Gummidipondi blocks. The major contributing factors for higher AC were high literacy rate, higher sex ratio and low population growth rate and the presence of relatively higher net irrigated area. The study results have been shared with the Department of Fisheries of Tamil Nadu to monitor the fish catch periodically (once in three months) of major *padus* to avoid use of unrestricted fishing gears. The data will help the future researchers to study about emerging issues in Pulicat Lake. So this will be the base research for future scholars. In terms of high adaptive capacity, fishing villages need to improve transport and communication facilities, market access, and reduce the distance to urban areas across the Pulicat Lake fishing villages.



Seafood Quality & Value Addition

Microbial Remediation of Fish Scale Bio-waste and its Potential Application in the Production of Biologically Active Compounds

(CIFE/2021/1/IF)

Project duration: 2021-2024

Principal Investigator
Dr. Sanath Kumar H.

Co-Principal Investigators: ,

Dr. Binaya Bhusan Nayak
Dr. Amjad K. Balange
Dr. Manjusha Lekshmi

This study aims to develop a bacteria-mediated mechanism to remediate fish scale biowaste, which is a significant environmental concern due to its slow rate of natural degradation. For this, bacteria isolated from different sources such as seawater, scales and coastal sediment were tested individually for scale degradation activity. Two isolates *Lysinibacillus fusiformis* KT_{02} and *Lysinibacillus fusiformis* KT_{05} exhibited significant scale degradation capabilities. Both the isolates could degrade scales in Luria Bertani broth efficiently after five days of incubation. The percentage degradation of scales is shown in Table 1. shows the degraded scales in the form of white residues.

Table 1. Scale degradation by *L. fusiformis* KT_{02} and KT_{05} strains

	Mixed carp scale			Pink perch scale		
L. fusiformis	Weight BD (g)	Weight AD (g)	Degradation (%)	Weight BD (g)	Weight AD (g)	Degradation (%)
KT_{02}	1.032	0.411	60.17%	1.025	0.307	70.04%
KT_{05}	1.031	0.504	51.11%	1.046	0.431	58.79%

BD = before degradation; AD= after degradation

Microbial degradation of scales resulted in significant increase in the ash content, and decrease in protein content (Table 2).

Table 2. Proximate composition of mixed carp scales before and after degradation with *Lysinibacillus fusiformis* Kt_{02}

Proximate composition	Before degradation (%)	After degradation (%)
Moisture	69.29 ± 1.16^{a}	70.88 ± 0.94^{a}
Protein	20.66 ± 0.69^{a}	12.42 ± 1.09^{b}
Ash	8.06 ± 0.12^{c}	15.68 ± 1.11^{a}
Fat	1.52 ± 0.07^{a}	0.95 ± 0.07^{b}

Data expressed as mean ± SD (n=3), the mean value in the same row with different superscripts are significantly different ($p<0.05$).

Key findings:

- Seawater is a good source of bacteria with the ability to degrade fish scales.
- Bacteria of *Lysinibacillus* group can potentially be useful in remediating fish scale wastes.

Fig. Mixed carp Scales (A) and pink perch scales (B) degraded with *L. fusiformis* KTo2

(CIFE/2019/PHT902/SR)

Controlled Bacterial Degradation of Fish Scales

Ashmita Pandey

Major Advisor: Dr. Sanath Kumar

Fish scales constitute a major component of fish waste, the disposal of which is a major challenge due to their slow degradation and environmental impact. The present study was carried out to seek a simple, cost-effective, and eco-friendly method for managing fish scale waste using bacteria. First, the ability of two isolates of *Lysinibacillus fusiformis* (KT02 and KT05) to degrade mixed carp and pink perch scales was tested. Both the isolates degraded the fish scales efficiently within 5 days. *Lysinibacillus fusiformis* KT02 exhibited better degradation of fish scales, 60.17% with mixed carp scales and 70.04% with pink perch scales. The moisture, protein, ash, and fat contents of degradation products of mixed carp scales were 70.88±0.94%, 12.42±1.09%, 15.68±1.11%, and 0.95±0.07, respectively. Similarly, in the case of pink perch scales the corresponding values after degradation were 69.39±0.38% for moisture, 12.97±0.15% for protein, 16.70±0.40% for ash, and 0.65±0.04% for fat. Glycine was the most abundant amino acid in both the scale types, and its percentage level decreased after degradation. Calcium was the most abundant mineral, followed by phosphorus in both scale types, and a sharp increase in their percentage composition was observed after degradation. Presence of short chain fatty acids was observed in scales after degradation. The study also investigated the presence of scale degrading bacteria in the marine and terrestrial environment, A total of 83 bacteria were isolated, 59 from seawater and 24 from fish scales and soil. Nineteen seawater isolates and 13 isolates from scale and soil samples were gelatinase positive. Of these, 13 isolates from seawater and 11 isolates from scale and soil samples exhibited good scale degrading activity. Three of these isolates efficiently degraded the scales in all media containing 0.01%, 0.03%, and 0.05% peptone. This study shows that bacteria of marine origin can be potentially useful in remediating fish scale biowaste and help to reduce environmental impact of fish waste.

Distribution of pathogenic microaerophilic Arcobacter sp. in seafood and development of a rapid method for its detection

(CIFE/2021/1001/IF)

Project duration: 2021-2024

Principal Investigator
Dr. B.B Nayak

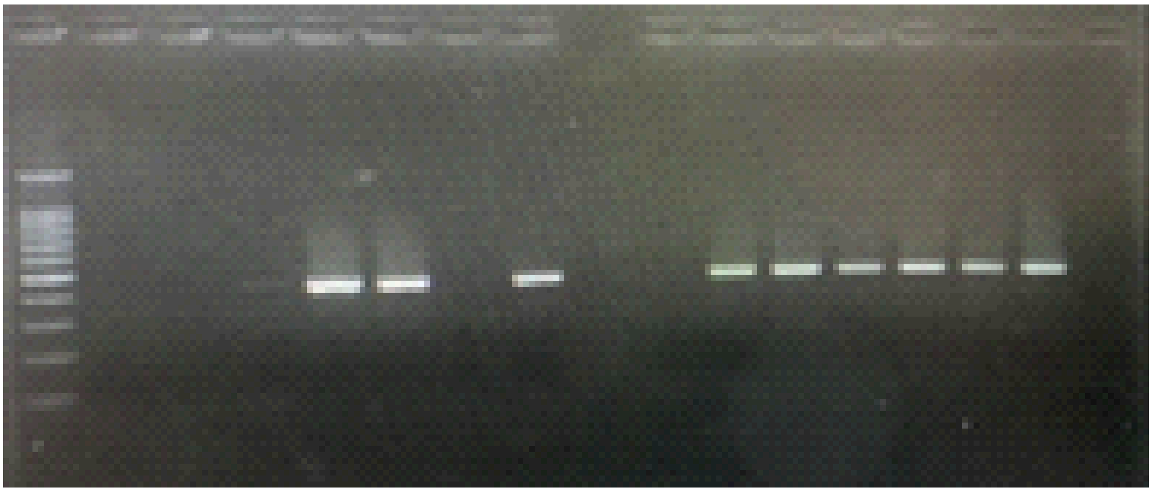
Co-Principal Investigators,

Dr. Sanath Kumar
Dr. Manjusha L.

Budget: 52.92 lakhs

Funding Agency:
Department of Biotechnology (DBT)

Arcobacter were isolated from seafood samples by selective enrichment in Arcobacter selective broth followed by selective plating in Arcobacter selective agar, supplemented with CAT/Arcobacter selective supplement and 5% laked horse blood. 60 bacterial isolates from various seafood samples collected from retail fish markets in Mumbai were presumptively identified as Arcobacter. Also, 40 isolates of Arcobacter spp. were revived in Arcobacter selective broth from laboratory repository.). The isolates were identified biochemically by gram staining, oxidase, catalase, and fluorescent in situ hybridization (FISH) and genetically by genus specific (ARCO-I: 5'- AGA GAT TAG CCT GTA TTG TAT C-3' and ARCO-II: 5'-TAG CAT CCC CGC TTC GAA TGA-3') and



species specific primers (BUTZ F: 5'-CCT GGA CTT GAC ATA GTA AGA ATGA-3' and ARCO R: 5'-CGT ATT CAC CGT AGC ATA GC-3'). Few of the isolates were sequenced for 16srRNA and confirmed as A.butzleri and A.skirrowii.

Development of a Pilot Scale Plant for Value Added Fish Products in NEH Region

(CIFE/2020/2/IF)

Project duration: 2020-2023

Principal Investigator
Dr. Amjad K Balange

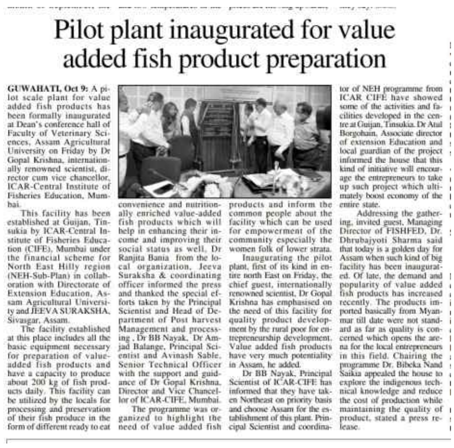
Co-Principal Investigators
Dr. Martin Xavier
Dr. Layana P.

Technical Associates
Mr. Avinash Sable
Mr. Bhanudas Phande

Installed a Pilot plant facility for value added fish products preparation with a capacity of processing 200kg fish products per day at Khairwe, Nawapur, Nandurbar district, Maharashtra. The facility was inaugurated on 16 September, 2021 and will provide a common facility for the tribal women SHGs in that area under TSP Scheme.

Installed a Pilot plant facility for value added fish products preparation with a capacity of processing 200kg fish products per day at Guijan, Tinsukia, Assam. The facility was inaugurated on 8th Oct 2021 and will provide a common facility for the women SHGs in that area under NEH Scheme.

Microplastic Contamination in Fishery



Pilot plant inaugurated for value added fish product preparation

GUWAHATI, Oct 9: A pilot scale plant for value added fish products has been formally inaugurated at Dean's conference hall of Faculty of Veterinary Sciences, Assam Agricultural University on Friday by Dr Gopal Krishna, internationally renowned scientist, director cum vice chancellor, ICAR-Central Institute of Fisheries Education, Mumbai.

This facility has been established at Guijan, Tinsukia by ICAR-Central Institute of Fisheries Education (CIFE), Mumbai under the financial scheme for North East Hilly region (NEH-Sub-Plan) in collaboration with Directorate of Extension Education, Assam Agricultural University and JEEVA SURAKSHA, Sivasgar, Assam.

The facility established at this place includes all the basic equipment necessary for preparation of value-added fish products and have a capacity to produce about 200 kg of fish products daily. This facility can be utilized by the locals for processing and preservation of their fish produce in the form of different ready to eat convenience and nutritionally enriched value-added fish products which will help in enhancing their income and improving their social status as well. Dr Ranjita Bania from the local organization, Jeeva Suraksha & coordinating officer informed the press and thanked the special efforts taken by the Principal Scientist and Head of Department of Post harvest Management and processing , Dr BB Nayak, Dr Amjad Balange, Principal Scientist and Avinash Sable, Senior Technical Officer with the support and guidance of Dr Gopal Krishna, Director and Vice Chancellor of ICAR-CIFE, Mumbai.

The programme was organized to highlight the need of value added fish products and inform the common people about the facility which can be used for empowerment of the community especially the women folk of lower strata.

Inaugurating the pilot plant, first of its kind in entire north East on Friday, the chief guest, internationally renowned scientist, Dr Gopal Krishna has emphasised on the need of this facility for quality product development by the rural poor for entrepreneurship development. Value added fish products have very much potentiality in Assam, he added.

Dr BB Nayak, Principal Scientist of ICAR-CIFE has informed that they have taken Northeast on priority basis and choose Assam for the establishment of this plant. Principal Scientist and coordinator of NEH programme from ICAR CIFE have showed some of the activities and facilities developed in the centre at Guijan, Tinsukia. Dr Atul Borgohain, Associate director of extension Education and local guardian of the project informed the house that this kind of initiative will encourage the entrepreneurs to take up such project which ultimately boost economy of the entire state.

Addressing the gathering, invited guest, Managing Director of FISHFED, Dr. Dhrubajyoti Sharma said that today is a golden day for Assam when such kind of big facility has been inaugurated. Of late, the demand and popularity of value added fish products has increased recently. The products imported basically from Myanmar till date were not standard as far as quality is concerned which opens the arena for the local entrepreneurs in this field. Chairing the programme Dr. Bibeka Nand Saikia appealed the house to explore the indigenous technical knowledge and reduce the cost of production while maintaining the quality of product, stated a press release.

Products

(CIFE/2021/9/IF)

Project duration: 2021-2024

Principal Investigator
Dr. K.A. Martin Xavier

Co-Principal Investigators
Dr. Layana P.
Dr. Amjad Balange
Dr. Binaya Bhusan Nayak

Dry fish samples were collected from Gujarat (12 species), Karwar (4 species), Mangalore (8 species) and Kozhikode (2 species) drying yards. Moisture, protein, crude lipids, total ash and salt contents were analysed. The moisture content of cured fish samples ranged from 9.57 - 23.14 %. The highest moisture content observed in the cured fish samples collected from Gujarat and the lowest from Kozhikode samples. Similarly, the crude protein content of cured fish samples are within the range of 51.16- 67.55 % and lipid content ranged from 0.57 - 9.47 %. Total mineral content was within the range of 9.93 - 29.68 %. The salt content of cured fish samples ranged from 3.63 - 27.59 % and the results are significantly different between the stations. Different microplastic extraction methods evaluated for checking the digestion efficiency for microplastic recovery. A literature survey conducted and the available methodologies were assessed. Nitric acid, KOH, NaOH, Enzyme, SDS, Hydrogen peroxide-based protocols were tried with dry fish samples. Cured fish tissue was treated with different chemicals at different temperatures and the residue retained was used for calculating the digestion efficiency (%). Results of this study showed poor performance with Sodium hydroxide (10%), Hydrogen peroxide (30%), Trypsin (5%), and Sodium dodecyl sulfate (10%) at different temperatures to digest the biological materials within 72 hours. Higher digestion efficiency (%) was shown in concentrated nitric acid at 60 °C (98.55%) followed by Hydrogen peroxide (74.73%), Sodium hydroxide (63.85%), Trypsin (57.60%). The lowest digestion efficiency (%) shown by SDS (40.30%). The results showed significant difference between the microplastic digestion methods and digestion efficiency among the reagents used for microplastic separation.

Microplastics were found in all the collected fish samples. Abundance of MPs were found at four different sampling stations across the west coast of India. The average incidence of micro litter across all the stations among the dried fish samples was 89.54 MPs items/g. Among the studied samples, the highest abundance of MPs was observed in dried fish samples of the Gujarat coast and the lowest was recorded in Kerala samples. Sun-dried fishes show fewer MPs than salt-cured fish. Eviscerated fish is highly contaminated with MPs than the whole fish. This may be due to high surface area exposure to salt during the drying process.

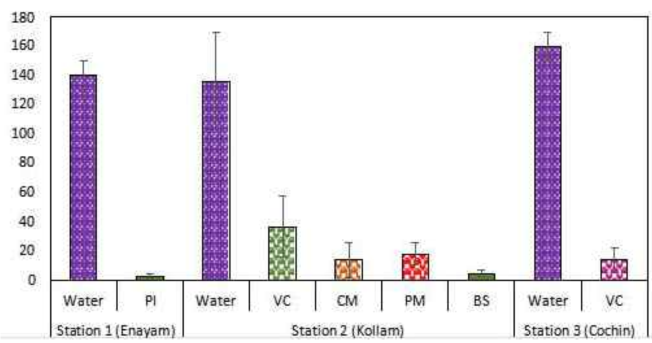
Microplastic Ingestion Exposure in Edible Bivalves and Gastropods from the South-West Coast of India

(CIFE/2019/FRM902/SR)

Abisha C.

Major Guide: Dr. Martin Xavier

Plastic pollution is emerging as one of the most significant global threats to the environment. Nowadays, microplastic pollution is becoming a centre of concern among researchers because of its ubiquitous and persistent nature, negative impacts on the natural environment and associated biota, and potential to cause human health risk. Therefore, the present study was carried out to assess and quantify the incidence of microplastics in edible species of bivalves and gastropods inhabiting along the southwest coast of India. For the investigation, 4 different bivalve species such as *Perna perna* (Linnaeus, 1758) (Brown mussel), *Villorita cyprinoides* Gray, 1825



(Black clam), *Crassostrea madrasensis* Preston, 1916 (Indian backwater oyster), *Paphia malabarica* Dillwyn, 1817 (short neck clam) and 1 gastropod species *Babylonia spirata* (Linnaeus, 1758) (Spiral Babylon), were selected as sentinel species as they are used for human consumption and contribute significantly to molluscan fishery of southwest coast of India. The mean abundance of microplastics, items/g of soft tissue in the studied species, *Perna perna* (3.02 ± 1.29) from Enayam, Tamil Nadu coast and *Villorita cyprinoides* (36.87 ± 21.03), *Crassostrea madrasensis* (14.03 ± 12.01), *Paphia malabarica* (18.31 ± 7.49), *Babylonia spirata* (5.17 ± 2.13) from Kollam and *Villorita cyprinoides* (14.12 ± 8.79) from Cochin, Kerala coast were significantly different from one another. The microplastics of >1000 µm size range that included fibers and transparent color microplastic were dominant in all studied species. The mean abundance of microplastics in water varied between 136.25 ± 33.24 to 160 ±10 items/L. The major polymers, identified in the water samples and molluscan species, were Polypropylene, Polyethylene, and Polyamide. Interestingly, a strong correlation was seen among microplastic abundance and total length, total weight and meat weight. Bivalves showed a negative correlation with size as the number of MPs per g of soft tissue decreased with increasing size of bivalves. In contrast, the gastropod species showed a positive correlation as MPs uptake per gram of soft tissue increased with size. This study also revealed a positive relationship between the number of microplastics and the concentration of heavy metals. Further, studies are needed to clarify the microplastic and heavy metal interaction, human microplastic exposure via bivalve and gastropod consumption and its health effects.

Microplastic Contamination in Cured Fishery Products (CIFE/2019/PHT908/SR)

Rakesh R.

Major Guide: Dr. Martin Xavier

Curing is one of the oldest and cheapest methods of fish preservation. The salt used in the curing process is prepared from the coastal seawater, which is highly contaminated with anthropogenic plastic particles. This study aimed to find out the incidence of microplastics in cured fish samples from different locations of the south west coast of India. Different tissue digestion procedures tried to standardize the best protocol for microplastics extraction. The extracted polymers were characterized based on size, morphology and colour. Polymer confirmation is done with the help of Fourier Transform Infrared Spectroscopy and Micro-Raman spectroscopy techniques. The concentrated nitric acid at 60 °C for 72 hrs. was found to be the best protocol and it showed >98% digestion efficiency. In this study, microplastics were observed in all cured and dry fish samples. The mean incidence of microplastics across all the studied stations was 89.54 MPs items /g of tissue. The highest incidence of MPs observed in cured fishes from Gujarat coast 121.83 MPs items /g of tissue, and there was no significant difference between the incidence of MPs from Karnataka and Kerala. To compare the effect of evisceration both the samples from eviscerated and whole dry fishes were analysed for the abundance of MPs. The highest incidence of MPs observed in eviscerated samples i.e., 135.36 MPs items /g of tissue and the lowest was found in the whole dried fish with 74.88 MPs items /g of tissue. The average number of MPs in salted and dried fish samples was 125.41 and 55.33 MPs items /g of tissue, respectively. Results showed a positive correlation between the salt content and the mean abundance of MPs in cured fish. Microplastics recovered from fish samples, 47.41 % belong to the size range of <100 µm and 23.46% belong to the size range between 100-250 µm. Approximately 93 % of the MPs items identified from the studied fish samples were fragments and fibres. Black coloured MPs plastics are dominant among the different colours. Polypropylene, polyamide, polyethylene, poly tetra fluoro ethane and poly (1-butyl) isotactic polymers identified by Fourier Transform Infrared Spectroscopy. The study concluded that cured fishery products could be one way in which humans are exposed to MPs. The use of contaminated sea salts for curing and drying is the main cause, which influences the microplastics abundance. More studies are required to establish the risks associated with human health through cured fish consumption.

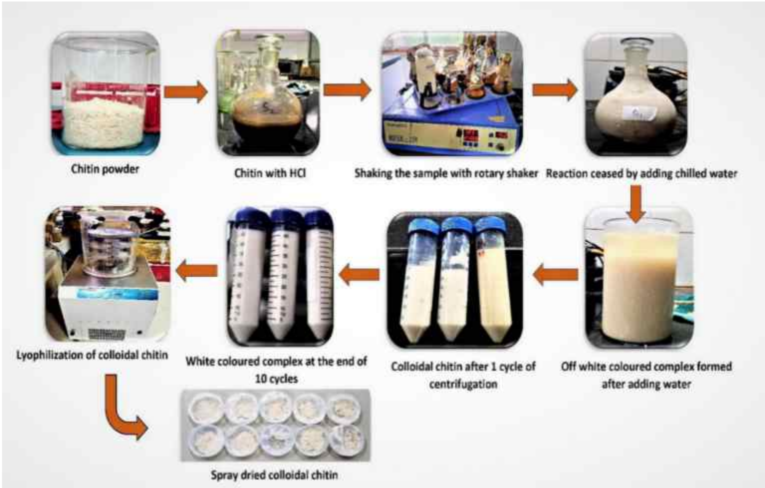
Preparation and characterization of colloidal chitin

(CIFE/2019/PHT906/SR)

Lokesh S.

Major Guide: Dr. Martin Xavier

Colloidal chitin are the short-chained, soluble dietary compounds linked by glycosidic bonds formed due to depolymerisation of chitin in the presence of acids under controlled conditions. The present study was aimed to standardize the chitin: acid ratios and the reaction time required for extracting colloidal chitin. The research was conducted by varying the chitin: acid ratios (1:3, 1:4 and 1:5) with different time intervals (120, 240 and 360 min) under ideal room temperature with concentrated acid strength. A comparative analysis of various biochemical properties was assessed to standardize conditions. The result revealed that acid treatment of 1:3 ratio at 120 min showed a better recovery rate and less nitrogen and mineral content. From the background of this study, the main work of optimization of colloidal chitin extraction was done with acid treatment at 1:3 ratio at different intervals (30, 60, 90, 120 and 150 min). The result suggested that at chitin: acid ratio of 1:3 at 150 min had better functional properties than other - treatments. A further analysis of various biochemical and functional properties revealed that they had a positive effect on the EC, WHC, FBC and solubility. Thus, as the acid treatment increases, recovery rate decreases with increase in soluble fraction, chitin nitrogen, mineral content and functional properties. But pH and redox potential did not show much variation and pH was maintained between 5.0-6.0. In addition, BD showed a negative correlation with TD, Solubility, WBC, EC and FBC. From HR and CI, it was displayed that at 30 min treatment gave good flowability of powder and it decreased with increase in treatment time. The color analysis had an impact on addition of colloidal chitin resulting in high lightness, low yellowness, and high whiteness due to a non-enzymatic reaction called the browning reaction. Further, the microstructure analysis displayed the tightness of the fibril structure starts loosening and pore formation begins to grow bigger in size with acid treatment. Maximum absorbance was seen at 190 nm at 90 mins and a lower peak displayed at 191 nm. The thermal degradation of colloidal chitin samples showed a wide endothermic peak, that centered between 50 and 130 °C with an onset temperature at around 50 °C. Thus, renders high interest for research studies and brings forth implementation in nutraceutical and food industries.



Utilization of Fish Waste as a Resource Strategy of Circular Economy to Develop Novel Fish Skin Leather

(CIFE/2019/FEC905/SR)

Shubham Soni

Major Guide: Dr. Arpita Sharma

It is estimated that 30-35% of the world's annual fish production is wasted or lost at different value chain stages. With growing demands for aquatic foods but perceived negative impacts of fisheries on the ecosystem, it is being highlighted that the sector that currently functions through the linear economic model needs a shift towards the adoption of a circular economy (CE). CE is an economic system aimed at continual use of resources while eliminating wastes. Changing the linear economic model to CE is not easy as it would entail transforming our current production and consumption pattern. This transformation can be brought by adopting one of the strategies of CE, 'using waste as a resource'. In this context, it is noted that fish skins account for 3-10% of the fishes' body and are usually thrown away in the garbage, leading to pollution. Thus, this study was undertaken with the objectives of documenting cases of CE in fisheries and aquaculture, adoption of 'use of waste as a resource' strategy of CE to develop novel fish skin leather from fish skin waste, and assessing the consumer perception of novel fish skin leather. Methodology of desk research and the use of electronic search engines by keyword search and Boolean operators were employed to document cases. A total of 95 cases were documented from African countries like Senegal; Asia like China, India, Indonesia, South Korea; Europe like Denmark, Finland, France, Germany, Greece, Italy, Malta, Portugal, Scotland, Spain, Sweden, and United Kingdom; North American countries like Canada, Mexico, and USA and South American countries like Chile, and Ecuador. Most used CE strategy was 'use waste as a resource' (70%). For the second objective, a novel fish skin leather with discarded skins was developed. The resultant fish skin leathers had satisfactory physical properties with a 14.29 N/mm2 (609.04 Nf) tensile strength, tear strength of 62.43 ± 2N/mm, and elongation at break of 28.78 % while the thickness of 0.71 mm. Consumer perception of novel fish skin leather was done by 145 respondents (5 leather professionals, 5 textile designers, 15 leather craftspersons, 60 leather consumers, and 60 fisheries professionals). Willingness to buy, factors to be considered for evaluating quality, and expected products that can be made from fish skin leather were also identified. Sensory evaluation of fish skin leather based on visual, olfactory, auditory and tactile attributes revealed that all attributes had high to very high acceptance among respondents with highest ratings for tactile attributes. Overall liking, market acceptability, product acceptance, and consumer acceptance had a high or very high acceptance range. Thus, it can be concluded from the study that fish skin waste has the potential of leather development using waste as a resource strategy of circular economy. Circular economy approach is being adopted by many countries. It is a win-win situation and has direct links with sustainable development goals. Governments can use a new incentive model so that the circular economy approach trickles across companies and other stakeholders.

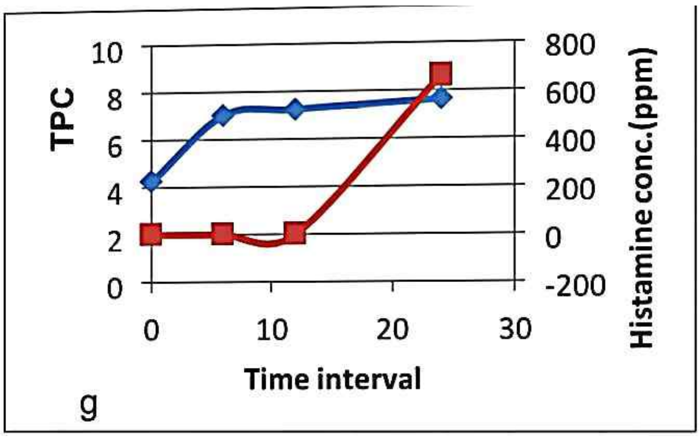
(CIFE/2019/PHT910/SR)

Comparison of Growth and Histamine Production Abilities of Prolific Histamine Formers in Different Culture Media

Vasanthi K.

Major Guide: Dr. B. B. Nayak

Histamine poisoning, otherwise known as scombroid poisoning, occurs in individuals consuming fishes having high levels of histamine. Histamine is formed due to the decarboxylation of free histidine present in the muscle tissue by bacteria like *Morganella morganii, Klebsiella variicola, Providencia rustigianii, Proteus vulgaris, Enterobacter aerogenes*, etc. Several factors such as pH, temperature, presence of other microbes, media, etc., influence the histamine forming ability of the bacteria. Growth media plays a very important role in the enumeration and histamine forming ability of the bacteria. In order to evaluate the growth and histamine forming ability of *Klebsiella*



variicola (KV-M12), *Providencia rustigianii* (PR-G21), *Morganella morganii* (MM-I5) and *Proteus vulgaris* (PV-M20), four fish infusion broths (Tuna Fish Infusion Broth, Non Scombroid Fish Infusion Broth, Freshwater Fish Infusion Broth, Shell Fish Infusion Broth) and one synthetic media (Luria-Bertani Broth) were taken. All the selected strains, when grown in LB broth supplemented with 1% histidine, reached mid log phase in less than 6 hours and had a very long stationary phase even after 24 hours showing the typical characteristic of a prolific histamine former. All the selected strains, when grown in different fish broths with and without histidine, showed less than 2 log increase in growth after 24 hours. As the amount of histamine formed was not within a detectable limit, several passages were performed for the selected strains. Histamine production was observed after the 5th passage in Tuna Fish Infusion Broth (TFIB) and after 6th passage in Shell Fish Infusion Broth (SFIB). Among the screened bacterial strains, *Proteus vulgaris* showed highest histamine production, whereas *Klebsiella variicola* showed the least in TFIB, whereas in SFIB, *Klebsiella variicola* produced highest histamine. Further studies are required to understand the contributions of the fish infusion broths towards the triggered increase of histamine production.

(CIFE/2019/PHT904/SR)

Phylogenetic Evaluation of Quinolone and Colistin Resistant *Escherichia coli.*

Dhanush C. K.

Major Guide: Dr. Sanath Kumar

Escherichia coli in seafood could be derived from diverse anthropogenic sources, due to the contamination of coastal-marine waters. *E.* coli is a human enteric pathogen and certain clonal types are emerging as highly resistant to multiple antibiotics. In the present, study the quinolone susceptibility patterns of 269 Extended Spectrum β-Lactamase (ESBL)-producing *E. coli* isolates from seafood were tested using first, second and third generation quinolones. The isolates were further tested for colistin susceptibility and the genetic factors conferring resistance to quinolones and colistin. The results showed that 73.60% of *E. coli* isolates were resistant to moxifloxacin, 57.99% to ciprofloxacin, 49.07% to nalidixic acid, 17.47% to norfloxacin, 14.49% to levofloxacin and 8.55% to ofloxacin. 150 (55.76%) *E. coli* isolates carried at least one of the three (*qnrS, qnrB, qnrA*) plasmid- mediated quinolone resistance (PMQR) genes tested. The *qnrS* was the most prevalent gene (53.90%), followed by *qnrB* (7.43%), while *qnrA* was not found in any of the isolates tested. The occurrence of mobilized colistin resistance gene (*mcr-2)* was detected in 38 (14.12 %) isolates. Twenty-one of these isolates (55.26%) had a colistin minimum inhibitory concentration (MIC) of 16 µg/ml, while 10 (26.31%) and seven (18.42%) isolates exhibited MICs of 8 µg/ml and 4 µg/ ml, respectively. Based on the Clermont *Escherichia coli* phylo-typing of 150 quinolone resistant isolates, 66 isolates (44%) belonged to the phylogroup B1, followed by 23 (15.33%) isolates to phylogroup A, 23 (15.33%) isolates to phylogroup UN, 18 (12%) to phylogroup D, 13 (8.66%) isolates to phylogroup C, 3 (2%) isolates each to phylogroup B2 and F, and 1 (0.66 %) isolate to phylogroup E. Among 38 *E. coli* isolates carrying colistin resistance gene (*mcr-2*), 27 (71.05%) isolates belonged to the phylogroup B1, followed by 4 (10.52%) isolates to phylogroup A, 2 (5.26%) isolates each to phylogroup D and UN, 1 (2.63 %) isolate each to phylogroups B2, C and E. The results suggest that *E. coli* phylogroups B1 and A harbouring plasmid-mediated quinolone and colistin resistance genes are predominant in seafood.

Physiological and Virulence Characteristics of Seafood-borne *Salmonella enterica*

(CIFE/2019/PHT905/SR)

Fathima Salam

Major Guide: Dr. Manjusha L.

Seafood is often contaminated with human pathogens like *Salmonella enterica*, indicating fecal contamination, as these organisms are not native inhabitants of coastal-marine waters. The present study focused on the physiological and genetic characterization of selected serotypes of *Salmonella* such as *S. Typhimurium, S. Tindenberg* and *S. Tennessee* isolated from seafood. The major objective was to evaluate the *Salmonella* Pathogenicity Islands (SPIs) for the presence of constitutive genes and to look for variations among the serotypes, if any. Eight isolates of *Salmonella enterica* serotypes previously isolated were used in the study. A total of 29 biochemical tests were carried out, comprising of TSI, LIA, urease, malonate, IMVic, carbohydrate utilization and amino acid decarboxylase tests. Genetic characterization with respect to five SPIs was done by PCR screening for target, such as *invA, hilA, iroB, avrA* (SPI-1), *spiC, ttrC* (SPI-2), *marT, mgtC, misL* (SPI-3), *orfL* (SPI-4), *sopB, pipD* (SPI-5) *stn* (toxin), *gogB* and *sodC* (prophage). In addition, the isolates were screened for all invasion-associated genes using newly designed primers for *avrA, invA, ivnB, invC, invE, invF, invG, invH, invI and invJ*. *Salmonella* Typhimurium ATCC 14028 was used the reference strain for all biochemical tests and genetic screening. All the test isolates showed typical *Salmonella* reactions for the biochemical tests such as TSI, LIA, and MR, urease, malonate, indole, VP tests, alanine and methionine decarboxylation tests, histidine and arginine decarboxylation, acid production using glucose, dextrose, mannitol, dulcitol, xylose, galactose, rhamnose, and melibiose, and non-fermentation of lactose, sucrose, adonitol, arabinose, raffinose and salicin. All test isolates were positive for *invA, invB, invC, invE, invF, invG, invH, invI, invJ, hilA, iroB, sopB, spiC, ttrC, marT, mgtC, misL, orfL, pipD* and *stn* genes. Variations were observed in inositol fermentation, citrate utilization and absence of *avrA*, *sodc* and *gogB* among the test isolates. The results of this study suggest that the uniform presence of virulence genes associated with important SPIs in *S. enterica* serovars isolated from seafood. Moreover, the presence of all the genes important for invasion suggests that the environmental isolates of *S. enterica* are typically similar in virulence characteristics to clinical strains. Further in vitro studies using cell lines can elucidate the pathogenicity of seafood-associated non-typhoidal *S. enterica*.

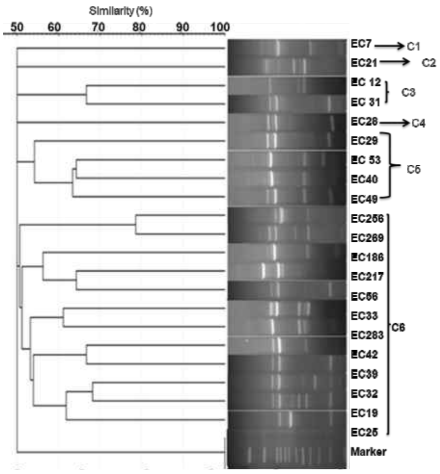
Molecular Mechanisms of Antibiotic Resistance in *Escherichia coli* Associated with Seafood

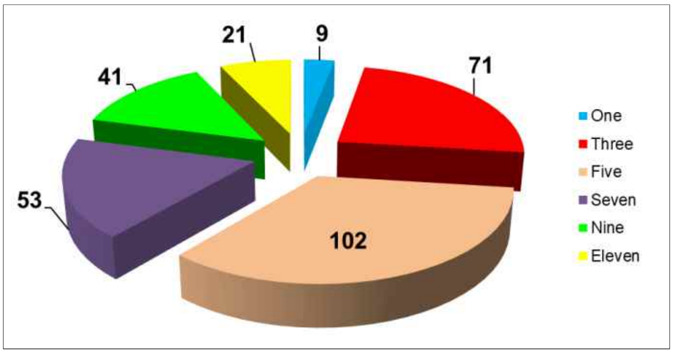
(CIFE/2015/PHT503/SR)

Asem Sanjit Singh

Major Guide: Dr. Sanath Kumar

Escherichia coli, a Gram-negative bacterium of the family *Enterobacteriaceae*, is a commensal bacterium associated with the gastrointestinal tract of warm-blooded animals. However, certain strains or lineages of *E. coli* have also evolved to become pathogens of humans and animals. *E. coli* is commonly used as an indicator of faecal contamination of seafood. In the present study, fresh seafood from landing centres and the retail markets were investigated for the presence of antibiotic resistant *Escherichia coli* and the distribution of important antibiotic resistance genes in them. A total of 50 fresh seafood samples comprising 37 fish and 13 shellfish samples were analyzed for *E. coli* by homogenizaiton of samples and plating on MacConkey agar. From these samples, 475 *E. coli* were isolated, of which 325 were from finfish and 150 were from shellfish. Of these, 340 (71.58%) exhibited extended-spectrum β-lactamase (ESBL)-positive phenotype and a high percentage of isolates were resistant to third generation cephalosporins such as cefotaxime (95%), cefpodoxime (90.88%) and ceftazidime (90.29%). Relatively higher susceptibilities were also recorded against imipenem (74.41%), cefoxitin (66.76%) and meropenem (51.18%). Further, 331(97.35%) isolates were found to have a multiple





antibiotic resistance (MAR) index of ≥0.18. The antibiotic resistance genes *bla*$_{CTX}$, *bla*$_{SHV}$, and *bla*$_{TEM}$ were detected in 62.37%, 23.35% and 2.6% of *E. coli* isolates, respectively. The ESBL-producing isolates also harboured the metallo- β-lactamase encoding genes *bla*$_{OXA}$ (7.06%), *bla*$_{NDM}$ (4.42%) and *bla*$_{VIM}$ (0.88%). In addition, 195 isolates harboured quinolone resistance genes, while the colistin resistance gene *mcr-1* was detected in 19 isolates. Conjugation experiments showed that the *bla*$_{NDM}$ gene could be horizontally transferred to a recipient *E. coli*. The survivability of *bla*$_{NDM}$-harbouring *E. coli* in shrimp (*Metapenaeus dobsonii*) in frozen (-20±2°C) and chilled (iced) storage was studied by artificial inoculation. The *bla*$_{NDM}^{+}$ *E. coli* (EC114) could survive at -20±2°C storage for 60 days with 2.46 log CFU/g reduction in counts. In ice-stored shrimp, the counts of EC114 decreased by <1-1.30 log CFU/g. This study highlights the risk of dissemination of multidrug resistant *E. coli* in seafood consumer communities and the need to improve the hygiene of the coastal water, landing centers and the retail markets.

(CIFE/2014/PHT405/SR)

Molecular Characterization of Seafood-borne Non-typhoidal in *Salmonella enterica*

Parmanand Prabhakar

Major Advisor: Dr. Sanath Kumar

Salmonella enterica is a significant food-borne human pathogen. This study was performed to understand the prevalence of non-typhoidal *Salmonella enterica* (NTS) in seafood in Mumbai and their virulence characteristics. Eighty-two seafood samples comprising of finfish (57) and shellfish (25) from 3 fish landing centres and 7 retail fish markets were analyzed for *Salmonella* by conventional isolation, biochemical identification and PCR (polymerase chain reaction) confirmation. Overall, 20.73% of the seafood samples were positive for the presence of *Salmonella* which included 31.25% of demersal and 29.26% of pelagic finfishes, while none of the shellfish samples was positive for *Salmonella*. The positive samples yielded 94 *Salmonella* isolates which were further screened for 14 virulence genes commonly associated with *Salmonella* Pathogenicity Islands (SPIs). The *invA* gene was found in all (100%) *Salmonella* isolates, while other genes such as *hilA* and *orfL* (97.9% each), *spiC* (95.74%), *marT* (94.68%), *mgtC* (91.5%), *ttrC* (88.3%), *misL* (72.34%), *pipD* (69.14%), *stn* (55.32%), *sodC* (29.78%), *iroB* (27.65%), *gogB* (26.59%) and *sopB* (14.89%) genes showed varying distributions. Five different serotypes were identified in the study of which *S.* Typhimurium was predominant (48.27%), followed by *S.* Tennessee (24.13%), *S.* Kentucky (17.24%), *S.* Weltevreden (6.89%) and *S.* Lindenberg (3.44%). Antibiotic susceptibility patterns of the 94 isolates against 17 antibiotics revealed that 4 (4.2%) isolates were multidrug resistant, 11 (11.7%) isolates were resistant to Cefotaxime followed by 10 (10.63 %) to Piperacilin/tazobactam, 7 (7.45 %) each to Nalidixic acid and Co-trimoxazole, 5 (5.32 %) to Ciprofloxacin, 4 (4.2 %) each to Cefpodoxime and Tetracycline and 2 (2.2 %) to Cefuroxime. None of the isolates were resistant to Ceftazidime, Chloramphenicol, Ertapenem, Meropenem and Aztreonam.

Two isolates belonging to *S*. Kentucky were resistant to 5 antibiotics. The study suggests similar levels of *Salmonella* contamination in fish landing centers and retail markets, but the diverse serotypes and virulence genotypes found suggests multiple sources of contamination. The study emphasizes the need to identify critical points of contamination, improve the hygiene in fish landing centers and markets and promote safe handling methods to prevent *Salmonella* contamination of seafood.

Effect of Alginate Oligosaccharides on Quality Preservation of Fish

(CIFE/2019/PHT901/SR)

Angela Brighty R.J.

Major Advisor: Dr. Layana P.

Alginate oligosaccharides (AOS) were prepared from sodium alginate by oxidative and enzymatic depolymerisation using hydrogen peroxide and alginate lyase respectively. The depolymerization of polysaccharide was confirmed by measuring the presence of unsaturated bonds and reducing terminals formed due to glycosidic bond cleavage and subsequent structural modifications during the process. The structural confirmation of depolymerisation was done by FTIR spectroscopy which clearly shows the breakdown of 1-4 glycosidic bonds at 948cm^{-1} in the AOS obtained. The antioxidant property of AOS was determined by DPPH and ABTS assays. The oxidative and enzymatically depolymerised samples exhibited DPPH inhibition of 48.33% and 62.71% respectively. ABTS radical scavenging activity of AOS prepared by enzymatic process is 36.68% whereas oxidatively obtained AOS did not exhibit any ABTS scavenging activity. To ascertain the cryoprotective role of AOS during freezing of fish, soaking treatments were given to the fish steaks (*Eleutheronema tetradactylum*) before freezing. The steaks were divided into four treatment lots, namely, T1 (water), T2 (Sodium tripolyphosphate), T3 (AOS obtained by oxidative process) and T4 (AOS obtained by enzymatic process). The changes in quality parameters such as proximate composition, pH, texture, drip loss, cook loss, expressible moisture content, total calcium ATPase activity, myofibrillar protein (MFP) extractability and its solubility, protein profiling by SDS-PAGE, fatty acid profiling and sensory evaluation were carried out. Drip loss, cook loss and expressible moisture content of AOS treated fish steaks were found to be significantly low compared to other treatments. Among the AOS treated steaks, T3 exhibited better water holding capacity, Calcium ATPase activity and MFP extractability and solubility than T4, which indicate the retention of a better form of MFP in T3. SDS page pattern of the MFP extracted also indicates that AOS has good effect on protecting protein structure during freezing. AOS treated steaks scored high in sensory evaluation due to its texture and taste comparable to that of fresh fish. This work demonstrated that AOS oligosaccharides with good antioxidant capacity can be prepared using hydrogen peroxide and alginate lyase enzyme. Soaking treatments given with oxidatively obtained AOS was found better at preventing the quality loss of fish steaks during freezing than other treatments.

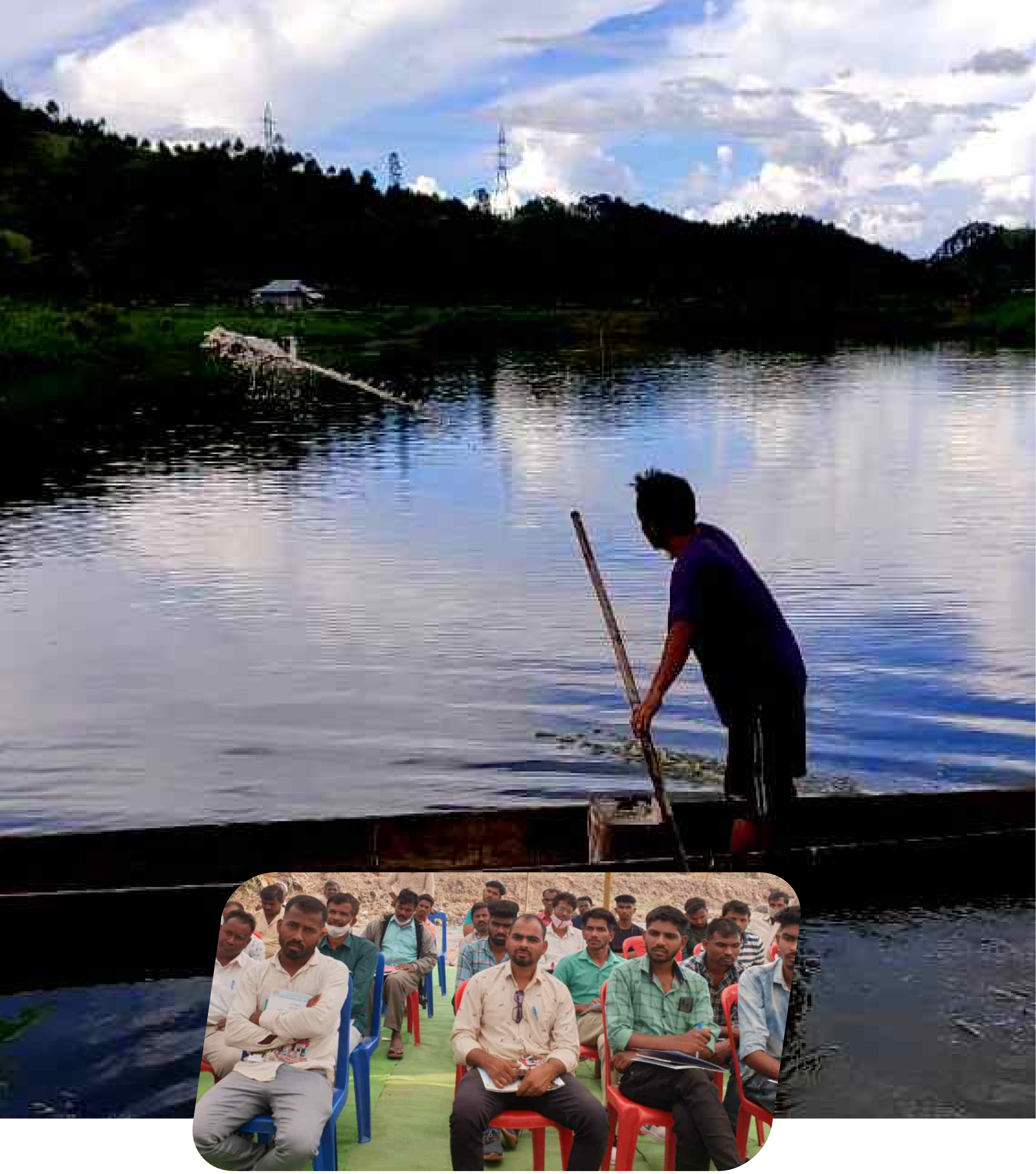
Use of microbes in different stages for chitin extraction

(CIFE/2019/PHT907/SR)

Nikesh N. Hajare

Major Advisor: Dr. B. B. Nayak

Next to cellulose, chitin is the most abundant biopolymer on earth and can be extracted from three sources, namely arthropods, mollusks and fungi. Crustacean shells are the main source of chitin extraction. Conventionally chitin extraction process employ harsh acid and alkali which harm its physico-chemical property and environment. In this study different biological treatment for chitin extraction from shrimp shells was investigated. Archaeal and bacterial combination were used for deproteinization and demineralization of shrimp shell. The result obtained were also compared with conventional chemical method which consist of first mineral removal and then protein removal sequence. Multiple treatments were applied using protease producer *Halobacterium salinarium*, lactic acid producer *Lactococcus lactis* and organic lactic acid. Different treatment, T1, T2 and T3 were performed with multiple stages for chitin extraction. Cooked shrimp shell was treated for 22 days. *Lactococcus lactis* removed minerals efficiently, while *Halobacterium salinarium* performed better in deproteinization process. Total nitrogen, protein and ash content were reduced gradually, while chitin content increased proportionally during the fermentation process. Among three treatments, T3 resulted lowest protein content (5.23%) with highest deproteinization of 91.48%, highest demineralization of 98.72% found in T2. The highest process yield (28.05%) was obtained in T2 with final chitin content 64.79%. The final chitin products are equally good, showing whiteness index of 93% to 94% indicating that all of them are similar in color. As compared to chemical method, biological methods may need time but results better yield, odor free deproteinization, environmental friendly application and avoidance of acid and alkali makes it more acceptable.



Extension, Gender and Livelihood

Percolation Tank Based Aquaculture for Tribals in Nashik District, Maharashtra by Convergence of Corporate Social Responsibility Model

(CIFE/2019/13/IF)

Project duration: 2019-2022

Principal Investigator
Dr. Arpita Sharma

Co-Principal Investigators
Dr. K.K. Krishnani
Dr. K. Pani Prasad
Dr. Ajit K. Verma

Freshwater aquaculture has vast potential for expansion in India as large numbers of water bodies are still underutilized and untapped. Percolation tanks being promoted by Gos, NGOs and Corporates as effective solutions for groundwater recharge in arid zones and rainwater harvesting is one such resource. Percolation tank is an artificially created surface water body in highly permeable land areas to collect run off and recharge the groundwater storage. They are found in states like Tamil Nadu, Maharashtra, Andhra Pradesh, Karnataka and Gujarat. Though in large numbers, utilization of percolation tanks for aquaculture has not become popular. A research project was undertaken with the objective of initiating percolation tank based aquaculture for livelihood generation for tribal youth with convergence of Corporate Social Responsibility (CSR).

A percolation tank situated in Laxmanpada hamlet, Pahine Village (Gram Panchayat), Taluka Trambakeshwar, District Nashik was purposely selected. This percolation tank was selected because it is located in a tribal village with about 200 households and a multinational company BOSCH which is situated in Nashik is involved in CSR in this area. The tank has water availability for 10 months and thus has aquaculture potential with convergence of CIFE, CSR and tribal youth community. Information was collected about Lakshmanpada percolation tank, CSR activities undertaken by BOSCH, village community and water availability in the tank. Water quality and primary productivity of the tank was analyzed. Formation of youth groups, training needs assessment (TNA) of youth groups, conduct of training programmes and initiation of aquaculture were done followed by analysis of effectiveness of training programmes. Challenges in implementing the study including constraints faced due to the Covid-19 pandemic were recorded and advisories were accordingly provided to reduce the constraints faced.

- Innovative extension Model of Convergence of Corporate Social Responsibility in Aquaculture (CCSRA) developed
- Aquaculture could be initiated in an untapped percolation tank
- This has resulted in an additional source of livelihood, food and nutrition for tribal youth in Nashik, Maharashtra

Based on this information and research a Model of Convergence of CSR in aquaculture was designed. It was due to convergence of CIFE (Government Organization)-Corporate Social Responsibility (CSR), BOSCH (Private)-Tribal youth (Community) that aquaculture could be initiated in an untapped water body i.e., percolation tank which has resulted in an additional source of livelihood, food and nutrition for tribal youth in Nashik, Maharashtra. Based on this research project, the Innovative Extension Model of Convergence of Corporate Social Responsibility in Aquaculture (CCSRA) has been developed. As an invited speaker, this CCSRA model was presented in the National Webinar on Sensitizing Extension Professionals for Successful Livestock Farming Models to develop Atma Nirbhar Kisan, organized by KVK, ICAR-IVRI, Izatnagar In association with ICAR-ATARI, Zone-III, Kanpur & Zone-VIII, Pune Sponsored by NABARD 19-20 February, 2021.

Skill and Knowledge Development for Fish Health Management in Freshwater Fish Culture System from Selected Tribal Region of Maharashtra

(CIFE/2021/7/IF)

Project duration: 2021-2024

Principal Investigator
Dr. Gayatri Tripathi

Co-Principal Investigators
Dr. Megha Bedekar
Dr. A. K. Balange
Dr. Vidya Shree Bharti
Dr. Arun Sharma
Dr. Kiran Rasal
Dr. Manish Jayant

The Project launch workshop was organized in November 2021 at Nav Jeevan Tribal Fisherman Co-Operative Society, Khairwe Village in Navapur Taluk, Nandurbar district that was attended by 100 fish farmers, MLA, Asst. Commissioner of Fisheries and other DoF staff. Two training and demonstration programmes were conducted with 50 participants on 'Disease management and sustainable aquaculture practices with good post-harvest techniques' and on 'Good Aquaculture Practices with special reference to the environment'. Survey was done and information about tribal farmers involved in fish farming, pond size, water level, species stocked, feed, income earned, etc. have been collected. A WhatsApp group of 40 tribal fish farmers in Nandurbar has been created to provide timely help and assistance. Teaching materials in Hindi and Marathi were provided to tribal fish farmers.

Fisheries and KVKs: Extension Strategies for Strengthening Development and Linkages

(CIFE/2021/6/IF)

Project duration:2021-2024

Principal Investigator
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Co-Principal Investigators
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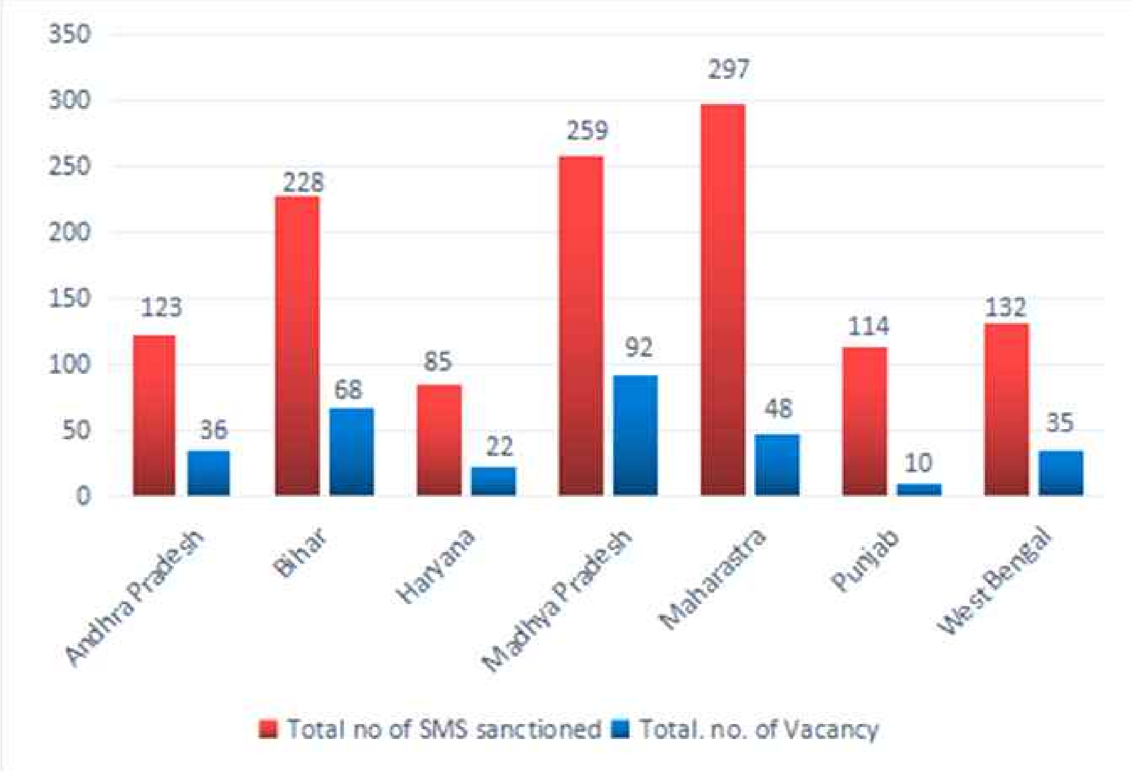
Dr. Munil Kumar S
Dr. Hari Krishna
Dr. Shyamala K.

Rationale

KVKs are the district Farm Science Centres designed as frontline extension agencies and a bridge between the research system (ICAR/SAUs), and the extension/development system (DoF/DoA) with farmers/fishers as primary clientele. KVKs have expertise in 3 core areas: technology adaptation, capacity development, and as a knowledge and resource center. Studies have indicated returns on investments in KVKs have brought rich development dividends in agriculture by increased production / productivity as well as household income by >2 times. But, there is no major evidence with respect to KVKs contribution to fisheries development, except few success stories. On the other hand, vast untapped potential and underutilised resources exist for fisheries development in many districts across the country. While the State fisheries departments are the primary vehicles of fisheries development at the district level, the scope of KVKs to fast-track fisheries development has not been given much attention so far.

CIFE's 26th Extension Council (February, 2021) meeting deliberated this issue and DDG (Extension), ICAR underscored the need for innovative pathways to strengthen the linkages between ICAR-FRIs/SAU-CoFs and the KVKs/ATARIs. Thus, this Project has been taken up with objectives to a) assess the KVKs status of and requirements for technical information & capacity building in relation to fisheries development; b) assess the



status of and the potential for fisheries development in each district of identified States; and c) design extension strategies, conduct capacity building programs & strengthen linkages with KVKs for furthering fisheries development.

Preliminary Findings

A review and analysis of secondary data done for the study area (Andhra Pradesh, Bihar, Haryana, Punjab, Maharashtra, Madhya Pradesh and West Bengal) showed presence of 231 KVKs across 219 districts with 929 Subject Matter Specialists (SMS) working as on November 2021. Though only 30 (13%) KVKs have fisheries SMS, nearly 68% of them (157) have at least one SMS belonging to fisheries / animal sciences / agricultural extension, indicating the scope and target for potential interventions. Only a handful of KVKs (15%) have reported to have conducted fisheries related training during 2018-2020. Quick estimates indicated availability of an average 28,816 ha of water resources / district in the 219 Project districts. The reported fish production / yield (1,795 kg/ha) in these districts was, however, found to be far less than the potential yield. This establishes the scope for KVKs to play catalystic role. The study will generate and analyse more granular data to critically assess KVKs' fisheries activities and their needs in coming months for designing evidence based interventions.

Enhancing fish productivity through farmer participatory research in Selected Districts of Manipur (Chandel) and Madhya Pradesh (Barwani)

(CIFE/2020/9/IF)

Project duration: 2020-2023

Principal Investigator
Dr. S. Munilkumar

Co-Principal Investigators
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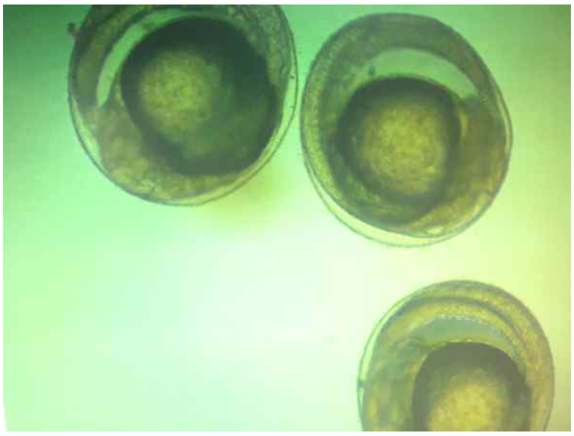
Dr. Ashutosh D Deo
Dr. Dhalong Reang
Dr. D. K. Singh
Dr. Shrinivas Jahageerdar

Chandel district (Manipur) and Barwani district (Madhya Pradesh) are two of the 117 Aspirational districts designated by NITI Aayog for improving Human Development. The fish farmers of these districts are resource poor and highly unskilled. The project is an attempt to understand the local environment and adapt carp culture accordingly to demonstrate the role of aquaculture in raising the living standards of people in these backward areas. Accordingly, 15 farmers Kaziphung, Chandel, Manipur were selected after conducting a survey while 6 farmers have been identified from 6 tehsils of Barwani District, MP in collaboration with the respective Fisheries Departments of these two states. Preliminary data on soil and water quality have been obtained from Kaziphung, Chandel, Manipur.

The selected farm size ranged from 0.4-1.0 ha with an average size of 0.5 ha. The age of farmers ranged from 25-65 years with most of them having completed 8th standard. Rohu, mrigal, grass carp, common carp, silver carp and tilapia are common species cultured. Culture period ranged from 6-12 months with an average of 7 months. April-June is the stocking period while multi-stocking is done in March and September. Use of lime was limited to 100 kg/ha. None used fertilizer as locally available grasses are used as feed at the rate of 40kg/day for a 0.5 ha pond. Only one farmer used formulated commercial feed producing around 5000 kg from his 1.25 ha pond. The overall production was reported to be in the range of 320-1040 Kg/ha. Water pH ranged from 6.42-6.75 while soil pH was 6.34. Dissolved Oxygen (mg/l) ranged between 4.0-6.0 when measured with test kits. Alkalinity was around 50 mg/l and phosphate content was 0.2 mg/l while nitrate was 7.00 mg/l.

Stocking density in 0.5 ha ponds consisted of grass carp 350-2000, rohu 400-2000, common carp 1000-3000, tilapia 600-1200, and silver carp 150. At Kaziphung, stocking ratio and size of seed have been modified and integrated with common carp, rohu, grass, silver carp, and tilapia. On an average, the farmers have invested Rs 60000-90000. A 3 day on-farm skill development training programme in collaboration with Fisheries Department, Govt of Manipur was conducted during September 2021 covering practical sessions on farm-made feeds with locally available leaves, fish health management, water quality testing, plankton estimation, etc. in the farmers ponds. A field trip to the successful fish farms in Imphal district was also organised to expose the farmers to modern fish farming methods. In Barwani district, farmers profile data have been collected and initial identification of farmers completed.



Mr. Keipha Akham Maring, a participating farmer form Chandel, Manipur won a Consolation Prize in Annual Fish Crop Competition (Manipur) with a production of 1797 kg form his 0.5 ha pond (3594 kg/ha)

Fish Farmers Livelihood and Fisheries Extension in Sikkim

(CIFE/2019/FEX902/SR)

Deepa Chettri

Major Advisor: Dr. S. N. Ojha

Sikkim has potential for capture and culture fisheries due to the abundance of coldwater resources . Species that are being cultured are rainbow trout (*Oncorhynchus mykiss*) and exotic carps. A study was conducted to assess the livelihood status of fish farmers in Sikkim, to analyze and suggest measures to strengthen the fisheries extension service in Sikkim, and to analyze constraints. A total of 120 fish farmers were selected from two districts of Sikkim (West and South Sikkim), and data were collected using a structured interview schedule. The study found that the majority of the respondents were male (94.16%). The majority of the fish farmers were between the age group of 40-50 years, and most of them belonged to Hindu religion. Most of the farmers had a high school level of education. The average annual family income of fish farmers was Rs. 2,18,618, and the average income from fish farming was Rs.1,60,000, and the average years of experience in fish farming were 25 years. In the state, 24.16 % of the farmers had debt, and the primary purpose of debt was to meet the family expenses. Livelihood resilience of fish farmers was conducted based on five capitals of sustainable livelihood.

It was found that the livelihood capitals of the fish farmers were moderate, where Physical Capital was weakest with the index value of 0.34 for West Sikkim and 0.37 for South Sikkim. Social Capital had an index value of 0.53 for West Sikkim and 0.49 for South Sikkim, which may have a positive impact on the livelihoods of fish farmers. Out of 120 farmers, 68.5% had attended training programmes, and the majority of the respondents (44.16%) had attended the training on breeding and culture practices. In Sikkim, 64.16% of farmers had not attended Fisheries Fields Tours organized by the Department of Fisheries (DoF). Inputs provided by the DoF included fish feed, fish seed and gears. In the state, 40% of the respondents were members of the cooperative society, and 47% of the farmers responded that DoF staff were their primary source of information. The study revealed that the extension support provided by the DoF was relatively weak as there was no inputs and marketing support or organizing fisheries field tours to farmers. Moreover, the DoF staff gave preference to progressive farmers only. Significant constraints faced by the fish farmers were the non-availability of quality feed, disease outbreaks, non-availability of feed mills and the high feed price. Therefore, the Fisheries Infrastructure Development Programme, and FPO/C can be promoted under Pradhan Mantri Matsya Sampada Yojana (PMMSY).

Assessing the Impact of ICAR-CIFE's Skill Development Programmes

(CIFE/2020/8/IF)

Project duration: 2020-2023

Principal Investigator
Dr. Shivaji Argade

Co-Principal Investigators
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The methodological tolos for data collection and analysis such as Training Impact Assessment Proforma, Success Story Format, Post-training Feedback Proforma, Training Effectiveness Index, Job Performance Index, Need Assessment format for fishers/fish farmers, etc were developed. An awareness-cum-exhibition programme on "Aquaculture as a Potential Livelihood Option for Tribal Communities" was conducted under the Tribal-sub-Plan component as part of the Project and the methodological tools were validated with the trainees responses. The programme was organized through online as well as offline mode and was attended by 119 tribal farmers (Male-116, Female-3) from 25 villages of Junnar block of Pune district. The feedback forms filled by 96 participants were analyzed. About 54.20% of trainees were below 35 years, and nearly half (45.90%) of them were graduates or post graduates. Only 17.70% trainees reported having a farm pond, though 81.30% wished to start fish farming after the program on aquaculture for the first time.

The major needs perceived by the trainees were a) provision of fish seed, feed and fish harvesting nets to start fish farming (70.80%); b) providing financial assistance for farm pond construction (62.50%) and c) establishment of fish hatcheries in nearby localities (39.60%). The suggestions to improve training effectiveness given by trainees were a) inclusion of practical demonstrations and field visits to successful fish farms (71.90%); b) organizing regular follow-up and need specific training to ensure wider adoption (61.50%); c) sharing of experiences by successful fish farmers and aqua preneurs during training (56.30%); d) increasing of training duration to 3-5 days (41.70%), and e) organizing training on effective fish marketing and value addition (24%). The majority of trainees have rated the program relevance and applicability as excellent (50%) or very good (39.60%). Secondary and primary data for CIFE's one year Post Graduate Diploma in Inland Fisheries & Aquaculture Management, Skill Development Program (SDP) on aquaculture for Telangana and Andhra Pradesh farmers, and online training programs were collected using the validated instruments and compiled for further analysis during the year.

Training Need Assessment of Shrimp Farmers and Extension Personnel in Maharashtra

(CIFE/2015/FEX504/SR)

Mr. Sandesh V. Patil

Major Advisor: Dr. Arpita Sharma

Shrimp aquaculture is one of the fastest growing forms of aquaculture and India ranks second globally. Among the states Andhra Pradesh ranks first and Maharashtra ranks sixth. Maharashtra has 10,400 ha as suitable for brackishwater aquaculture but only 1291 ha (12%) is under shrimp farming. This study was conducted with the objectives of studying the profile, assessing the training needs and analyzing the constraints faced by shrimp farmers and extension personnel. Out of 165 operational shrimp farms in Maharashtra, 151 shrimp farmers (91.51%) from all coastal districts were studied. Out of 70 extension personnel at DoF, Maharashtra information was collected from 78.57% i.e., 55. Interview schedule and Likert scales for which reliability was tested, and the Borich Need Assessment Model which prioritizes training needs by using Mean Weighted Discrepancy Score (MWDS) based on perceived level of importance and competency were used. It was found that all shrimp farmers were male, belonged to the middle age group with farming experience up to five years and cultured *Litopenaeus vannamei.* They had owned/leased ponds with an area of 2 to 5 ha.All shrimp farmers were educated up to higher secondary level and had representation of fisheries graduates.

Average annual net income was reported to be Rs.6,60,000/crop/ha and cultured 2 crops/year with stocking density of 16-30 nos./m2. Main source of information for farming was aqua company technicians followed by internet/social media. Extension personnel were post graduates (83.64%) with Master's Degree in Fisheries Science or Zoology. Around 47.27% of extension personnel had service experience up to ten years. Majority of extension personnel (58.18%) had not attended any formal training in scientific shrimp farming and extension management (72.73%). Internet/social media was the main source of information for the majority of extension personnel (74%). About half of them had only occasional contact with shrimp farmers and 58.18% used mobile phones as preferred mode for contacting farmers. TNA revealed that many training areas scored high on importance but low on competency. Mean score of importance for 13 training needs and 8 for competencies were significantly different between districts. The top three prioritized training needs were for shrimp diseases and management (MWDS=11.26), nursery management (MWDS=8.23), and feeding management (MWDS=6.76. For extension personnel, it was shrimp disease and its management (MWDS=10.28), shrimp farming with biofloc technology (MWDS=9.85), and biosecurity in shrimp farming (MWDS=9.65).

Even though production related constraints ranked higher for shrimp farmers followed by extension related constraints, there was no statistically significant difference between them ($p = 0.192$). No statistically significant difference was found among the districts also. Kruskal-Wallis test results showed that there is no significant difference ($p>0.05$) for the different constraints faced by shrimp farmers. In case of extension personnel, extension related constraints were higher followed by administrative and financial constraints. Awareness about any fisheries related mobile apps was missing and not much interest was shown towards them. It is suggested to develop Result Demonstration Farmers (RDF) for farmer to farmer extension and also suggested to organize Virtual Shrimp Farmer School (VSFS) at each stage of shrimp farming. Forming a scientist shrimp farmers forum in every coastal district, setting up Aqua One Centres (AOCs), creation of a unit for extension services in DoF, and developing training modules that relies on experiential learning are recommended.

(CIFE/2019/FEX903/SR)

Gender Dynamics in Marine Fisheries Based Livelihood of Tamil Nadu

Ganeshkumar K.

Major Advisor: Dr. Shivaji Argade

Women play key roles in harvest and post-harvest activities in marine fisheries. But their participation and contribution to the marine fisheries sector is being made visible only during recent years as gender disaggregated data along the fisheries value chain are rather limited. The present study was undertaken in Ramanathapuram district of Tamil Nadu with a sample of 40 fishermen and 40 fisherwomen to assess gender dimensions of marine fisheries based livelihood. The study reported men dominance in terms of family headship, house ownership, boat ownership and decision making. The gender dimensions analysis revealed that there was significant differences between fishermen and women status in terms of social participation (p=0.017), drudgery (p=<0.001), decision making (p=<0.001), participation in fishing activities (p=0.024) and gender empowerment (p=0.001). Fisher women worked 3.5 hours more than fishermen by combining their reproductive and productive work hours. Majority of women preferred fishing, seaweed farming and value addition as their livelihood options but men mostly preferred fishing and cage culture as their livelihood options.

The major needs perceived by women fishers were training on seaweed farming, requirements of fishing nets and information on fisheries schemes and programmes, while men wanted training on new fishing techniques, well equipped boats & fishing nets, and information on schemes and subsidies for fishers. The major constraints faced by fisher women were physical illness due to burden of work and inadequate sanitation and marketing facilities. The major constraint faced by fishermen was poor market facilities. The study identified the major gender issues as poor education and capability, men's dominance in ownership of resources and assets, limited use of information sources, limited access to fisheries resources and services, less participation in decision making, overburden of works, high drudgery, poor marketing and sanitation facilities, limited extension participation, and poor technological adoption. The strategies suggested for gender mainstreaming in marine fisheries based livelihood were gender specific skill development, gender sensitive time, place and personnel for organizing extension activities, promotion of joint ownership of resources and assets, develop women friendly business models, gender sensitization, gender equitable access to resources and services and promotion of gender friendly technology interventions.

(CIFE/2019/FEX906/SR)

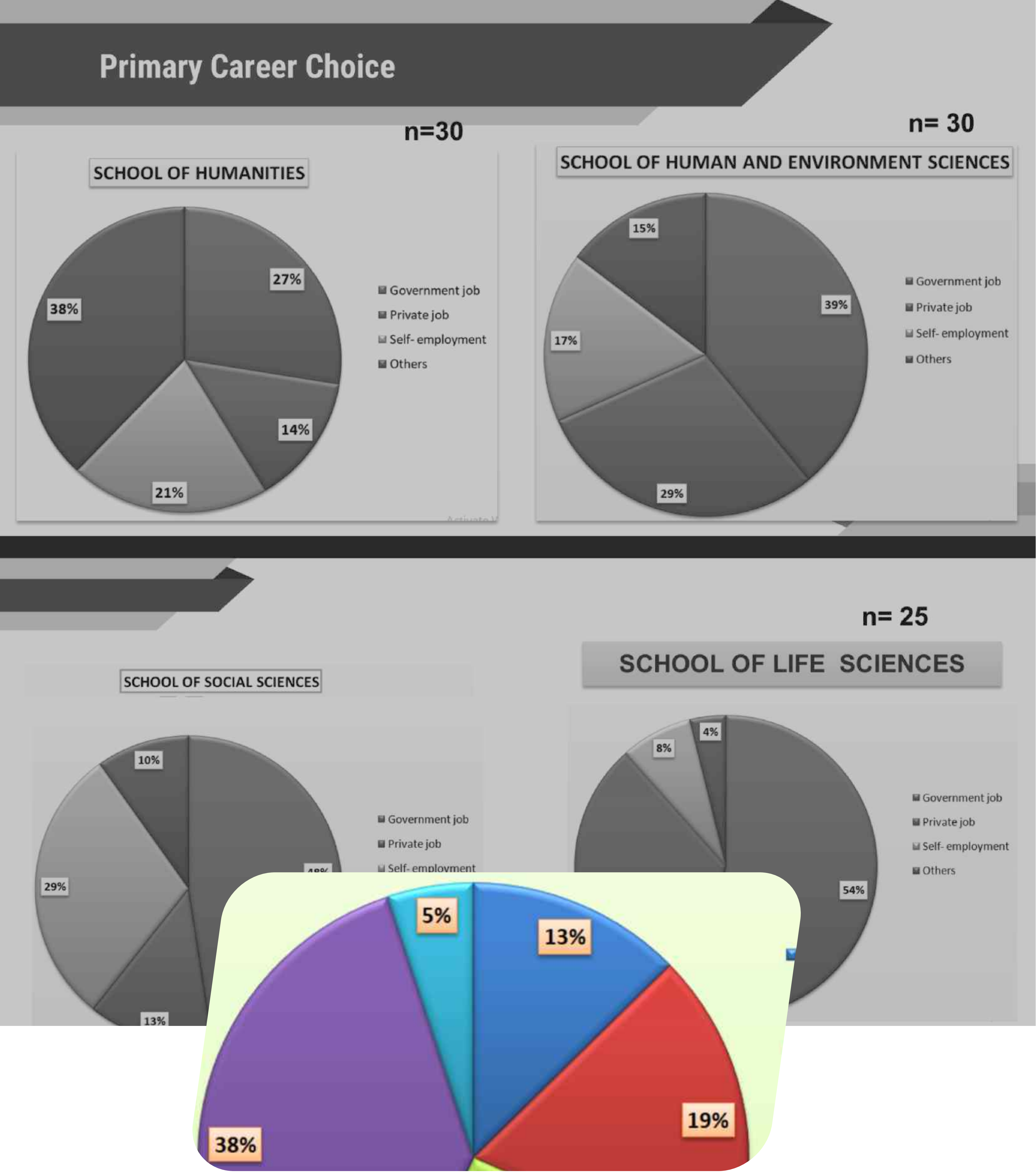
Gender Dynamics in Culture Fisheries Based Livelihoods of Tripura

Sourav Debnath

Major Advisor: Dr. Shivaji Argade

Globally, women play key roles in harvest and post-harvest activities of fisheries and aquaculture. But their participation and contribution to the culture fisheries sector remain invisible due to a lack of gender disaggregated data. The present study was undertaken in Gomati district of Tripura with a sample of 60 men and 60 women fish farmers to assess gender dimensions in culture fisheries based livelihoods. The study reported men's dominance in family headship, house ownership, land ownership and decision making. There was significant difference between men fish farmers and women fish farmers status in terms of social participation, extent of using information sources, gender work hours, drudgery, technology adoption, gender empowerment, access to resources and services, participation, decision making and capability demonstrating the existence of strong gender dynamics. The major needs perceived by women fish farmers were credit/loan, information on application dosages of liming, fertilization, manuring, etc. and training on fish pond management.

The major needs perceived by men fish farmers were information on government schemes and subsidies for fish farming, training on new fish farming techniques and need for high quality fish seed. The major production constraints perceived by women farmers were lack of credit /loan facilities and high seed/feed cost whereas stable marketing price, poor information access, disease issues and poor transportation facilities were the major production constraints perceived by men fish farmers. The gender issues identified were gender gap in fish production and income, men's dominance in ownership of resources and assets, poor skills and capability, less extension participation and use of information sources, limited access to fish production resources and services, less participation in decision making, overburden of works, drudgery and poor technological adoption. The strategies suggested for gender mainstreaming were gender specific skill and capability development, provision of gender sensitive extension system and services, promoting joint ownership of resources and assets, developing gender-friendly business models, gender equitable access to resources and services, and designing gender friendly technological interventions.



Economics, Institutions and Policy

Assessing Economic Feasibility of Farm Ponds for Aquaculture in Maharashtra

(CIFE/2021/5/IF)

Project duration: 2021- 2024

Principal Investigator
Dr. Ankush L. Kamble

Co-Principal Investigators
Dr. Neha Wajahat Qureshi
Dr. Ananthan P. S.
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Dr. K. K. Krishnani

Farm ponds with plastic lining are privately owned ponds that are dug out in the fields and are filled using surface runoff or groundwater through water pumps. The various schemes of the government provide subsidies for construction and plastic lining of farm ponds. As a result, nearly 3.7 lakhs farm ponds have been built under the *Magel Tyala Shet-Tale* (farm pond on demand) and other schemes in Maharashtra since 2011-12. Primarily, farm ponds are meant to store water for irrigation of the agricultural crops, livestock rearing and domestic consumption in times of water scarcity. However, they offer a huge potential to rear fish and other aquatic organisms providing for diversification of farm enterprises, reduction of risk, provide fish that's a good source of protein, help supplement/double farmers income, and achieve the goal of 'more crop per drop' . Except for few success stories here and there, farm ponds have not been tapped for aquaculture yet in Maharashtra.

Therefore, exploring the feasibility of farm pond water resources for fish farming and examining its various dimensions is the core objective of this research project. The information generated from this project will be useful in promoting largely untapped private / farmers's farm pond water resources that can increase the present inland fish production from Maharashtra by 30-35% in next 3 years. Region-wise and district-wise secondary data on number of farm ponds, expenditure and subsidy distribution to the farm ponds in Maharashtra. Based on literature review and preliminary field visits, data collection tools and appropriate methodology for data analysis have been prepared for the collection of primary data from the farm pond owning farmers, KVK professionals, agriculture and fisheries department staff, input output dealers, etc.

Accounting and Valuation of Professional Human Capital in Indian Fisheries Higher Education

(CIFE/2021/4/IF)

Project duration: 2021- 2024

Principal Investigator
Dr. Neha Wajahat Qureshi

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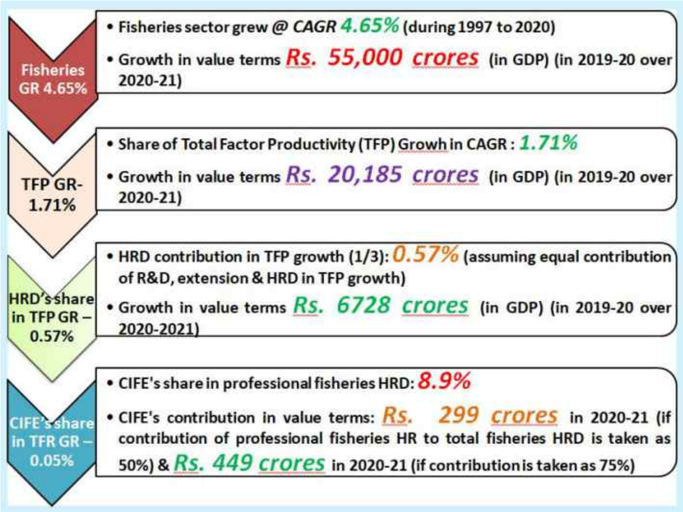
Mr. Dasari Bhoomaiah

Human capital alters the productive capacity of the economy by changing the size or productivity of the workforce. The present study proposes to quantify the investment (expenditure) being made by Fisheries Universities / Colleges in India for generating human capital and their subsequent benefits (returns) in the form of economic value to the fisheries sector. A baseline work on HRA (1995-2015) of ICAR-CIFE, Mumbai was done by Sahoo et al. in 2018. This study updated the data (2016-20) and compared it with earlier period for ICAR-CIFE. It also studied the investments and returns for the state fisheries college namely the Faculty of Fishery Sciences (F.F.Sc.), Kolkata. Besides descriptive statistics, **Modified Flamholtz's Human cost accounting method** was used to examine the investments made and costs incurred for generation of professional fisheries human capital in India. **Lev and Schwartz model and the Divisia Index method (TFP)** were used to evaluate the professional fisheries human capital and determine their contribution to the development of fisheries sector.

In CIFE, 424 MFSc students, 217 (51%) boys and 207 (49%) girls, enrolled between 2016 and 2020. Of them, as high as 92% have successfully completed. In Ph.D. 205 students got admitted, 126 (62%) boys and 79 (38%) girls, and 82% (169 nos.) of whom are still continuing. In the case of F.F.Sc., more than 800 passed out during 2010 to 2020 with near 100% completion rate for BFSc, 87% in MFSc and 79% in PhD. The net investment / expenditure made by CIFE on each master's student and doctoral student were **Rs. 8,15,207 and Rs. 20,31,466 respectively**, while the figures for FFSc's 4 year BFSc student, MFSc and PhD scholars were Rs.



48,34,097, Rs. 8,12,722 and Rs. 17,13,136 respectively. CIFE students found placements in State departments of fisheries (50%), SAUs (23%) during last 5 years while maximum students got placed in ICAR as scientists (32%) during 1995-2017. In case of F.F.Sc., 58% of students (2010-2020) got jobs at State DoF and 11% in SAU. Though few takers, entrepreneurship was found to have the highest net worth i.e.,Rs. 6,60,106 followed by ICAR-ARS (Rs. 5,23,785) indicating greater scope for entrepreneurship in near future.

Contribution of CIFE to the nation was found to be 4.7 billion which is almost **6 times the investment made** (791.8 million) while it was 5.2 times for the period 2016-17. In the case of F.F.Sc., the investment and returns were Rs. 2.4 billion and Rs. 4.8 billion. Total Factor Productivity (TFP) model revealed that ICAR-CIFE contributed **Rs. 299 crores during 2020-21** assuming 50% of the jobs in fisheries sector were occupied by professional graduates and would amount to Rs. 449 crores (if it was assumed 75%). Similarly, F.F.Sc.'s contribution was **Rs. 161 crores** and Rs. 242 crores during 2020-21 (if it was assumed 50% and 75% respectively). Greater attention to entrepreneurship development has emerged as one of the focal areas of intervention in fisheries higher education to ensure that public investment into the fisheries HRD has a **substantial multiplier** effect on the national output of the fisheries sector.

Dynamics of seafood export, trend and competitiveness of Maharashtra

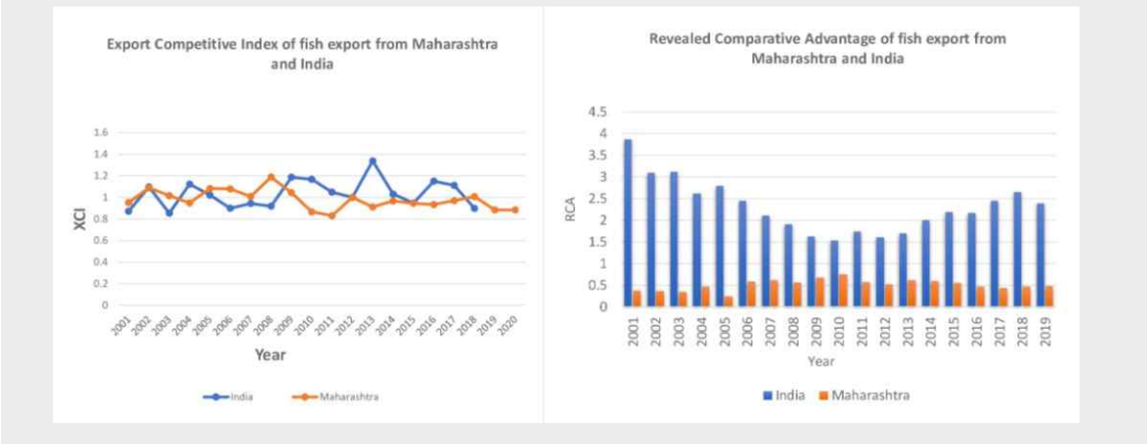
(CIFE/2019/FEC901/SR)

Dhiraj Devkate

Major Advisor: Dr. Rama Sharma

Fisheries export sector is lucrative and a multibillion dollar industry contributing significantly to the national GDP. Since the beginning of 2020, COVID-19 pandemic has severely disrupted the international trade and global supply chain. Maharashtra is the one of the leading fish exporting states in the country and contributes around 10% to export both in quantity and value terms. Current study was carried out with the objectives to analyze the fish export status, composition, trend, growth, instability, structural changes and the effect of COVID-19 in

Seafood export trend and competitiveness of Maharashtra



Maharashtra. Secondary data for the period 2000-2020 was collected from MPEDA and other sources. Various statistical/economic analysis namely percentage analysis, graphical representation, CAGR, trend analysis, market share, Revealed and Export Competitive Advantage (RCA & XCI), Unit Value Realization (UVR), Cuddy Della Valle Index (CDVI), Markov chain approach were used to analyze the export performance.

Results of the analysis indicated that export from Maharashtra was found to fluctuate over the two decades (R^2=0.94) due to high dependency on wild capture. State had focused more on export of frozen shrimp, frozen fish, frozen squid items with EU and China being main markets. Among all the exported items, the state had shown positive comparative advantage for frozen fish, squid, and chilled items, and the pattern was changing from low value fish to high value. The UVR had continuously improved and recorded the highest ($4.77/kg) in 2020, which was supported by high CDVI scores for export value (18.15) as compared to quantity (10.88). The transition probability matrix demonstrated that USA has been the most stable market followed by SE countries, whereas the direction of trade indicated that these two] countries remained highly loyal markets for India and frozen shrimp items were highly loyal export items. Reduced fish landings, scarcity of labours, limited availability of air cargo and stringent COVID restrictions are found to have significant effect on seafood export from Maharashtra. Thus, it is suggested that the state should provide adequate insurance coverage of the fisheries and aquaculture sector, including informal workers. Product and market diversification should be done to decrease the higher dependence on few markets.

(CIFE/2019/FEC902/SR)

Value chain analysis of *Penaeus vannamei* hatcheries in Tamil Nadu

Kaviin. S

Major Advisor: Dr. Swadesh Prakash

India is among the largest producer and exporter of shrimp in the world. In 2019-20, the total export was about 12.90 lakh tons, out of which frozen shrimp accounted for 73%, dominated by *Litopenaeus vannamei.* The large number of hatcheries supplying quality seeds have helped attain this feat. In this study, the profile of 30 hatcheries and entrepreneurs were studied in Villupuram & Kancheepuram districts of Tamil Nadu, which showed that hatcheries had an average production capacity of about 60 million, a survival rate of approximately 46.6% with the broodstock mainly imported from Florida and replaced every 3 months. Squid meal & CPF Blanca were the most preferred feed for broodstock. All the entrepreneurs were males, most of them were doctorates though specialization in fisheries and aquaculture was very low. Two value chains existed, Chain A & B. Chain A had five stages with a profit percentage of about 109.13%, while in Chain B, an incentive was given for sales promotion that adds a significant value to the gate price, but reduced to profit share to 82.43%. Mean gate price per seed was about ₹0.31. The average no. of days required to produce a batch of seeds was about 22-23 days.

Analysis of chain A:

Stage	Cost added (₹)	Cost at the end of each stage (₹)	% share	Cumulative share
Broodstock management				
Cost of broodstock	50964.29		34.4%	
Live feed	3283.33		2.2%	
Artificial feed	2891.67		2.0%	
Lab charges	4316.67		2.9%	
Total		61456.00		**41.5%**
Pre PL (Naupli to Mysis)				
Lab charges	**4316.67**		**2.9%**	
Algal production	**5532.54**		**3.7%**	
Total		**9849.25**		**6.6%**
Post larval				
Artemia (10 tins)	39066.67		26.4%	
Artificial feed (0.8- 1.2 Kg)	1625.00		1.1%	
Chemicals & Probiotics	29833.33		20.1%	
Lab charges	4316.67		2.9%	
Total		74841.75		**50.5%**

The cost analysis showed that broodstock, natural & live feed, chemicals & probiotics contributed the lion's share of 32.33%, 30.38%, 18.93%, respectively. The benefit-cost ratio was about 1.96

to the total cost of production. Disease outbreaks and technical difficulties in the live feed culture were ranked top among the production curbs, which can be sorted out by implementing BMPs for *vannamei* hatcheries and establishment of new live feed culture parks. Establishment of training institutes to develop skilled human resources to work in hatcheries will improve their socio-economic status and create employment opportunities that will resolve the issue of non-availability of technical manpower. A scorecard or rating can be provided to the hatcheries, which can help the farmer identify the reliable hatcheries with quality seeds, which can benefit both the hatcheries and farmers. This will eventually result in high production and high returns to the shrimp farmer.

(CIFE/2019/FEC907/SR)

An Economic Analysis of Dudhawa Reservoir Fisheries, Chhattisgarh

Shravan Kumar

Major Advisor: Dr. Rama Sharma

Chhattisgarh is the sixth-largest producer of inland fisheries, with 1,770 reservoirs covering an area of 0.82 lakh ha. Dudhawa was constructed on the Mahanadi River in Kanker district and is the fifth largest reservoir in the state. The present study was carried out to understand the economics of Dudhawa reservoir fisheries to assess the socio-economic status of the fisher's dependent on this reservoir, its cost and returns, and the constraints faced by fisher. Altogether, 14 villages are dependent on this reservoir for their livelihood, and 390 fishers are the registered members of an active Adivasi Shivshakti Fish Cooperative Society Ltd. Stratified random sampling technique, data was collected from 120 fishers using a pre-tested structured interview schedule. Various statistical/economic techniques such as percentage analysis, graphical representation, CAGR, farm-business analysis, B-C ratio were used to analyze the data. Results revealed that the majority of the fishers were Hindu males, in the middle age group (36-55 years), educated up to primary level, residing in a joint family, practicing fishing as a primary occupation, have their own houses and agricultural lands, and also have savings in cooperative/commercial bank. Among the selected fishers, nearly 13.3% fishers were females, who were involved in the collection of small fishes and selling them in live/smoked form.

The majority of fishers fall in low-income groups and are involved in agriculture also. The average per capita annual income of fishers' households was found to be Rs. 81,100/-, which was less than the overall State value (Rs 98,281/-). The CAGR of fish seed stocking in Dudhawa reservoir has been found out as 11.17% and of fish production as 8.05% for a decade (2010-11 to 2019-20) with several fluctuations. Maximum of IMCs fish species are stocked along with other spp. (exotic carps) and reservoir fisheries are found to be highly feasible and profitable with a B-C Ratio of 1.77. Fish production of Dudhawa reservoir was 225kg/ha with an overall cost incurred of Rs.64/kg and net return of Rs. 11,053/ha. Rank Based Quotient method has been used to

Table 4.3.2 Cost-Benefit Analysis of Dudhawa Reservoir Fisheries during 2019-20

Total Fish Production (in Kg)			5,66,204
Species	Production (kg)	Selling Price	
Indian Major Carps	225777	Rs.140/kg	3,16,08,850
Catfishes	20686	Rs.220/kg	45,50,810
Local Minor	103969	Rs.100/kg	1,03,96,900
Minnows	215772	Rs.80/kg	1,72,61,760
Total Output	566204 kg		6,38,18,320
Gross Income (in Rs.)			6,38,18,320
Net Profit (in Rs.)			2,77,53,437
Benefit-Cost Ratio (BCR)			1.77
Per hectare fish production (in kg)			225
Cost for Per kg fish production (in Rs.)			64

analyze the constraints, and results indicated that inadequate wages followed by lack of motorized boats, shortage of fishing gear, etc. are the major constraints faced by fishers. This clearly indicates that though the reservoir fishery is highly profitable, the entire benefit goes to the contractor, to whom the reservoir is leased, instead of the fisher's dependent on the reservoir. Therefore, it is suggested that the Fisheries Federation should take necessary steps to increase fishers' wage rate and provide them more subsidies for craft and gear to enhance the sustainable livelihood of fishers.

(CIFE/2019/FEC904/SR)

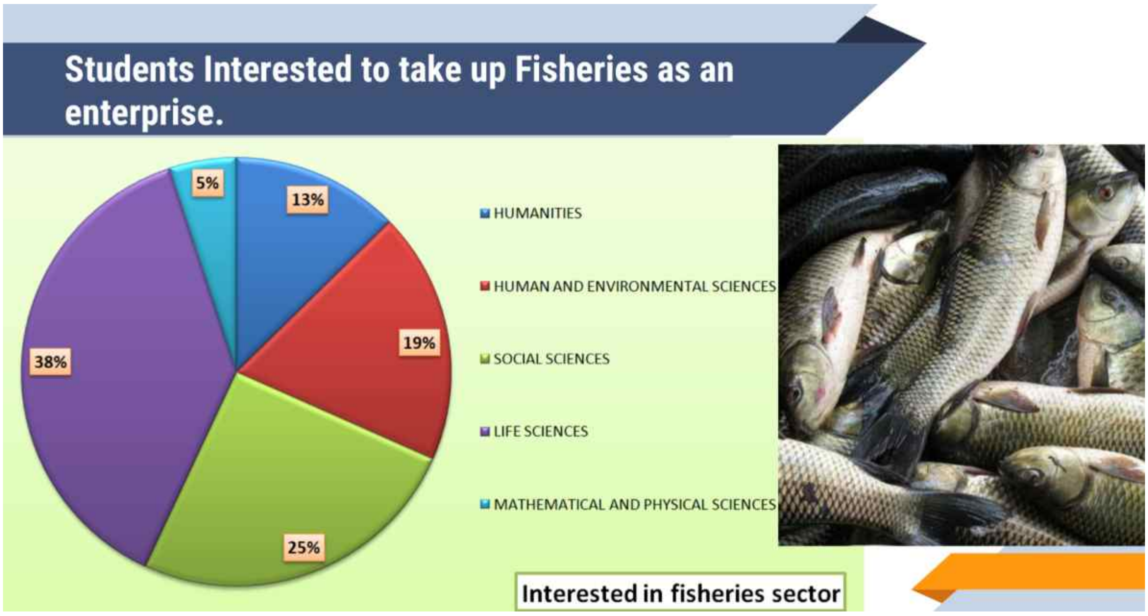
Students' Aspirations and Attitudes to Entrepreneurship in Manipur

Martina Meinam

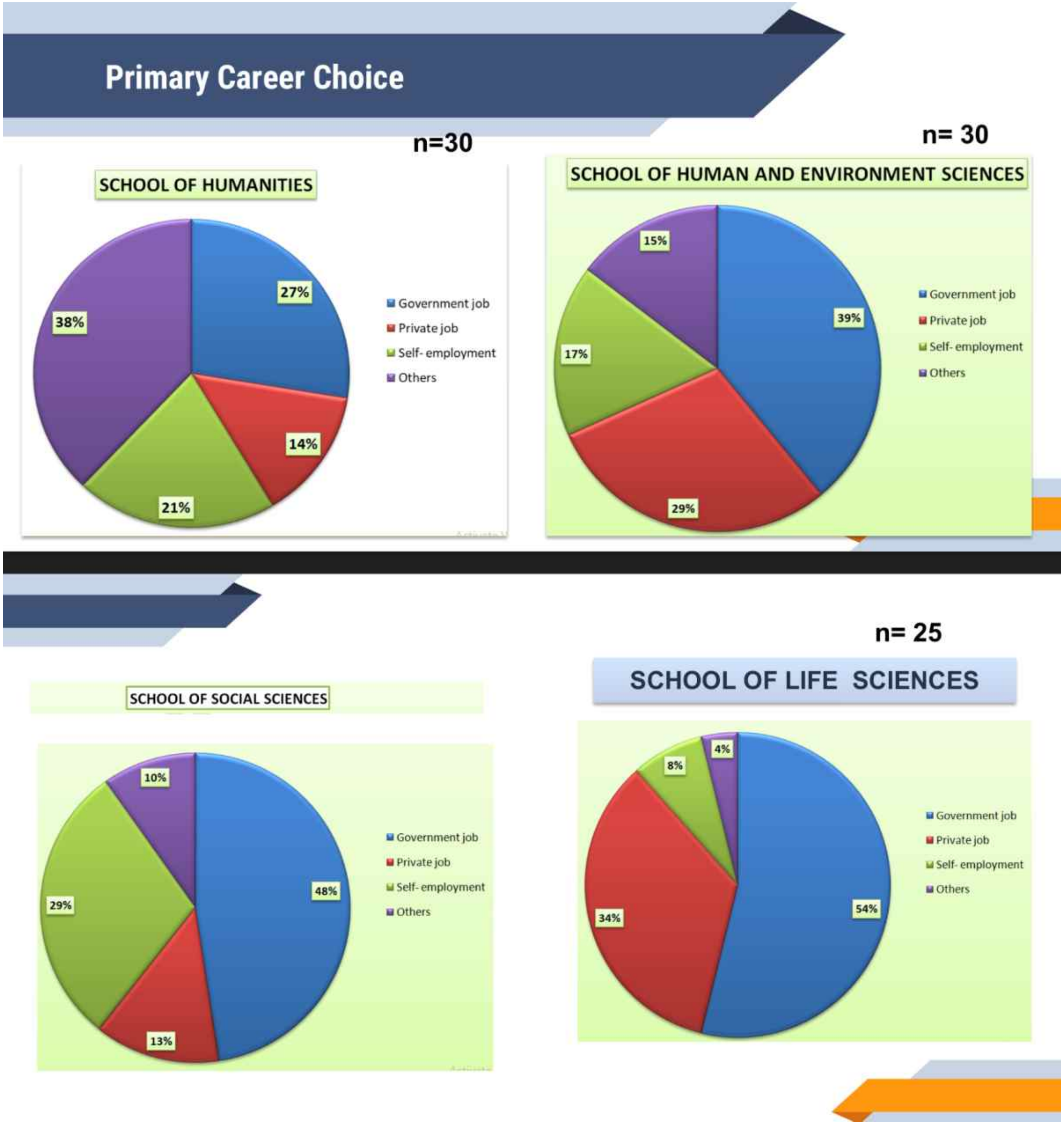
Major Advisor: Dr. S.N. Ojha

The entrepreneurs are not simply innovators as their roles are vital in developing countries for using innovations to exploit the available resources in a high literacy-high unemployment scenario. One of the best ways to address this is by developing entrepreneurship. The study assessed aspirations and attitudes towards entrepreneurship and its determinants for students of Manipur University. Students were chosen through stratified random sampling from 5 schools of study. A structured questionnaire was designed, and data were collected from 160 respondents. The majority of respondents (58.24%) were male, 43.32 % belonged to OBC, and 31.76% had a family occupation as farming and allied activities. The majority of 78% of the students wanted to pursue higher studies. It was found that students with a family occupation having private job had significantly higher educational aspiration followed by students with family occupations having government job. Students of the School of Human and Environmental Sciences showed the highest Achievement Likelihood of Educational Aspiration (ALEA) Index. It was also found out that parents' support improved their educational aspirations. School of Social Science Students showed a higher Achievement Likelihood of Career Aspiration (ALCA) Index followed by School of Human and Environmental Sciences.

Primary motivations for Career Aspirations included job security followed by income. The primary source of career advice was found out to be students' own interest / passion. Factors affecting career aspirants of students include job security followed by mass media /social media. The majority of the students i.e. 58.28% were moderately favourable towards entrepreneurship and 44.14 % showed a positive attitude towards entrepreneurship. The overall score of students' attitude towards entrepreneurship was found to be 0.65. The majority of the students had a medium level of attitude towards entrepreneurship. School of Social



Science students showed the highest attitude towards entrepreneurship. Boys showed higher attitudes towards entrepreneurship than girls. Students with family occupations in business showed the highest attitude towards entrepreneurship. Salary / income from different careers followed by job security, own interest / passion affected the attitudes towards entrepreneurship. Students were also asked about their interest in the fisheries sector, and the findings indicated that students of the School of Life Sciences were more aware of fisheries, and related schemes and programs, followed by students of the School of Social Sciences. Promoting student's entrepreneurship in Manipur University includes Start-Up Manipur, Manipur Entrepreneurs Association (AMEA), vocational courses at Centre for Entrepreneurship, etc. Students should be made aware about PMSSY, MANAGE's Agri-Clinics and Agri-Business Centre (ACABC), and the University may establish Business Incubation units by availing DST funding.



04

Extension Achievements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4.1 Tribal Sub Plan (TSP)

Under the TSP component, ICAR-CIFE has conducted several tribal community development activities. During 2021 a total of 18 training programmes were conducted in Maharashtra, Tripura, Meghalaya, Jharkhand, Manipur and West Bengal including a launch workshop benefiting as many as 1468 participants. Dr. K.A. Martin Xavier was the nodal officer for conducting all the activities under this component. A descriptive summary of these programs are given below.

1. Training Programme on Aquaculture in Percolation Tank (Online)

Coordinators: Dr. Arpita Sharma Dr. K.K. Krishnani, Dr. K. Pani Prasad & Dr. Ajit. K. Verma

A training programme was held on 19 January, 2021 "Aquaculture in Percolation Tank" in hindi/marathi (रिसाव तालाब में मछली पालन/ पाझर तलावामध्ये मत्स्यपालन) for 15 tribal youth of Nashik. The local coordinators from BOSCH, Nashik were Mr. Susanta Rout and Mr. SachinGiram from Corporate Social Responsibility (CSR) Division, BOSCH, Nashik. The training programme had sessions in Hindi on convergence of CSR of BOSCH with aquaculture progress and constraints faced by the tribal youth of Lakshmanpada village, Nashik, validation of training need assessments and feedback on ICAR-CIFE's Advisory. It included sessions on best management aquaculture practices in multiple water use percolation tank, disease management, Matsya Sampada yojana and Aquaponics. Sessions in Marathi were conducted on pre stocking management, seed transportation and stocking, Water and soil quality management, feed and feeding, harvest and post-harvest management.

2. Training Programme on Modern Methods of Freshwater Aquaculture for Fsh Farmers at Kamalpur, Dhalai, Tripura

Coordinator: Dr S. Dasgupta

A training programme on Modern Methods of Freshwater Aquaculture was organized during 9-10 February, 2021 through online as well as offline mode at Kamalpur, Dhalai, Tripura. The programme was conducted by ICAR-CIFE Kolkata Center in collaboration with the Department of Fisheries, Government of Tripura. A total of 100 participants attended this training. The training program was inaugurated by Dr D. K. Chakma, Director of Fisheries, Govt. of tripura with his valuable remarks on the importance of training programme for sensitizing tribal fishers for initiating scientific aquaculture to boost the production and earn double. Dr G.H. Pailan, Officer in charge, ICAR-CIFE Kolkata Center delivered an introductory speech emphasizing the role of aquaculture for enhancing livelihoods of fishers. Dr S. Dasgupta, Principal scientist, CIFE Kolkata Center and Dr Apu Das, Fishery Officer, Govt. of Tripura jointly coordinated the programme. Evaluation of pretraining knowledge and expectation of the fisher participants was conducted.

3. Training Programme on Ornamental Fish Culture for Women Fish Farmers of Dimbhe, Maharashtra (Online)

Coordinator: Dr. Madhuri Pathak

A training programme on "Ornamental Fish Culture" was organized by the Division of Aquaculture ICAR-CIFE Mumbai during 2-4 March, 2021 in order to impart knowledge of ornamental fish culture to the tribal women of Dimbhe, Maharashtra . A total of 45 tribal women participated from three villages around the Dimbhe reservoir viz. Kondhare, Jambhori, Phulwade, Manchar, Borghar, Junnar and Ambegaon. Mr. Budhaji Damse, Head, Shashwat Trust, Junnar facilitated the activities of this program. The programme began with an inaugural session and the participants were briefed with the details of the programme by course coordinator Dr. Madhuri Pathak. The inaugural address was delivered by Dr. Kishore Krishnani, Head of Division, Aquaculture. A total of 6 theory and 4 practical classes encompassing various aspects of ornamental fish culture. A field visit at Dimbhe reservoir was organized to show the rearing of ornamental fish culture in cages. During the valedictory function, inputs were supplied to enhance their interest towards the ornamental fish culture. Aquarium tanks, aquarium accessories and two pairs of ornamental fish (seed) were distributed to all the tribal women participants to enhance their interest towards ornamental fish culture. The training was highly appreciated with good feedback from the trainees and it was published in newspapers 'Ambegaon News' and 'Samna'.

4. Training programme on Modern Methods of Freshwater Aquaculture at RiBhoi district, Meghalaya

Coordinator: Dr. B. K. Mahapatra

A training programme on "Modern Methods of Freshwater Aquaculture" for 25 tribal fish farmers of RiBhoi district, Meghalaya was conducted at RiBhoi district, Meghalaya during 3-5 March, 2021. This program was organized by the ICAR-CIFE Kolkata Center and Department of Fisheries, Meghalaya. The inaugural address was delivered by Dr. G. H. Pailan, Officer-in-Charge, Kolkata Center. He mentioned the role of CIFE in education and research of fish and fisheries. Dr. B. K. Mahapatra, course coordinator delivered a lecture on recent advancement in freshwater aquaculture and ornamental fish culture. Mr. D. Kharwanlang, Principal, Fishery Training Institute, DOF, Meghalaya delivered lecture on composite fish culture. Mr. P. Suting, Fishery Officer, DOF, Meghalaya discussed Pre-stocking management in fish culture, integrated fish culture. The participants visited fish farms of RiBhoi district, Meghalaya under guidance of Mr. P. Lamin, Fishery Officer, DOF, Meghalaya to know practical aspects of freshwater aquaculture.

5. Training Programme on Ornamental Fish Culture for Women Farmers of Ranchi, Jharkhand (Online)

Coordinator: Dr. Madhuri Pathak

A training programme on "Ornamental Fish Culture" was organized during 5-8 March, 2021 by the Division of Aquaculture, ICAR-CIFE, Mumbai in association with the State Fisheries Department, Jharkhand. A total of 29 tribal women (Fish keepers and entrepreneurs) participated from different villages from Ranchi, Gumla and Khunti districts of Jharkhand. Chief Instructor, Fish farmer training Centre- Shalimar, Ranchi (Jharkhand) facilitated all the activities of this program online. The programme began with an inaugural session and the participants were briefed with the details of the programme by course coordinator Dr. Madhuri Pathak. The inaugural address was delivered by Dr. Kishore Krishnani, Head of Division, Aquaculture. A total of 6 theory and 4 practical classes encompassing various aspects of ornamental fish culture *viz.* Present status of ornamental fishes farming, fabrication of aquarium, aquarium accessories, feed management, different varieties of ornamental fish and plants, water quality management in aquarium, Stresses to ornamental fish and their mitigation and Aquaponics system for ornamental fish culture etc. Major emphasis was given for the hands-on demonstration of fabrication of aquarium tanks. A visit to the aquarium gallery at Fish Farmer Training Center, ornamental fish farm was conducted to show the rearing of ornamental fish culture in cement tanks.

6. Training Programme on Modern Methods of Freshwater Aquaculture at Ranchi, Jharkhand

Coordinators: Dr. Gouranga Biswas & Dr. Dilip Kumar Singh

A training program was organized by ICAR-CIFE, Kolkata Center in collaboration with State Fisheries Department, Jharkhand at Fish Farmer Training Center Ranchi, Jharkhand on "Modern Methods of Freshwater Aquaculture" for the tribal fisher folks of Ranchi, Jharkhand during 9-11 March. The training was inaugurated on by Mr. Simon Oraon honored with Padma Shri and Dr. H. N. Dwivedi, Director of Fisheries, Jharkhand. Mr. Simon Oraon urged the tribal farmers to participate more in this training to avail themselves for self-employment. Dr. H. N. Dwivedi urged the participants to adopt scientific fish farming practices to enhance productivity and improve their livelihood through fish farming. About 60 tribal fish farmers attended the programme. Dr. Gouranga Biswas, Senior Scientist, ICAR-CIFE Kolkata Centre delivered lectures on composite fish culture, integrated fish farming and fish health management in aquaculture. Dr. Dilip Kumar Singh, Scientist, ICAR-CIFE, Kolkata Center delivered lectures on feed and feeding strategies in aquaculture, water and soil management in fish ponds and sustainable use of chemicals in aquaculture, farm made aquafeeds using locally available cheap feed ingredients to reduce the feed cost. Practical demonstration of water quality analysis and preparation of fish feed was done to show pen and cage culture and Ratufun Kesle biofloc Ranchi, Jharkhand. The training was highly appreciated with good feedback from the trainees and it was published in 5-6 local newspapers such as 'Dainik Bhaskar', 'Desh Patra', 'Dabang Hind', 'Purbanchal Suye' and 'Rastriye Naveen Mail' etc.

7. Awareness Program on Hygienic Fish Handling and Value-added Fish Product at Durga Chowmani Block, Dhalai District, Tripura

Coordinator: Mr. Dhalongsaih Reang

A one-day awareness program was conducted at the Office of the Fishery Officer, Durga Chowmani Block under Dhalai district of North Tripura on 13 March, 2021. This program was attended by 50 participants. The main objectives of the program was to create awareness regarding hygienic fish handling for quality fish as well as value addition of fish products. The program was coordinated with the Department of fisheries, Govt. of Tripura. Dr. Apu Das, Fisheries Officer was present during the program and presented his lecture on improving the income from fisheries through value addition of fish products. Mr. Dhalongsaih Reang, Scientist, ICAR-CIFE, Powarkheda Center interacted with the fish farmers regarding various aspects of aquaculture. Participants had shown interest towards the training on fish product development, biofloc based fish culture, need for the construction of perennial ponds and FRP hatchery construction for small scale fish seed production.

8. Awareness Program on Hygienic Fish Handling and Value-added fish product at Avanga, Kamalpur, Dhalai District, Tripura

Coordinator: Mr. Dhalongsaih Reang

A one day awareness program was conducted at the Office of the Superintendent of Fisheries, Avanga, Kamalpur Sub Division under Dhalai district, North Tripura on 16 March, 2021. This program was attended by 50 participants. This program was conducted under the theme of ygienic fish handling and value-added fish products. The program was conducted in coordination with the Department of Fisheries, Govt of Tripura. Mr. Narayan Debbarma, Fishery Officer of Salema Block, Dhalai was also present in the program. Various aspects of freshwater aquaculture and issues were discussed during the program. Participants had shown the interest towards the exposure visit to ICAR-CIFE processing unit for hands on training on various value-added fish products, creation of cold storage facility in the locality for preserving fish and increasing the market value, establishment of fermented fish (Sidal) processing unit for SHGs or in clusters in addition to training on fish product development and biofloc based fish culture.

9. Awareness Programme on Aquaculture as a Potential Livelihood Option for Tribal Communities at Pune District, Maharashtra

Coordinators: Dr. Shivaji Argade, Dr. Kapil Sukhdhane, Dr. Karankumar Ramteke, Dr. Manoj Brahmane, Dr. Ankush Kamble & Dr. Kiran Rasal

An awareness programme on "Aquaculture as a Potential Livelihood Option for Tribal Communities" under tribal sub-plan at Krishi Vigyan Kendra (KVK), Narayangaon (Pune) was organised on 19 March, 2021. The purpose of organising an awareness programme was to make tribal communities aware about small-scale aquaculture and fish farming. The programme was organised through online as well as offline mode, attended by 153 participants. In the inaugural address, Dr. S. N. Ojha, HoD, FEES Division, ICAR-CIFE Mumbai highlighted the importance of water and land in the life of tribal communities. Dr. Shivaji Argade, Scientist briefed about the purpose, structure, evaluation and post-programme activities of the programme. He also discussed fish marketing strategies and value added fish products to earn good profit from fish farming. Dr. Kapil Sukhdhane, Scientist delivered a talk on 'Aquaculture in farm ponds'. He discussed the Five 'W' and One 'H' of pond fish farming. Dr. Karankumar Ramteke, Scientist deliberated on 'Fish harvesting gears and crafts'. Dr. Manoj Pandit Brahmane, Principal Scientist talked on the 'GIFT Tilapia Culture' which was highly appreciated by the participants. Further, Mr. Bhaskar Sanap, Assistant Fisheries

Development Officer (Junnar) informed about provisions schemes under PMMSY for promoting fish farming. The vote of thanks was proposed by Dr. Ankush Kamble, Scientist. On this occasion, Poshan Bagh (Nutri-Garden) Kits (containing vegetable seeds grown throughout the year) were distributed to all the trainees. The programme was covered by the newspaper, 'Agrowon' (Sakal).

10. Awareness Programme on Aquaculture as a Potential Livelihood Option for Tribal Communities at Malad, Mumbai Western Suburb District, Maharshtra

Coordinators: Dr. Kapil Sukhdhane, Dr. Shivaji Argade & Dr. Ankush Kamble

A one-day awareness-cum-training programme was organised on "Aquaculture as a Potential Livelihood option for Tribal Communities" by Division of Aquaculture, ICAR-CIFE for tribal society of Dharavali Gaon, Mud-Marve, Malad on 24 March 2021. The training programme was attended by the 63 tribal participants from Shree Kalbadevi Adivasi Matsya Vyavsay Sahakari Sanstha Ltd society. The programme began with an inaugural session and the participants were briefed with the details of the programme by course coordinator Dr. Kapil Sukhdhane. The inaugural address was delivered by Dr. Kishore Krishnani, Head of Division, Aquaculture. The participants expressed their expectations with the training programme and future support from the institute. The identified tribal groups were interested to work on crab fattening since they collect wild crabs and hold in desired locations to gain a proper weight for the sale. Crab fattening approaches in small enclosures in mangroves and using plastic boxes were explained to the farmers through the scientific talks. Farmers were also explained about the different success stories in different locations. Dr. Shivaji Argade delivered a talk on technology adoption and need based assessment in the crab fattening. Dr. Ankush Kamble explained about different schemes and subsidies available under Pradhan Mantri Matsya Sampada Yojana, Government of India. The training was highly appreciated with good feedback from the trainees as they desired to adopt the scientific fattening practices.

11. Training Programme under TSP on Modern Methods of Freshwater Aquaculture at Falakata Block, Alipurduar, West Bengal (Online)

Coordinator: Dr. S. Datta

A training programme on "Modern Methods of Freshwater Aquaculture" under TSP scheme was organized by ICAR-CIFE, Kolkata Center in collaboration with KVK of WBUA & FS, Ramshai, Jalpaiguri, at Falakata Block of Dist-Alipurduar, West Bengal on 21 August, 2021. A total of 100 tribal farmers participated in the programme. The training programme was inaugurated by Dr. G.H. Pailan, Principal Scientist & Officer-in-Charge, ICAR-CIFE, Kolkata Centre.In technical session Dr. Gouranga Biswas, Senior Scientist, discussed "Composite fish farming" and he explained regarding suitable fish farming methods, species selection, farming management and feed management. Water and soil quality management for aquaculture was explained in detail by programme coordinator, Dr. Subhendu Datta, Principal Scientist ICAR-CIFE Kolkata Centre. He also demonstrated CIFE water testing pH kits developed by the Center. Fish health management was presented by Mr. Indranil Ghosh, SMS (Fisheries), KVK of WBUA & FS, Jalpaiguri. He explained different fish diseases and what are the control measures for such incidence. Essential inputs such as aluminum hundi 14.5 inch for fish holding, fishing net (cast net) for fish catch, Tarpaulin polythene sheet 300 gm (24'x17'), Lime: 25 kg/farmer, Vermicompost: 20 kg/farmer, CIFE pH water testing kit were distributed among the tribal farmers.

12. Awareness Program on Disease Management and Sustainable Aquaculture Practices with Good Post-Harvest Techniques at Nandurbar District, Maharashtra

Coordinators: Dr. Gayatri Tripathi, Dr. A. K. Balange, Dr. Vidyashree Bharti, Dr. Kiran Rasal & Dr. Manish Jayant

A training programme on "Disease management and sustainable aquaculture practices with good post-harvest techniques" was conducted on 16 September, 2021 Navapur, Nandurbar. Total 50 participants from various villages of Navapur Tehsil, Nandurbar have participated in this training programme. During this programme, various topics such as carp culture in farmed ponds, species selection, pond preparation before seed stocking, seed stocking, water and soil quality management, on-farm feed preparation, disease identification and control, harvesting and quality control were taken up and farmer's queries were answered.

13. Training cum Demonstration on Value Added Fish Products Preparation from Freshwater Fish at Nandurbar, Maharashtra

Coordinator: Dr A. K. Balange

A training program on "Value Added Fish Products Preparation from Freshwater Fish " was conducted at Khairwe, Nawapur, Nandurbar district, Maharashtra from 17-20 September, 2021. Different aspects of value added fish products preparation were demonstrated to the 100 tribal women participants from the Khairwe village. Facility is developed by installation of a pilot plant for value added fish products preparation with a capacity of processing 200 kg fish products per day. The facility will provide a common facility for the women SHGs in that area. The training was highly appreciated with good feedback from the trainees and it was published in the newspaper, 'Lokmat'.

14. Training Programme under TSP on Modern Methods of Freshwater Aquaculture at Kharibari, Darjeeling, West Bengal (Online)

Coordinator: Mrs. Husne Banu

A training program on "modern methods of Freshwater Fish culture" was organized by ICAR-CIFE, Kolkata Center at Kharibari Darjeeling in virtual mode for the tribal people of Darjeeling on 18- 20 September, 2021. The training was attended by 100 participants.The programme was inaugurated by Dr. G.H. Pailan, Principal Scientist & Officer-in-Charge, ICAR-CIFE, Kolkata Center briefed the farmers regarding aquaculture practices and how to get maximum profit out of it by implementing modern methods. In the technical session Dr. Gouranga Biswas, Senior Scientist, discussed "Composite fish farming" and he explained regarding suitable fish farming methods, species selection, farming management and feed management. Water and soil quality management was explained in detail by Dr. Suman Manna, Scientist. He also demonstrated CIFE water testing pH kits developed by the Center. Health management practices of fish in aquaculture was presented by Ms. Husne Banu, Scientist. She explained different fish diseases and what are the control measures for such incidence. She also explained better management practices need to be followed while doing aquaculture. Vote of thanks was given by Ms. Husne Banu, training coordinator.

15. Training Program on Enhancing Fish Productivity through Farmers Participatory Research at Chandel, Manipur

Coordinators: Dr. S. Munilkumar & Dr. A. D. Deo

A training programme for fish farmers of Chandel district under Tribal Sub Plan was organised by ICAR-CIFE Kolkata Center in collaboration with Fisheries Department, Govt of Manipur, during 23-25 September, 2021. Dr S. Munilkumar, Principal Investigator, TSP project, ICAR-CIFE Kolkata Centre coordinated the programme with Dr. A.D. Deo, Principal Scientist, ICAR-CIFE Mumbai. A total of 50 participants attended this programme. The program was part of a research project to develop a sustainable farming model for the district and enhance fish productivity through farmers' participatory research. Farming techniques relevant to local conditions were demonstrated for farmers of

Kaziphung village, Chandel district farmers. Various topics on farm-made feeds with locally available leaves, fish health management, water quality testing, plankton estimation etc., were discussed. The demonstrations on fish stocking, water quality management, farm made feed and feeding strategies and health management were done. Practical demonstrations were also conducted along with the sensitization of farming practices with flash cards and videos. A field trip to the successful fish farm of M/S S. Tomba and Sons at Hiyangthang was also conducted to show modern fish farming methods. Renowned progressive fish farmer Mr Soibam Surchandra Singh shared his vast experience and techniques for the benefit of the farmers. The programme was facilitated by Mr. Jeneshing Tarao, District Fishery Officer, Chandel district, Manipur.

16. Awareness Program on Modern Methods of Freshwater Aquaculture at Mirik, Darjeeling District, West Bengal

Coordinators: Dr. S. Munilkumar & Dr. A. D. Deo

An Awareness program was organised by ICAR-CIFE Kolkata Centre on "Modern Methods of Freshwater Aquaculture" at Pulbazar Community Hall, Pokhribong, Mirik, Darjeeling District, West Bengal on 3 October, 2021. On the previous day a field survey cum interactions was done at 5 locations of Avongrove Tea estate, Tamkulay, Mangarjung TE, Bahadur Gaon, Sankaman Gaon, Nagri TE regarding water quality testing, maintenance of water quality, feeding etc. 110 trainees including 58 female participants from different blocks of Pokhribong, Mirik attended the program. A plastic lined pond system for rearing common carp was discussed and initiated in farmers ponds. Dr. G.H. Pailan, Officer in charge of Kolkata Centre discussed the role of farm made feeds while Dr. S. Munilkumar, Principal Scientist described the suitable fish farming methods of the region. Mr. P. K. Behera, Sr. Tech Asst. demonstrated water quality testing and estimation of natural food productivity of ponds. The programme was conducted in association with Sundarban Dreams, Mirik, Darjeeling, NGO which promotes agriculture including fish farming as a livelihood option in West Bengal.

17. Awareness Programme on Biofloc Fish Farming for Participants from Palghar District, Maharashtra for the fish farmers of Palghar district, Maharshtra (Online)

Coordinator: Dr. Babitha Rani. A. M

Division of Aquaculture, ICAR- Central Institute of Fisheries Education, Mumbai organized an awareness cum training programme on "Biofloc Fish Farming" at seminar hall of Thane Belapur industries Association, Ghansoli, Navi Mumbai for participants from Pathardi, Mokhada, District Palghar, Maharashtra on 8 October, 2021. The programme was conducted online in association with The Energy and Resources Institute, TERI. A total of 10 participants attended the programme. Dr. N. K. Chadha, HOD, Division of Aquaculture, had given the introductory lecture followed by co-ordinator Dr. Babitha Rani. A.M and then by Dr. Kapil Sukhdhane. The lectures and discussions covered were: the importance of fish culture in rural livelihood and sustainable use of resources for aquaculture, introduction to biofloc technology, development of inoculum, tank construction, pre stocking management, stocking, post stocking management, feeding and disease management, water quality management etc. After the lectures, there was a discussion session and the participants actively participated and have shown their interest to be part of further demonstrations and establishment of units at their locations. From TERI, Dr. Anjali Prasanis briefed about the role of nutritional upliftment of the community through aquaculture and its necessity, and also Ms. Pranali and Mr.Lalit Mohan Joshi from TERI attended the program. For giving hands-on training to the farmers, the biofloc unit was constructed under this TSP program at ICAR-CIFE New campus and the beneficiaries were further demonstrated with the practical construction of the biofloc unit in the online training programme. The biofloc unit developed at the institute will be used for demonstrating the technology to the tribal beneficiaries as and when required in collaboration with TERI.

18. Awareness cum Demonstration Programme on Good Aquaculture Practices with Special Reference to Environment at Nandurbar, Maharashtra

Coordinators: Dr. Gayatri Tripathi, Dr. Vidyashree Bharti & Dr. Kiran Rasal

The one-day training-cum-demonstration programme on "Good Aquaculture Practices with special reference to environment" was organized on 4 December, 2021 at the Nandurbar District. A total of 50 participants attended this program. Lectures and onsite practical were conducted to develop farmers' skills on pond preparations, importance of feed quality, water and soil quality management and common diseases of Indian Major Carps fry. The tribal fish farmers were taught about the importance of employing good aquaculture practices in fish farms which would help them to achieve enhanced growth and better production and shall improve their socio-economic status. A technical book in Marathi on 'Fish disease diagnosis and treatment' and a brochure in Hindi on 'Water and Soil management in aquaculture' along with a training kit was distributed to the participants. The training program was followed by on-site demonstration of release of IMC seeds in experimental ponds. The samples of stocked fish, water and soil were collected for further analysis.

19. Pilot Plant & Launch Workshop of Projects under Tribal Sub-Plan at Nandurbar District, Maharashtra

Coordinators: Dr. B.B. Nayak, Dr. Gayatri Tripathi, , Dr. A. K. Balange, Dr. Vidyashree Bharti, Dr. Kiran Rasal & Dr. Manish Jayant

An inauguration programme for opening of a new pilot plant for preparation of value-added fish products, along with the launch of two projects aiming at the development of tribal fishermen, was organized on 16 September, 2021 at Navjeevan Tribal Fisherman Co-Operative Society, Khairwe, Navapur, Nandurbar. A total of 100 participants attended this workshop. Honourable Member of Legislative Assembly (MLA) from Nandurbar, Dr Vijay Kumar Gavitji was the Chief Guest of the programme. Dr. Gopal Krishna, Director and Vice-Chancellor, ICAR-CIFE, Mumbai presided over the function and Mr Kiran Padvi, Asst. Commissioner of Fisheries, Nandurbar was the Guest of Honour. Dr. B. B. Nayak, Head, Fisheries Resources Harvest and Post-Harvest Management Division welcomed all the guests and briefed everyone about the inauguration program. The invited dignitaries also launched two projects of ICAR-CIFE, Mumbai for a three-year period in the tribal area of Nandurbar district.

Dr. A. K. Balange, Principal Scientist & PI, ICAR-CIFE, Mumbai, delivered a keynote address on "Implementation of improved technological interventions in fish farming and processing in Nandurbar District". The Guest of Honor, Mr. Kiran Padvi, addressed the gathering and highlighted the importance and usefulness of the pilot plant for doubling the income of the tribal community. He also highlighted the importance of disease management and about the good practices in fish farming. Director & Vice-Chancellor, ICAR-CIFE, Dr. Gopal Krishna, in his presidential address highlighted the activities of ICAR-CIFE, Mumbai in the tribal areas of different parts of the country. He also mentioned that the main objective of the Institute in running these skill development activities is to develop entrepreneurship and to improve the socio-economic status of the tribal community. He mentioned that the facility will be beneficial to the tribal community for carrying out value-addition of fish products and for improving their livelihood. He assured that ICAR-CIFE, Mumbai will impart necessary hands-on training in fish health management and shall help in skill development of the tribal communities. The Chief Guest of the programme, Dr. Vijay Kumar Gavitji, mentioned in his inaugural speech that these kinds of activities are being implemented for the first time in the tribal area of Nandurbar. He emphasized that tribal fish farmers are ignorant about fish diseases and suffer economic losses due to stagnant growth and mortality of fish. Two brochures regarding the above two projects and a training manual on "Value-added fish products preparation from freshwater fish" were also released by the dignitaries during the programme. The programme was covered by the local Newspaper 'Lokmat'.

20. Fish Feed Demonstration and Preparation Using Leaf or Fermented leaf Meals along with Locally available Ingredients at Sonebhadra district, UP (In collaboration with ICAR-NBFGR)

Coordinators: Dr. Sikendra Kumar & Dr. Dilip Kumar Singh

Alternative ingredients to replace the conventional ingredients is a researchable issue in fish nutrition. Locally available ingredients may help in preparing low-cost farm made formulae for the tribal population in Sonebhadra District. Total 18 no of local ingredients collected from the Sonebhadra district. The proximate composition and antinutritional factors of all the eighteen leaves have been analyzed.The programme was developed in collaboration with ICAR-NBFGR, Lucknow.

4.2 Scheduled Caste Sub Plan (SCSP) Component

Under the SCSP component, ICAR-CIFE has conducted several training programmes for the development of the SC community. During 2021 a total of 12 training programmes were conducted in West Bengal, Andhra Pradesh and Jharkhand benefiting as many as 928 participants. Dr. Parimal Sardar was the nodal officer for conducting all the activities under this component. A descriptive summary of these programs are given below.

1. Training Programme on Integrated Aquaculture

Coordinator: Dr. Sujata Sahoo

A training programme on "Integrated Aquaculture" was organized by ICAR-CIFE, Kolkata Centre on 28 January and 1 February, 2021 for SC farmers at different villages of Canning , South 24 PGS, West Bengal. A total number of 106 fish farmers were benefited by this training programme. The training programme was inaugurated by Mr. Tapan Saha, Member Zilla Parishad, Itkhola, Canning I at Kulagharani. As a farmer himself, he has appreciated the effort of ICAR-CIFE, Kolkata Centre and encouraged the farmers to learn maximally from the training. Dr. G.H. Pailan, Principal Scientist & Officer-in-Charge of Kolkata Centre addressed about the importance of integrated fish farming systems and how to manage the different inputs for successful integration. Different lectures on the role of feed in aquaculture practices and utilization of locally available cheap ingredients, management of water quality parameters, integrated fish farming system for sustainable income and managing water quality parameters and disease in integrated fish farming. Practical demonstration on feed preparation and water analysis was conducted. This training programme was coordinated by Dr. Sujata Sahoo, Senior Scientist and the resource persons were Dr. G. H. Pailan, Dr. D. K. Singh, Dr. Suman Manna and Mr. P. K. Behra from ICAR-CIFE, Kolkata Centre. Bengali leaflets published by ICAR-CIFE, Kolkata center were also distributed. Farmer-scientist interaction was held where all the farmers were actively involved in the discussion.

2. Training Programme on Freshwater Fish Culture (Online)

Coordinator: Dr. S. Munilkumar

A training programme on "Freshwater Fish Culture" was organized by ICAR- CIFE, Kolkata center, Salt Lake, West Bengal, at Namsai, Jalpaiguri, West Bengal on 29 January, 8 & 9 February, 2021 in collaboration with Krishi Vigyan Kendra (West Bengal University of Animal & Fishery Sciences), Jalpaiguri. A total of 102 participants from various KVK adopted FPOs and FPCs of Jalpaiguri district. The said programme was illuminated by the dignitaries like Mr. Soham Roy Bosuniya- Sabhapati of Maynaguri Panchayat Samity, Mr. Soumyodeep Mazumder- Asst Director of Agriculture, Matiali block, Govt of West Bengal, Dr. Biplab Das, Programme Coordinator of Jalpaiguri KVK, ATMA, officials, representatives of Vivekananda Institute of Biotechnology (Jalpaiguri project). Various aspects of freshwater fish culture were discussed along with a session of scientist- farmer interaction on each day. Dr. G.H. Pailan, Principal Scientist/Officer in Charge, Dr. S. Datta, Principal Scientist, Dr. S. Dasgupta, Principal Scientist and Dr. A. Biswas, Chief Tech Officer delivered topics on feed & feeding strategies in aquaculture, Management of water & soil, polyculture of carps, Fish health management. The programme was coordinated by Dr. S. Munilkumar, Principal Scientist, Kolkata Centre and Mr. Indranil Ghosh, SMS (Fishery Sciences), Jalpaiguri KVK.

3. Training Programme on Integrated Aquaculture

Coordinator: Dr. Dilip Kumar Singh

A one day training programme on "Integrated Aquaculture" was organized by ICAR-CIFE, Kolkata Centre on 9 February, 2021 fish farmers at Gosaba, South 24 PGS, West Bengal. A total number of 125 fish farmers benefited from this training programme. The training programme was inaugurated by Mr. Gour Sardar, Panchayat Pradhan of Masjidbati Grampanchayat. Dr. G. Biswas Senior Scientist of Kolkata Centre addressed about the activities of ICAR-CIFE and objective of the said training programme. Different lectures on composite fish culture, integrated fish farming and fish health management in aquaculture, innovative feeding strategies in aquaculture and utilization of locally available cheap ingredients for making feed while reducing the feed cost for sustainable fish production. Demonstration of water quality analysis by pH kit & DO kit developed by ICAR-CIFE was given for fish farmers. Along with the classes farmers were distributed Bengali leaflets published by ICAR-CIFE, Kolkata center. This programme was coordinated by Dr. Dilip Kumar Singh, Scientist and the resource persons were Dr. G. Biswas, Dr. Suman Manna and Mr. P. K. Behra. All the farmers actively participated in the discussion. Bengali leaflets published by ICAR-CIFE, Kolkata center were also distributed. Farmer-scientist interaction was held where all the farmers were actively involved in the discussion.

4. Training Programme on Modern Methods of Freshwater Aquaculture

Coordinator: Dr. Suman Manna

Skill development training programme on "Modern Methods of Freshwater Aquaculture" was organized by ICAR-CIFE, Kolkata Centre on 19 February, 2021 for fish farmers at Ramapur, Sahebkhali GP, Hingalganj, North 24 PGS, West Bengal. A total number of 150 fish farmers benefited from this training programme. This training programme was coordinated by Dr. Suman manna and inaugurated by Mr. Shudhangshu Mandal, member of Sahebkhali GP. Dr. G.H. Pailan, Principal Scientist & Officer-in-Charge of Kolkata Center spoke about the activities of ICAR-CIFE and delivered a lecture on the importance of feed in aquaculture practices and utilization of locally available cheap ingredients for making feed while reducing the feed cost for sustainable fish production. Different lectures on freshwater aquaculture, basic pond management practices, water and soil quality parameters for freshwater carp culture. Practical demonstration and distribution of pH kit & DO kit developed by ICAR-CIFE to the fish farmers.

5. Training Programme on Demonstration of Leaf Meal based Farm Made Aqua-feed Preparation and on-farm Feeding Management

Coordinators: Dr. Sikendra Kumar& Dr. Dilip Kumar Singh

A training program was organized by ICAR-CIFE, Mumbai in collaboration with State Fisheries Department, Jharkhand at KVK Chatra, Jharkhand on "Demonstration of Leaf Meal Based Farm- made Aqua-feed Preparation and On-Farm Feeding Management" for scheduled caste farmers under SCSP programme during 2-5 March, 2021. The training was inaugurated by Mr. Amrendra Kumar, DFO, Chatra, Jharkhand, Dr. Vinod Kumar Pandey, Dr. Dharma Oraon and Upendra Kumar Singh from KVK, Chatra. Deputy Commissioner, Chatra, Jharkhand interacted with the trainees. About 50 scheduled caste farmers of Kunda Block of Chatra district, Jharkhand attended the programme. Five lectures on composite fish culture, farm-made feed preparation, availability of local feed ingredients including leaf meals, pellet feed preparation etc., and three practical on farm-made feed preparation, leaf meal based pellet feed preparation and feeding methods in composite fish culture system were demonstrated to the trainees during the programme.

6. Training Programme on Preparation of Value Added Fishery Products (Online)

Coordinators: Dr. Muralidhar P. Ande Dr. Karthireddy Syamala & Dr. Martin Xavier

A one day farmer's training on "Preparation of Value Added Fishery Products" was organised by ICAR-CIFE Kakinada center on 15 March 2021 at Panchalavaram village, Amruthalur Block, Guntur District, Andhra Pradesh. Dr. Muralidhar P. Ande in his inaugural address emphasized the importance of value added fishery products, their nutritive values and the importance of the SCSP scheme. Participants were explained for preparation of various value added fishery products such as Fish samosa, fish cutlets, fish wafers, fish and prawn pickles, fish momo etc. in telugu language. About 60 beneficiaries had attended the programme. Dr.P. SrinivasaRao, CTO and Mr. R.R.S. Patnaik, ACTO, Mr. Suresh and Mr. KonadalaRao of ICAR-CIFE, Kakinada Centre participated in the training programme. Ms.Mahija, FDO, Ms. Devi Sri, VFA, Mr. Anil, P.S and Ms. Soujanaya, Panchayat Secretary, Panchalavaram village participated in the event. The programme was highly successful with good feedback from the participants and published in local newspapers.

7. Training Programme on Modern Methods of Freshwater Aquaculture

Coordinator: Dr. B. K. Mahapatra

One day training programme on modern methods of Fresh Water Aquaculture was organised by ICAR-CIFE, Kolkata Center in collaboration with Dakshin Dinajpur Krishi Vigyan Kendra, UBKV on 18 March, 2021. A total of 25 farmers participated in training. The training was inaugurated by Dr. G.H. Pailan, Principal Scientist and Officer In charge, ICAR-CIFE, Kolkata Center and Mr. S. Singh, Senior Scientist and Head, Dakshin Dinajpur KVK, UBKV. During the inauguration they addressed the values and opportunities of modern methods of fish culture. The participants were trained on feeding management, modern methods of fish culture, Soil and Water quality management, Air breathing fish breeding and culture. This training programme was coordinated by Dr. B. K. Mahapatra and the resource persons were Dr. G. H. Pailan, Dr. B. K. Mahapatra, Dr. S. Dutta and Dr. B. Goswami. During the feedback session the participants expressed their interest in establishing a fish culture pond with help of KVK and CIFE.

8. Training Programme on Livelihood Improvement of Fisherwomen through Value addition (Online)

Coordinators: Dr. Muralidhar P. Ande Dr. Karthireddy Syamala & Dr. Martin Xavier

A one day farmer's training on "Livelihood improvement of fisherwomen through value addition" was organised by ICAR-CIFE, Kakinada Center on 19 March 2021 at Thurumella village, Amruthalur Block, Guntur District, Andhra Pradesh. Dr. Muralidhar P. Ande in his inaugural address emphasized the importance of value added fishery products for improvement of livelihood of local fisherwomen and the importance of the SCSP scheme. Dr. K. Syamala, Scientist, ICAR-CIFE, Kakinada Center given a brief training on preparation of various value added fishery products such as Prawn pickles, fish Burgers, fish samosa, fish cutlets, fish wafers, and fish momo etc. in local telugu language. About 60 beneficiaries had attended the programme. Dr. P. Srinivasa Rao, CTO and Mr. R.R.S. Patnaik, ACTO, Mr. Suresh and Mr. Konadala Rao of ICAR-CIFE, Kakinada Centre Mrs. A. Indiramma, Sarpanch and Ms. B. Pushpa Latha, Panchayat Secretary, Thurumella village participated in the event.

9. Training programme on Basics in Aquaculture Practices (Online)

Coordinators: Dr. Muralidhar P. Ande & Dr. Karthireddy Syamala

A Training programme on "Basics in Aquaculture Practices" was organised by ICAR-CIFE, Kakinada Center on 20 March 2021 at Kuchipudi-Pedapudi village, Amruthalur Block, Guntur District, Andhra Pradesh. Dr. Muralidhar P. Ande, Senior Scientist & Officer In-charge, ICAR-CIFE, Kakinada Center, Dr. Karthireddy Syamala, Scientist have coordinated this program. Dr. Muralidhar P. Ande, in his inaugural address emphasised the importance of basics in aquaculture practices for profitable aquaculture and the importance of the SCSP scheme. Shri. Ravi Shankar Patnaik, ACTO delivered a talk on "Induced breeding of Indian Major Carps and its nursery and rearing pond management" and Dr. P. Srinivasa Rao, CTO delivered a talk on "Site selection, soil and water quality management and carp culture pond management" in telugu language. As a part of the training programme, water analysis kits (D.O, pH, Chlorine kits & Thermometers) were distributed to the participants. About 50 beneficiaries have attended the programme. Mr. Suresh and Mr. Konadala Rao of ICAR-CIFE Kakinada Centre, Ms. Himaja, FDO, Kuchipudi, Ms. Devi Sri, VFA, Mr. Anil, Panchayat Secretary and Mr. K. Kotesawara Rao, President, Fishermen Co-operative society, Kuchipudi village were participated in the event. The programme was highly successful with good feedback from the participants and published in local newspapers.

10. Training Programme on Modern Methods of Freshwater Aquaculture

Coordinator: Dr. B. K. Mahapatra

One-day skill development training programme on "Modern methods of freshwater aquaculture" was organized by ICAR-CIFE, Kolkata Centre on 17April, 2021 for fish farmers at Pratapnagar, Sonarpur, South 24 PGS, West Bengal. A total number of 100 fish farmers benefited from this training programme. The farmers were selected with the help of Sasya Shyamala KVK, Narendrapur, South 24 PGS. The training programme was inaugurated by, Shri Mrinmoy Roy, Principal, Pratapnagar Giridhari High School and Dr. G.H. Pailan, Principal Scientist & Officer-in-Charge of Kolkata Centre. Different lectures on freshwater aquaculture, basic pond management practices, integrated farming system and its types, Dr. Swagata Ghosh, SMS, KVK, Narendrapur also highlighted the diseases found in fishes and health management in fishes. Practical demonstration and distribution of pH kit & DO kit developed by ICAR-CIFE to the fish farmers. Farmers were also supplied with inputs such as aluminum hundies, fishing nets and caps for their aquaculture activities. This training programme was coordinated by Mrs. Sweta Pradhan and the resource persons were Dr. G. H. Pailan, Dr. Gouranga Biswas. Farmer-Scientist Interaction was also held.

11. Training Programme on Modern Methods of Freshwater Aquaculture

Coordinator: Dr. Ashok Biswas

A training programme on "Modern Methods of Freshwater Aquaculture" in online cum offline was organized by ICAR-CIFE, Kolkata Center in collaboration with Jalpaiguri Krishi Vigyan Kendra at Ramsai, Jalpaiguri, West Bengal during 6- 9 July, 2021. A total of 100 participants from various KVK adopted FPOs and FPCs of Jalpaiguri district participated in the programme. This programme was illuminated by dignitaries like Mr. Subrata Nandy, Block Development Officer, Maynaguri, Jalpaiguri, Government of West Bengal, Dr. Biplab Das, Programme Coordinator of Jalpaiguri KVK. Dr. G.H. Pailan, Principal Scientist & Officer-in-Charge delivered the inaugural address. Various aspects of freshwater fish culture were discussed such as Poly-culture of carps, soil & water quality management and fish health management. Farmers were also supplied with inputs such as aluminum hundies, fishing nets and caps for their aquaculture activities. The programme was coordinated by Dr. A. Biswas, Chief Tech Officer and Mr. Indranil Ghosh, SMS (Fishery Sciences), Jalpaiguri KVK and resource persons were Dr. G.H. Pailan, Dr. G. Biswas and Dr. S. Manna from ICAR-CIFE, Kolkata Center. .

12. Training Program on Modern Methods of Freshwater Aquaculture

Coordinator: Dr. G. Biswas

A training programme on "Modern Methods of Freshwater Aquaculture" under SCSP scheme was organized by ICAR-CIFE, Kolkata Centre at Rajbari Ramkrishna Ashram, Sandeshkhali, North 24 Parganas, West Bengal on 10 September, 2021. A total of 100 participants from Sandeshkhali-II of North 24 Parganas district participated in the programme. The training programme was inaugurated by Maharaj Swami Atmatyaganandaji of Ramkrishna Ashram. Mr. Dilip Kumar Mandal, Asst. Director of Agriculture, Gosaba, Govt. of West Bengal graced the programme as a guest of honor. Dr. G.H. Pailan, Principal Scientist & Officer-in-Charge delivered the welcome address. Different lectures on advanced practices of freshwater and brackishwater aquaculture, feed and feeding management in aquaculture were discussed in detail. Practical demonstration on feed preparation and water analysis was conducted. Farmers were also supplied with inputs such as pH test kits, aluminum hundies, fishing nets and caps for their aquaculture activities. The participants expressed their happiness and appreciation for the conduct of the training in a very simple and easy to understand way and receipt of the useful inputs for their farming. The training programme was covered by two widely circulated newspapers of West Bengal.

4.3 Programmes under North-Eastern Hill States

Under the NEH programmes, ICAR-CIFE conducted several training programmes. During 2021 a total of 6 awareness cum demonstration and training programmes were conducted at Arunachal Pradesh, Tripura, Manipur and Assam including a launch workshop. A total of 376 participants were benefitted. Dr. A. K. Balange was the nodal officer for conducting all the activities under this component. A descriptive summary of these programs are given below.

1. Training programme on Modern Methods for Sustainable Aquaculture at Lower Dibang Valley, Arunachal Pradesh

Coordinators: Dr. Dilip Kumar Singh and Dr. Suman Manna

A skill development training programme on "Modern Methods for Sustainable Aquaculture" for fish farmers was organized during 23 -25 February, 2021 by ICAR-CIFE, Kolkata Center in collaboration with KVK, Lower Dibang Valley at its office premises of Balek village. Mr. Nabam Tania, DFDO, Lower Dibang Valley as chief guest, inaugurated the programme. About 31 farmers of Lower Dibang Valley district, Arunachal Pradesh attended the programme. Five lectures on different topics and two practical sessions on farm-made feed preparation and water testing kits were demonstrated to the trainees during the programme. Field visit conducted at local area farmer fish pond of Lower Dibang Valley, Arunachal Pradesh. Dr. D. K. Singh, Scientist emphasized upon composite fish culture, fish health management and the importance of farm made aquafeed, utilizing locally available cheap feed ingredients to reduce the feed cost. Dr. Suman Manna, Scientist, mainly focused upon fish health management through rational feeding, soil & water quality monitoring and sustainable use of chemicals in aquaculture. Dr. Deepanjali Deori, Senior Scientist and Head, KVK, Lower Dibang, Valley expressed that this training would immensely benefit poor fish farmers to improve their livelihood by adopting modern methods to improve fish production. Cast nets were distributed to the 30 farmers. The training was highly appreciated with good feedback from the trainees and it was published in a newspaper 'The Dawnlit Post'.

2. Awareness program on Demonstration of Genetically improved fish for Tilla land farming at Bokafa Block of South Tripura district, Tripura

Coordinators: Mr. Dhalongsaih Reang

One day awareness program on "Demonstration of Genetically improved fish for Tilla land farming" for higher income of the selected SHGs of Bokafa Block of South Tripura district was organised by ICAR-CIFE, Mumbai on 15 March, 2021 at Krishi Vigyan Kendra, Birchandra Manu, South Tripura. The program was conducted in collaboration with KVK (ICAR) and the State fisheries department, Govt of Tripura. This program is conducted under the North East Hill region (NEH) component in a project mode. There were 25 numbers of participants belonging to 10 SHGs. The program was inaugurated by Superintendent of Fisheries of Santir Bazar subdivision Shri Jayanta Chakraborty and attended by Dr. Biswajit Debnath, Head and Senior Scientist, KVK, Birchandra Manu. Mr. Dhalongsaih Reang, Scientist, ICAR-CIFE, Powarkheda coordinated the program. Moreover, technical support was given by Dr. A K Balange, Dr. G H Pailan, Dr. S Munil Kumar and Dr. S K Nayak from ICAR-CIFE Headquarter and centers. Shri Jayanta Chakraborty emphasized on the role of women in fisheries and Dr. Biswajit Debnath presented his lecture on the status of fisheries in South Tripura. This program will continue in the next phase wherein the SHGs will be provided 10000 lit tarpaulin sheet tanks with GIFT tilapia and all the aquaculture inputs.

3. Training Programme on Modern Methods of Sustainable Aquaculture at Senapati district, Manipur

Coordinators: Dr. S. Munilkumar & Mr P. K. Behera

A skill development training programme on "Modern Methods of Sustainable Aquaculture" for Senapati District, Manipur was organized during 16-18th March, 2021 under NEH programme of ICAR-CIFE, Mumbai at Multipurpose Hall District Commissioner Office, Senapati, Manipur. The programme was conducted by ICAR- Central Institute of Fisheries Education, Kolkata Centre in collaboration with the Office of District Fisheries Officer (Senapati District), Department of Fisheries, Government of Manipur. The programme was inaugurated by the chief guest, Mr. A. Adahrii Maheo, Additional Deputy Commissioner, Senapati District, on 16th March 2021. He appealed to the farmers to learn the modern techniques of fish farming and contribute to society's upliftment. The programme's objectives were to impart knowledge on management for water quality and feed for sustainable Aquaculture. Various topics on pond construction, hatchery design, integrated fish culture, design construction of carp hatchery, and biofloc fish culture were covered during the programme. Demonstration of farm-made feed and water quality testing kits was conducted. A field was made to a successful seed farm at Hiyangthang and biofloc unit at Takyel in Imphal district. A total of 70 participants including 17 female trainees, attended the programme. Hiyangthang, Imphal west district for field demonstration of farm operation. The programme was facilitated by Mrs L. Sanatombi Devi, District Fishery Officer, Senapati district, Manipur and conducted by Dr S. Munilkumar, Principal Scientist, and Mr P.K. Behera Sr Tech Asst, ICAR-CIFE, Kolkata Centre. An illustrative manual on carp culture was also released. An animation film on "Composite Fish Culture" was shown to understand scientific fish farming for sustainable fish production. The programme attracted media attention from the local newspaper and TV channel, including Doordarshan.

4. Training program on Value added fish products preparation from freshwater fish at Tinsukia district, Assam

Coordinator: Dr A. K. Balange

A three days capacity building programme on Value added fish product preparation has been organized by ICAR-Central Institute of fisheries Education, Mumbai in Collaboration with Jeeva Suraksha, Sivasagar and Directorate of Extension Education, Assam Agricultural University, Khanapara, Guwahati on 4 to 6 October at Guijan, Tinsukia. Department of fishery, Govt Assam has constantly supported the programme via the District Fisheries office, Tinsukia. The programme was organized to impart hands-on training on hygienic handling of fish and preparation of different value-added fish products. Preparation of value added fish products like Fish pickle, fish chukli, fish sev, fish cutlet and dried fish snacks were demonstrated during the training programme. The Programme was inaugurated by Shri Punakon Baruah, Local MLA of Chabua Constituency who was highly satisfied with the infrastructure facility provided at Guijan and expected commercial production from the unit very soon. Over 80 participants of different age groups and backgrounds benefited from this training programme and were given the opportunity to prepare the fish products individually. The training was highly appreciated with good feedback from the trainees and it was published in several newspapers of the state, such as 'Pratikshan' and 'The Assam Tribune'.

5. Training program on Modern Methods of Freshwater Aquaculture at Lower Dibang valley, Arunachal Pradesh

Coordinator: Dr. D. K. Singh

A three-day Skill Development Training Programme on "Modern Methods of Freshwater Aquaculture" was organised during 22-24th November, 2021 by ICAR-CIFE, Kolkata Center in collaboration with KVK, Lower Dibang Valley at its office premises of Balek village, Roing, Arunachal Pradesh. Mr. Jatan Pulu, a progressive fish farmer and national awardee, Yibuk village participated as the chief guest and inaugurated the programme. He shared his experiences on traditional fish farming systems. Ms. Kime Janu, Fishery Officer, Roing, Lower Dibang Valley attended the inaugural programme as a special guest and briefed about various developmental schemes of Arunachal Pradesh Fisheries Department. Dr. Gouranga Biswas, Senior Scientist, ICAR-CIFE Kolkata Center delivered various classes as a resource person on composite fish culture, integrated fish farming methods, and fish health and disease management. Dr. Dilip Kumar Singh, Scientist, ICAR-CIFE, Kolkata Center delivered classes as a resource person on the importance of farm made aquafeed utilizing locally available cheap feed ingredients to reduce the feed cost and water quality management in aquaculture. He also practically demonstrated preparation of fish feed and analysis of water quality parameters. Dr. Deepanjali Deori, Senior Scientist and Head, KVK, Lower Dibang Valley expressed that this training would immensely benefit tribal fish farmers who lack knowledge on scientific fish farming to improve their livelihood by adopting modern methods of aquaculture. Mr. Jimmy Mize, Subject Matter Specialist (Fishery Science), KVK, Lower Dibang Valley briefed about various activities and services of KVK for the benefit of farmers. A total of 50 tribal fish farmers actively participated and received critical inputs for fish farming, such as fish feed, lime, live carp seeds and study materials from the organizers. The training was highly appreciated with good feedback from the trainees and it was published in several newspapers of the state, such as 'The Dawnlit Post' and 'The Arunachal'

6. Pilot Plant Launch Workshop of for value added fish products preparation under NEH project Guijan, Tinsukia district, Assam

Coordinator: Dr. A. K. Balange

Installation of Pilot plant facility for value added fish products preparation with a capacity of processing 200kg fish products per day at Guijan, Tinsukia, Assam. The facility was inaugurated on 8 October, 2021 and will provide a common facility for the women SHGs in that area. The inaugural programme was attended by eminent guests viz. Mr Sarfarz Haque, ADC, Tinsukia, Prof S P Biswas, Dibrugarh University, Dr. Rishi Das, Former Vice Principal, Tinsukia College, Sanjay Das, Member of Zila Parishad,Pranab Sharma, DFDO, Tinsukia, Suman Dutta, writer, Dhiraj Bikash Gogoi , entrepreneur, Jotin Konwar etc.

Preparation of value-added fish products which includes the basic information about importance of fish in human diet, different types of traditional and advanced methods of fish processing and preservation, complete recipe of different value-added fish products preparation etc. were discussed in the programme. The facility established at this place includes all the basic equipment necessary for preparation of those value-added fish products and has a capacity to produce about 150 kg of fish products daily. This facility can be utilized by the locals for processing and preservation of their fish produce in the form of different ready to eat convenience and nutritionally enriched value-added fish products which will help in enhancing their income and improving their social status as well- Dr Ranjita Bania from the local organization, Jeeva Suraksha informed and thanked the special efforts taken by the Principal project investigator Dr Amjad Balange, Principal Scientist and Mr Avinash Sable, Senior Technical Officer with the support and guidance of Dr Gopal Krishna, Director and Vice Chancellor of ICAR-CIFE, Mumbai. The activity was very well supported by Dr Atul Borgohain, Associate Director of Extension and team of Jeeva suraksha.

4.4 Skill Development Programmes (SDP) / In-plant Training

ICAR-CIFE has conducted several skill development programmes for various stakeholders such as farmers, entrepreneurs, fisheries professionals, research scholars and students through online, in-person and hybrid modes. During 2021 a total of 22 SDPs were conducted, including 3 in-plant training programs for students at Powarkheda Centre and 10 customised SDPs for Bihar fish farmers benefiting as many as 514 participants. A descriptive summary of these programs are given below.

1. SDP on Value Added Fish Products Preparation

Coordinator: Dr. A. K. Balange

CIFE's post-harvest technology lab has developed several value-added products such as coated shrimps, shrimp pickle, wafer, chakli, shev, papad, dehydrated shrimp, etc. that are regularly demonstrated to various stakeholders through various skill development programs. During this year, preparation, packaging and marketing of value added shrimp products were disseminated to Datiware fishermen cooperative society (6 January, 2021) in Palghar district, and to the women self-help groups in Rajapur (20 January, 2021) and Lanja (22January, 2021) in Ratnagiri district. A total of 154 participants have benefited from these programmes. The trained participants are now imparting training to more self-help groups and fisher societies resulting in further dissemination and popularisation of technologies. CIFE has received letters of appreciation for conducting these programmes from each society.

2. SDP on Basic and Advanced Computational Tools for Molecular Genetics

Coordinators: Dr. A. Pavan Kumar, Dr. M.P. Brahmane & Mr. Kiran D. Rasal

The hands-on training program on "Basic and Advanced Computational Tools for Molecular Genetics" was organized by Fish Genetics and Biotechnology Division, ICAR-CIFE, Mumbai from 16 - 22 February, 2021 in online and off-line modes. The training was directed by Dr. Aparna Chaudhari, Head, FGBD and coordinated by Dr. A. Pavan Kumar, Dr. M.P. Brahmane and Mr. Kiran D. Rasal. Thirty-two participants (14 men and 18 women) from various ICAR institutes (17) and ASUs/CAUs (15) such as ICAR-CIFRI, Barrackpore; ICAR-CIFA, Bhubaneswar; TNFU, Ponneri; Andhra University, SKAUST, Jammu, etc. participated in this program. Seven participants attended the training in-person following necessary precautions. During the inaugural function, Dr. Gopal Krishna, Director and VC, ICAR-CIFE addressed the participants and emphasized the importance of bioinformatics in current biological research. During this program, molecular basis of evolution, basic DNA sequence analysis, primer designing, DNA barcoding, phylogenetics, sequencing techniques, and NGS data analysis using Geneious Prime software, etc. were covered along with hands-on training on related techniques and software. A training manual was also distributed to the trainees. The pre- and post-training evaluation of trainees was performed and participants gained 50-60% improvement in their knowledge with regard to DNA sequence data analysis. The participants rated the training as excellent and appreciated that hands-on training was made available online. The training program was completed with certificate distribution during the valedictory function by Dr. Aparna Chaudhari, Course Director.

3. SDP on Preparation of leaf meals-based feed (Online)

Coordinator: Dr. Sikendra Kumar

The Fish Nutrition, Biochemistry and Physiology division has conducted a training on the "Preparation of leaf meals-based feed" from 16-19 February, 2021 on virtual mode. Total 23 no. of participants across different states of India participated in the programme. The training was given on Introduction about use of leaf meals in aqua-feed, proximate and anti-nutritional factors (ANFs) analysis of leaf meals, Fermentation of leaf meals and its nutritional and ANFs analysis, proximate analysis of leaf meal based feed & feed evaluation. The training was conducted very successfully with good feedback from participants.

4. SDP on Application of zebrafish as vertebrate model for biomedical studies

Coordinator: Dr N. S. Nagpure & Dr. Mujahidkhan A. Pathan

The Skill Development Programme on "Application of Zebrafish as Vertebrate Model for Biomedical Studies" was conducted during 23 February - 5 March, 2021 at Fish genetics and Breeding Division, ICAR-CIFE. Dr. Aparna Chaudhari was the Course Director, and Dr N. S. Nagpure and Dr. Mujahidkhan A. Pathan were the Coordinators. The program was inaugurated by Dr. Gopal Krishna, Director, ICAR-CIFE. Six participants from Haffkine Institute, Bombay Pharmacy College, ACTREC and MGM Medical College, Mumbai, attended the training program. All the participants use zebrafish as a model in their research. The topics included various applications of zebrafish as a vertebrate model, husbandry, breeding, embryogenesis and early development, genetic management of zebrafish, water quality management, disease surveillance in the culture facility, histology, in vivo and in vitro toxicity assays, microinjection of DNA into zebrafish embryos, transfection into cell lines, along with basic molecular biology techniques. A post training evaluation was also conducted and the participants performed extremely well. Head FGB Division distributed the certificates and the training manual on the final day of the training.

5. SDP on Statistics for Social Science Scholars (Online)

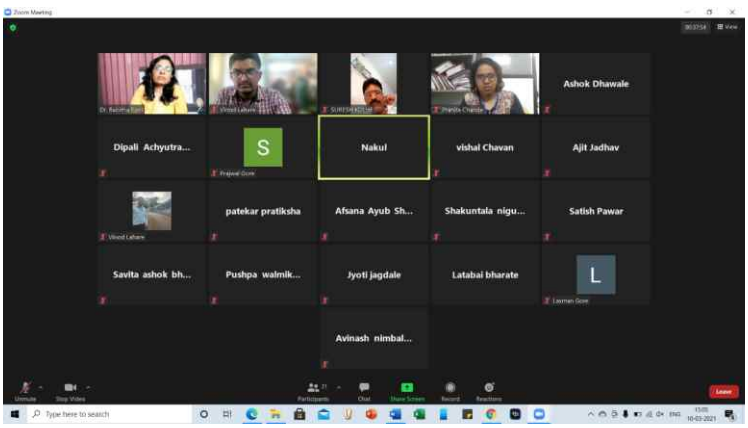
Coordinator: Dr. Shivaji Argade & Dr. Neha Qureshi

ICAR-CIFE organised a 4-week online customized "Field Experience Training" (FET) for a total of 22 MFSc (FEC and FEX) students and few interested Ph.D. students of FEES division entitled "Statistics for Social Science Scholars" from 23 February to 22 March, 2021 in collaboration with ICAR-Indian Agricultural Statistics Research Institute, New Delhi. The programme was customised to fulfil the needs of our students. Almost 15-18 theory and hands-on sessions were taken by eminent scientists of ICAR-IASRI on use of various quantitative and qualitative techniques for analysis using various software like R, SPSS and STATA.

6. SDP on Biofloc Technology in Fish Farming for Fisheries officials from Ahmednagar District, Maharashtra (Online)

Coordinator: Dr. Babitha Rani. A. M.

Division of Aquaculture, ICAR-CIFE, Mumbai organised a Skill development programme on "Biofloc Technology in fish farming" from 8-10 March, 2021 for participants and Fisheries officials from Ahmednagar District, Maharashtra. The programme was attended by 27 participants including officials who have registered for the programme. The programme began with an inaugural session and the participants were briefed with the details of the programme by course coordinator Dr. Babitha Rani. A. M. Participants expressed their expectations with the training programme and future support from the institute. The course contained theory and virtual practical sessions including various aspects of biofloc aquaculture such as overview, tank design and construction, inoculum development, carbon nitrogen ratio manipulation, feed management, water quality management, routine management, stress management, candidate species and economics of biofloc fish farming. The various aspects related to theory were virtually demonstrated too. The participants expressed their interest in starting the biofloc culture system at their respective places.



7. SDP on Molecular Taxonomy

Coordinator: Dr. A. Pavan Kumar & Dr. Kiran D. Rasal

A skill development program on "Molecular Taxonomy" was organised by Fish Genetics and Biotechnology division, ICAR-CIFE, Mumbai from 22 to 28 March, 2021. The training was directed by Dr. Aparna Chaudhari and coordinated by Dr. A. Pavan Kumar and Dr. Kiran Rasal. A total of 7 participants (5 boys and 2 girls) from several fisheries colleges participated in this program. Theoretical aspects on species concepts, molecular basis of evolution, DNA barcoding, phylogenetics and cyto-taxonomy were covered along with hands-on training on related techniques and software. The pre- and post-training evaluation of trainees showed 60-70% improvement in their knowledge in the field of training. The trainees expressed complete satisfaction with the course, but requested the course duration to be increased to 2 weeks since the subject was totally new to most of them. During the Valedictory Program Dr. Gopal Krishna, Director, ICAR-CIFE addressed the participants and emphasised the role of molecular tools in biodiversity characterization and conservation.

8. SDP on Biofloc Technology in Fish Farming (Online)

Coordinator: Dr. Babitha Rani. A. M.

Division of Aquaculture, ICAR-CIFE, Mumbai organised an Online Skill development programme on "Biofloc Technology in fish farming" from 16-18 July, 2021. The training programme was attended by 36 participants including entrepreneurs and farmers. The programme began with an inaugural session and the participants were briefed with the details of the programme by course coordinator Dr. Babitha Rani. A. M. The inaugural address was delivered by Head of the Division, Dr. N. K. Chadha and the participants expressed their expectations with the training programme and future support from the institute. The course contained theory and virtual practical sessions including various aspects of biofloc aquaculture such as overview, tank design and construction, inoculum development, carbon nitrogen ratio manipulation, feed management, water quality management, routine management, stress management, candidate species and economics of biofloc fish farming. The various aspects related to theory were virtually demonstrated too. The participants expressed their interest in starting the biofloc culture system at their respective places.

9. In-plant Training on Advances in Finfish Aquaculture, Breeding and Hatchery Management

Coordinator: Dr. Sunil Kumar Nayak, Mr. Dhalongsaih Reang & Dr. Harsha Haridas

ICAR-CIFE Powarkheda Centre conducted an in-plant training program for the students of College of Fisheries, NDVSU, Jabalpur. A total of 28 students comprising 11 female and 17 male students attended a 15 days in-plant training program on "Advances in Finfish Aquaculture, Breeding and Hatchery Management" from 5-19 August. The training schedule consisted of theory as well as practical classes. Students were given hands-on training on culture practices as well as breeding and seed production of finfishes.

10. In-plant Training on Recent advances in carp and catfish breeding and rearing

Coordinator: Dr. Sunil Kumar Nayak, Dr. Arun Sharma, Mr. Dhalongsaih Reang & Dr. Harsha Haridas

ICAR-CIFE, Powarkheda Center, conducted in-plant training on "Recent advances in carp and catfish breeding and rearing" was conducted from 20 August -20 October 2021. There were four female and eight male fourth-year BFSc students in the batch. The students were exposed to various day-to-day management practices in the field, including pre stocking, stocking and post stocking management, and various laboratory analytical protocols for molecular, soil and water analysis.

11. In-plant Training on Recent advances in carp and catfish breeding and culture

Coordinator: Dr. Sunil Kumar Nayak, Mr. Dhalongsaih Reang & Dr. Harsha Haridas

A two months training on "Recent advances in carp breeding and culture" was conducted by ICAR-CIFE, Powarkheda Center for students from COFRC, Etawa from 10 November, 2021 - 4 January, 2022. A total of 15 no. of students participated in this programme. The students were given hands-on training on best management practices in aquaculture as well as broodstock selection, induced breeding and seed production of common carp.

12. Professional Attachment Training on Impact of Microplastic on the environment and effects on the organisms

Coordinator: Dr. Gayatri Tripathi & Dr. Martin Xavier

Mrs. Garima, Scientist, ICAR-Directorate of Cold Water Fisheries, Bhimtal has undergone three-months Professional Attachment Training on "Impact of Microplastic on the environment and effects on the organisms" during 16 August - 1 December, 2021.

13. SDPs for Bihar Fish Farmers

ICAR-CIFE has been conducting customized training programmes specially designed as per the needs of fish farmers of Bihar. These training programmes are conducted at ICAR-CIFE's regional centers namely Kolkata, Kakinada and Powarkheda in batches. In spite of the Covid-19 related disruptions, 9 SDPs were conducted at ICAR-CIFE Kolkata Center and one at ICAR-CIFE Kakinada Center during 2021. A total of 151 fish farmers were trained through this customized training program.

13.1 SDP on Freshwater Fish Culture (*Mithe Pani Me Machli Palan*) at Kolkata Centre

ICAR-CIFE, Kolkata Center has conducted 9 skill development training programmes on Freshwater Fish Culture "Mithe Pani Me Machli Palan". A total of 126 fish farmers from Gaya, Vaishali, Kishanganj, Madhepura, Samastipur, Bhagalpur, West Champaran, Aurangabad and Buxar districts of Bihar participated and benefited from this training. Details of the programme are given below.

Name of Coordinators	Date	No. of Participants (District in Bihar)
Dr. Dilip Kumar Singh	2-8 September, 2021	15 (Gaya, Bihar)
Dr. Suman Manna	23-29 September, 2021	15 (Vaishali, Bihar)
Dr. S. Dasgupta	1-7 October, 2021	15 (Kishanganj, Bihar)
Dr. Gouranga Biswas	22-28 October, 2021	14 (Madhepura, Bihar)
Mrs. Sweta Pradhan	16-22 November, 2021	11 (Samastipur, Bihar)
Dr. G. H. Pailan	25 November – 1 December, 2021	15 (Bhagalpur, Bihar)
Dr. Sujata Sahoo	4-10 December, 2021	15 (West Champaran, Bihar)
Mrs. Husne Banu1	4-20 December, 2021	11 (Aurangabad, Bihar)
Dr. S. Munilkumar	21-27 December, 2021	15 (Buxar, Bihar)

13.2 SDP on Fish and Prawn Culture at ICAR-CIFE Kakinada Center

Coordinator: Dr. Muralidhar P Ande, Dr. Karthireddy Syamala & Dr. P. Srinivasa Rao

A seven days skill development training program on "Fish and Prawn Culture" for fish farmers of Patna District, Bihar was conducted during 14-20 December, 2021 by ICAR-CIFE, Kakinada Center. A total of 25 fish farmers participated in the programme. The farmers were given training on various aspects of freshwater fish culture, prawn culture, feed management and disease management. Field exposure visits were conducted to freshwater finfish hatchery and integrated farming systems were conducted to practically demonstrate the nursery management harvesting and packing procedures for Indian major carp and Magur.

13.3 Online Training Programmes

One day SDPs were conducted by ICAR-CIFE, Kolkata and Kakinada center as per the advice of the Ministry of Fisheries, Govt. of India. Several resource persons have contributed based on their area of expertise. A total of 300-500 participants were benefited by each training programme. Youtube links of every programme are available for the viewers. Details of the programmes are given below.

Name of Coordinators	Title of the training	Date
Dr. S. Munilkumar Dr. S. Dasgupta	Off season seed production & quality improvement	5 January, 2021
Dr. S. Datta Dr. Suman Manna	Management of soil & water quality in aquaculture	13 January, 2021
Dr. B. K. Mahapatra	Winter breeding & culture of ornamental fish Mr. Amit Dutta, District Fisheries Officer, Directorate of Fisheries, Govt. of West Bengal gave a lecture on Winter breeding of ornamental fish scope and constraints	18 January, 2021
Dr. Dilip Kumar Singh	Feed and feeding methods in aquaculture Dr. Shivendra Kumar, Associate Professor, College of Fisheries, Dholi gave a lecture on Quality and cost effective feed for aquaculture	22 January, 2021
Dr. S. Munilkumar Dr. S. Dasgupta	Diversification in aquaculture Dr A.K. Reddy, Retd Principal Scientist, Hyderabad gave a lecture on Freshwater prawn farming	30 January, 2021
Dr. Ashok Biswas Ms. Husne Banu	Health management of finfish & shellfish	2 February, 2021
Dr. Muralidhar. P Ande Dr. Karthireddy Syamala	Crab Fattening Mr. P. Koteswara Rao, Additional Director of Fisheries & Principal, State Institute of Fisheries Technology, Kakinada gave a lecture on "Present Scenario of crab culture in Andhra Pradesh"	5 February, 2021
Dr. S. Munilkumar Dr. K. Syamala	Live feed culture and feeding technique of ornamental fish	6 February, 2021
Dr. Parimal Sardar	Farm made fish feed Dr T. K. Ghoshal, Principal Scientist ICAR-CIBA, Kakdwip gave a lecture on Farm made feed preparation and its management in brackish water fish and shrimp culture	12 February, 2021
Dr. S. Munilkumar Dr. S. Dasgupta	Peri-urban aquaculture Dr. Subhendu Adhikari, Principal Scientist & Head, ICAR-CIFA, Rahara gave a lecture on Wastewater Aquaculture Dr. Anirban Chanda, Managing Director and Principal Consultant. Blue planet Urban Agro Services Pvt. Ltd. Kolkata gave a lecture on High density urban aquaculture with Aquaponics	20 February, 2021
Dr. S. Datta Dr. Suman Manna	Use of chemicals and their effect in aquaculture	27 February, 2021

Dr. Gayatri Tripathi Ms. Husne Banu	Ornamental fish diseases and their management	6 March, 2021
Dr. Dilip Kumar Singh Dr. Md Aklakur	Functional fish feed Dr. A. K. Pal, Former Joint Director, ICAR-CIFE, Mumbai, gave a lecture on Functional feed additives in aqua feeds	12 March, 2021
Dr. Gouranga Biswas	Multi-trophic Aquaculture Mrs. Kouberi Nath, Scientist, ICAR Research Complex for NEH region, Tripura gave a lecture on Freshwater integrated multi-trophic aquaculture	20 March, 2021
Dr. Muralidhar. P Ande Dr. Karthireddy Syamala	Better management practices for shrimp farming Mr. B. Ravi Kumar, General Manager, Growel feeds Pvt. Ltd gave a lecture on Feeds and feeding management in *Penaeus vannamei* farming	25 March 2021
Mrs. Husne Banu	Application of drugs and chemicals in aquaculture Dr. Sanjib Kumar Manna, Principal Scientist, ICAR-CIFRI, Barrackpore gave a lecture on Anti-microbial drugs and chemicals applied in aquaculture	
	Dr. Gadadhar Dash, Professor, WBUAFS, Kolkata gave a lecture on Methods of drug application in aquaculture	27 March, 2021
Dr. Muralidhar. P Ande Dr. Karthireddy Syamala	Alternative species for brackishwater aquaculture Dr. M. Sekar, Scientist, ICAR-CMFRI, Visakhapatnam Regional Centre, Andhra Pradesh gave a lecture on Cage culture of Indian Pompano and Orange spotted grouper	
	Dr. Dinakaran, Assistant Project Manager, RGCA, Karaikal, Tamilnadu gave a lecture on Culture practices of Lates calcarifer	27 March, 2021
Crab Fattening- in Telugu	Dr. Muralidhar. P Ande & Dr. Karthireddy Syamala,	30 March, 2021
	Mr. B. Suresh, Assistant Technical Manager, RGCA, Karaikal delivered a lecture on Nursery and grow-out culture of mud crab	
Mrs. Sweta Pradhan	Freshwater Pearl culture technology	6 April, 2021

4.5 Workshops, Seminars & Farmers Meet

1. National Fish Farmers' Day Programme (Bharat ka Amrut Mahotsav)

ICAR- CIFE at its headquarter and 5 regional centers, celebrated the national Fish Farmers Day on 10 July, 2021 by organizing online and offline programs on Ecosystem Management for Sustainable Fisheries in different languages. Eminent guests, officials and farmers were invited. The theme of this event was "Ecosystem Management for Sustainable Fisheries" as decided by the Fisheries Division, ICAR. A total of 500 persons participated.

1.1 ICAR-CIFE, Mumbai (HQ)

ICAR-CIFE, Mumbai organised the online National Fish Farmers' Day programme under the ongoing celebrations of Bharat ka Amrut Mahotsav. About 150 participants including students, staff and farmers/ fishermen were present. All the Regional Centres also participated along with farmers of 5 States. Dr. Mahesh K. Farejiya, Director General, Fish Survey of India was the Chief Guest on this occasion. He spoke on 'Marine Ecosystem Management for Sustainable Fisheries' and urged the fishermen to follow the guidelines of responsible fishing. Dr. Geetanjali Deshmukhe, Principal Scientist, FRHPHM Division, gave a talk on "Role of Mangroves in Sustaining Coastal Communities and Fishery in Maharashtra ". Mr. Vikas Koli, Bhoomiputra Foundation Versova shared his concerns and ideas on plastic pollution that is affecting the livelihoods of fishermen. Fish farmers from Bihar and Powarkheda shared their excitement about starting new fish hatchery/ aquaculture ventures. Dr. N. P. Sahu, Jt. Director, CIFE flagged the importance of environment and how the emphasis has now shifted to sustainable production. In his Presidential Address Dr. Gopal Krishna, Director and Vice-Chancellor, CIFE, spoke about the commitment of this Institute to work towards sustainability in a holistic manner combining quality education, meaningful research and committed extension. The event concluded with a vote of thanks by Dr. S. N. Ojha. The event was coordinated by Dr. Aparna Chaudhari (Coordinator, Bharat ka Amrut Mahotsav Celebrations, CIFE) and Dr. S. N. Ojha (Head, FEES Division, CIFE).

1.2 ICAR-CIFE, Kolkata Center

ICAR-Central Institute of Fisheries Education, Kolkata Center observed the National Fish Farmers' Day on 10 July 2021 to pay homage to pioneer Scientists, Prof. H. L. Chaudhuri and Dr. K.H. Alikunhi for their achievement on induced breeding in major carp. A total of 65 farmers from different parts of West Bengal participated in the programme on a virtual mode and the program was organized in local language (Bengali). At the beginning, Dr. G. H. Pailan, Principal Scientist and Officer-in-Charge welcomed all dignitaries and participants, and narrated the importance of the day. The programme witnessed the gracious presence of Dr. M.V. Rao, IAS, Additional Chief Secretary, Panchayat and Rural Development Department, Govt. of West Bengal, who inaugurated the programme and in his inaugural speech, he stressed on the development and dissemination of farmer-friendly technologies that will benefit large numbers of small and marginal farmers. Prof. Ratan Kumar Saha, Dean, College of Fisheries, Agartala delivered the keynote address on ecosystem approach for aquaculture and fisheries management. Five progressive fish farmers and entrepreneurs namely Mr. Milon Sinha, Mr. Tapan Maiti, Mr. Bablu Ghosh, Md. G. Mustafa and Mr. Supravat Dutta shared their experience on successful aquaculture ventures that are motivating to farmers. As a token of appreciation and encouragement, two progressive fish farmers, named Md. G. Mustafa and Mr. Bishnupada Mondal were felicitated with the Best Fish Farmers Award 2021. The participants appreciated the importance of celebration of this programme and interacted on their various issues related to fisheries and aquaculture. The programme ended with a vote of thanks proposed by Dr. Gouranga Biswas, Senior Scientist. On this occasion a plantation program was also organized in the institute campus.

1.3 ICAR-CIFE, Kakinada Center

ICAR-CIFE, Kakinada Center celebrated the National Fish Farmers day by organising a programme in the local language. Dr. Muralidhar P. Ande, Senior Scientist and Officer Incharge, ICAR-CIFE, Kakinada center gave the welcome address. Dr. K. Syamala, Scientist, ICAR-CIFE, Kakinada center delivered a speech on the significance of the theme. As a part of this programme two eminent speakers Dr. K. Shanmukha Rao, CEO, NaCSA, Kakinada delivered a talk on "Adoption of Better Management Practices in Aqua Societies for Sustainable Aquaculture" and Dr. A.K. Reddy, Principal Scientist (Retd.) delivered a talk on "Effective Management of Aquatic Resources for Sustainable Aquaculture". During this program two progressive farmers Shri. S.V.V. Dora Prasad Reddy and Shri. J. Nageswara Rao were identified as best progressive fish farmers. About 100 participants participated in the programme.

1.4 ICAR-CIFE, Rohtak Center

ICAR-CIFE, Rohtak Center celebrated National Fish Farmers Day. Around 50 participants including students, staff and farmers were present during this auspicious occasion. Smt. Asha Hudda, District Fisheries officer and Sri. Rakesh Kumar, Fisheries Officer from Department of Fisheries, Rohtak was the Chief Guest for this programme. Officer-in- charge gave the inaugural address and delivered the National Fish Farmers' Day message to all the attendees and remembered the contribution made by Dr. Hiralal Chaudhuri and Dr. K.H. Alikunhi for successful revolution in fish seed production by introducing hypophysation technique (Induced Breeding). The Chief Guest spoke on various existing policies & schemes for fisheries under PMMSY. A speech was delivered on sustainable fisheries and ecosystem management by Shri. Rakesh Kumar.

1.5 ICAR-CIFE, Powarkheda Center

ICAR-CIFE, Powarkheda Center celebrated National Fish Farmers Day. 35 farmers visited the Center to attend the online programme conducted by Mumbai HQ. Later, an offline program was organized at the Center. The Chief Guest of the function was Ms. Priyanshi, Fisheries Extension Officer, Department of Fisheries, Hoshangabad, M.P. Dr. Sunil Kumar Nayak, OIC, CIFE Powarkheda Center welcomed the guests and spoke about the importance of the occasion and Center's activities in M.P. State. The Chief Guest stressed the coordination among research institutes, State administration and farmers for effective communication and transfer of technology. Mr. Dhalongsaih Reang, Scientist, ICAR-CIFE, Powarkheda Center reminded about the contribution of Dr. C. H. Alikunhi and Dr. Hiralal Choudhari to national fisheries sector. Mrs. Harsha Haridas, Scientist, ICAR-CIFE, Powarkheda Center pointed out the importance of adopting eco-friendly aquaculture practices such as Biofloc technology and integrated farming to enhance maximum production from minimum resources in a sustainable manner. Mr. L. P. Bamaliya, ACTO, ICAR-CIFE Powarkheda Center proposed the vote of thanks. The program ended with the pledge to conserve productive ecosystems for sustainable aquaculture.

1.6 ICAR-CIFE, RRTC Motipur Center

The celebration of National Fish Farmers Day under the Bharat Ka Amrut Mahotsav, a national campaign on ecosystem management and sustainable fisheries was done on 10 July, 2021. A technical discussion for creating awareness on wetland in Bihar and its management was conducted in local language. The program started with the theme discussion was done by OIC, RRTC Motipur Dr. Md. Aklakur, followed by remarks of Dr. S. N Ojha Nodal Officer RRTC Motipur. A detailed presentation on State fisheries policies and PMMSY was given by Mr. Nishat Ahmed, Jt. Director Department of State Fisheries, Bihar. Fish farmers and entrepreneurs enquired about new technologies in aquaculture and associated issues. Dr. Md Aklakur delivered a talk on wetland and aquatic resource conservation. Dr. N P Sahu, Jt. Director ICAR-CIFE, stressed the importance of ecosystem management and aquatic environment conservation in his speech. The program ended with a vote of thanks by Dr. Aklakur.

2. Awareness Program on Value Added Product Preparation from Fish and Shellfish, and Marketing

National Agricultural Innovative Fund (NAIF) - Agri-Business Incubation (ABI) project organized demonstration program on 'Value added product preparation from fish and shellfish, and marketing' for women SHG at Purnagad, Ratnagiri, and Ratnagiri city, Maharashtra on 6-7 August, 2021 respectively. Total 55 participants participated in the programs. Women from different Self Help Groups registered for the program that was conducted in coordination with College of Fisheries, Ratnagiri and 'Ratnagiri Jilha

Prasadik Bhajan Mandal, Abhar Sanstha, Ratnagiri'. A Youtube link (https://youtu.be/rfIN-6WqDY8) for this training program was also prepared for wider publicity. The participants were briefed about the importance of value addition in fish, its quality aspects and marketing strategies. The role of ABI was also explained to them for incubation of interested women SHGs in future. The participants got hands-on training for preparing different value added products like shrimp pickle, fish shev, fish chakley, fish cutlet, prawn wafers, jawla chatney, etc. The program was technically supported by Mr. Bhanudas Phande and Ms. Snehal Shitole and co-ordinated by Dr. B. B. Nayak and Dr. A. K. Balange under the guidance of Dr. Gopal Krishna, Director and Vice Chancellor, CIFE, Mumbai.

3. Sensitization and Awareness Programme

National Agricultural Innovation Fund (NAIF) – Institute Technology Management Unit (ITMU) and Agri Business Incubation (ABI) Center, organized a sensitization and awareness programme on 12 November, 2021 in hybrid mode. A total of 55 participants attended the programme. Dr. B. B. Nayak, Incharge – ITMU & Head, Fisheries Resources Harvest and Post-Harvest Management Division welcomed all the guests and briefed about the program. The programme was preceded by Dr. N.P. Sahu (Director, ICAR – CIFE), where he urged students to focus on entrepreneurship and appreciated efforts of ITMU and ABI committee members for organizing awareness programmes for encouragement of student's entrepreneurship development. The invited guests were Dr. Vikram Singh, (Scientist-Agril Extension, IP & TM UNIT, ICAR, New Delhi) delivered a talk on "Innovation ecosystem in India and its relevance to Start-ups" and Dr. K.S. Mayadevi (Deputy General Manager, NABARD, Mumbai Office) on "Entrepreneurial and Managerial Development through Incubation" to the Agri Business Incubation (ABI) incubatees and students of ICAR – CIFE. A vote of thanks was given by Dr. Arpita Sharma, Principal Scientist, FEES Division.

4. National Campaign on Antimicrobial Resistance in Fish (Online)

ICAR- Central Institute of Fisheries Education (ICAR-CIFE), Mumbai organized several activities on one of the most relevant topic- Antimicrobial Resistance (AMR) in Fish as part of National Campaign on AMR coinciding with World Antimicrobial Awareness Week (18-24 November). A Webinar on "National Campaign on Antimicrobial Resistance in Fish", an awareness campaign on antimicrobial resistance and student poster competition was organised during 22-23 November, 2021.

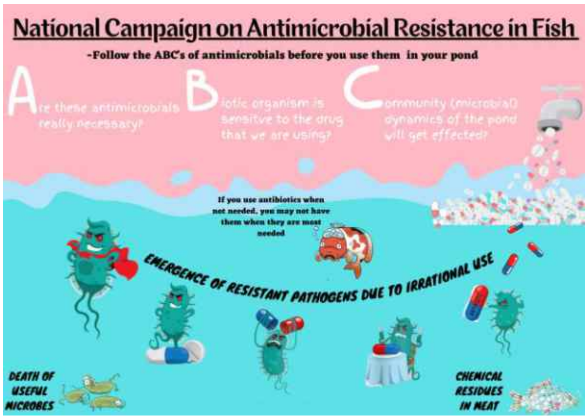
4.1 Webinar on National Campaign on Antimicrobial Resistance in Fish

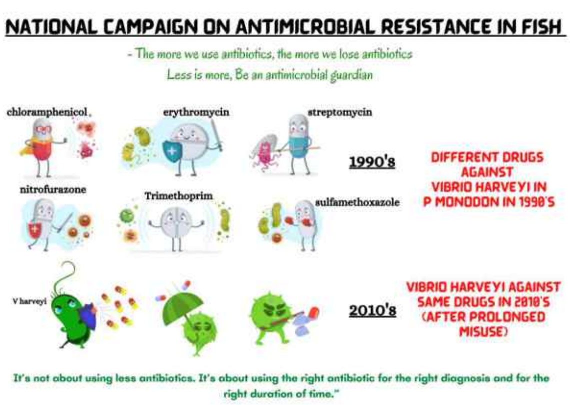
The webinar started with a welcome address by Dr. N. P. Sahu, Director (Acting) ICAR-CIFE. He welcomed the Chief Guest Dr. Joy Krushna Jena, Deputy Director General (Fisheries Science), ICAR, New Delhi. He also welcomed three invited speakers, Dr. Sher Ali, Distinguished Professor, Dept. of Life Sciences, Sharda University, Greater Noida & (Retd) Head, Molecular Genetics Division NII, New Delhi, Dr. Indrani Karunasagar, Director (Project & NuTEC), Nitte University, Mangalore and Dr. K. Pani Prasad, Principal Scientist, Aquatic Environment & Health Division, ICAR-CIFE. Participants from various research institutes and students from Universities were also welcomed to the event.

The Chief Guest Dr. J.K Jena, Deputy Director General (Fisheries Science), ICAR deliberated on the initiatives taken by ICAR in addressing AMR. He briefed on the National Action Plan to combat Antimicrobial Resistance (AMR). He elaborated on the network which has been named as the Indian Network for Fisheries and Animal Antimicrobial Resistance (INFAAR). The role of ICAR in creating INFAAR with technical and financial support from FAO in forging a network of laboratories from different parts of India to undertake surveillance of AMR in animal health and fisheries sectors was emphasized. Three experts from this scheduled webinar gave an elaborative presentation on the topics such as "Mechanisms of Antimicrobial Resistance in Bacteria" by Dr. Sher Ali. The second speaker Dr. Indrani Karunasagar spoke on "Antimicrobial Resistance in Fish: In the Context of OneHealth" and the last presentation was from Dr. K. Pani Prasad on the topic "Overview of AMR in Fisheries and Aquaculture in India: Status and Way Forward".A total of 250 participants from all over the country representing various Universities and research institutes participated in the webinar.

4.2 Awareness Campaign on AMR & Students Competition

The awareness program was especially organised for Administrative, Technical and Contractual Staff (including data entry operators and lab/ housekeeping/ garden workers). Dr. Aparna Chaudhari, Nodal Officer, Bharat ka Amrut Mahotsav welcomed the Chief Guest Dr. Arun Kumar (M.B.B.S) who explained the consequences of misusing antibiotics and other drugs. Dr. N. P. Sahu. Director (Acting) addressed the audience and simplified the message so that everyone could understand. A total of 500 participants attended this awareness program from headquarter and all the centers. ICAR-CIFE, Students have also contributed in creating awareness on AMR through the poster presentations.





Fishers/Farmers' Meet

Fishers/Farmers' Meet / Online Webinars Organised

Title	Name of Coordinators	Date and Place	Approx. No. of farmers registered Total (Male+ Female)
Lecture on Filing a Patent Application, Prosecution and Grant of Patent in India by Mr. Samprati Basant, (Patent Attorney, KAN AND KRISHME, West Delhi, Delhi, India)	Organizing Secretary: Dr. N.P. Sahu Cordinators: Dr. Rupam Sharma Dr. Shashi Bhushan Dr. Saurav Kumar Dr. Shamna Mr. D. Bhoomaiah	23 January, 2021 Online (ICAR-CIFE, Mumbai)	63+22 = 85
Biofloc Vidhi Se Machli Palan Evam Prabandhan	Dr. Md.Aklakur	4 February, 2021 (ICAR-CIFE, Motipur)	369
Water quality management in Inland saline shrimp farming	Mr. V. Harikrishna, Dr. Pankaj Kumar, Dr. Sreedharan K, Mr. Satya Prakash Mr. Ashok Kumar	15 February, 2021 Online (ICAR-CIFE, Rohtak)	57+51= 108
Nutrition and feed management practices in inland saline aquaculture	Mr. V. Harikrishna Dr. Pankaj Kumar Dr. Sreedharan K Mr. Satya Prakash Mr. Ashok Kumar	16 February, 2021 Online (ICAR-CIFE, Rohtak)	57+51= 108
Disease and health management in shrimp farming	Mr. V. Harikrishna Dr. Pankaj Kumar Dr. Sreedharan K Mr. Satya Prakash Mr. Ashok Kumar	17 February, 2021 Online (ICAR-CIFE, Rohtak)	57+51=108
आधुनिक मत्स्यपालन एवं प्रबंधन	Dr. Md.Aklakur	22 February, 2021 (ICAR-CIFE Motipur)	77
मत्स्य आहार प्रबंधन	Dr. MdAklakur	24 February, 2021 (ICAR-CIFE Motipur)	251
Farmer Field School-cum-Awareness Programme	Dr. G.H. Pailan Dr. G. Biswas	25 February, 2021 Dhamua, Block, South 24 Parganas, W.B	28+2= 30 .
Lecture Blue finance to support small-scale fisheries by Ms. Suchitra Upare (FAO consultant, CAFI-SSF Network, New York Area, USA)	Organizing Secretary: Dr. N.P. Sahu Cordinators: Dr. Rupam Sharma Dr. Shashi Bhushan Dr. Saurav Kumar Dr. Shamna Mr. D. Bhoomaiah	26 February, 2021 Online (ICAR-CIFE, Mumbai)	53+41= 94

Lecture (Hindi) on "Basic Concepts of Aquaculture Economics" for tribal youth of Nashik District	Dr. Arpita Sharma	2 March, 2021	30
Awareness-cum -Exhibition Programme on 'Aquaculture as a Potential Livelihood Option for Tribal Communities' under Tribal Sub-Plan	Dr Shivaji Argade Dr Ankush Kamble Dr MP Brahmane	19 March, 2021 Krishi Vigyan Kendra Narayangaon (Pune)	300
Valuing Water: Conservation and Management	Organizing Secretary: Dr. N.P. Sahu Cordinators: Dr. Parimal Sardar Dr. Rupam Sharma Dr. A. Pavan Kumar Dr. ShashiBhushan Dr. Saurav Kumar	22 March, 2021 Online (ICAR-CIFE, Mumbai)	69+31=100
Inland saline aquaculture management practices	Shri. V. Harikrishna Dr. Pankaj Kumar Dr. Sreedharan K Shri. Satya Prakash Shri. Ashok Kumar	26 March, 2021 Online (ICAR-CIFE, Rohtak)	17+16=33
"Role and contribution of industry in the growth of aquaculture" by Dr. Thomas Gitterle (Breeding and Genetics Director, Regal Springs, Florida)	Organizing Secretary: Dr. N.P. Sahu Cordinators: Dr. Rupam Sharma Dr. Shashi Bhushan Dr. Mujahidkhan A. Pathan Nodal Officer: Dr. Gayatri Tripathi	28 May, 2021 Online (ICAR-CIFE, Mumbai)	66+34=100
National campaign on "Ecosystem management for sustainable fisheries"	Dr. Muralidhar. P Ande Dr. KarthireddySyamala Dr. P. Srinivasa Rao Mr. R.R.S. Patnaik	10 July, 2021 (ICAR-CIFE, Kakinada)	100
National fish farmer's day celebration. The theme for the event is "Ecosystem management for sustainable fisheries"	Dr. Sunil Kumar Nayak Mr. Dhalongsaih Reang Mrs. Harsha Haridas	10 July, 2021 (ICAR-CIFE, Powarkheda)	35

Professional Practice in Aquaculture Lecture Series by SAP to University Students	Dr. BB Nayak Dr Gayatri Tripathi Dr A K Balange	17 July - 21 August, 2021 Online (ICAR-CIFE)	65+70 = 135
Bharat ka amrut mahotshav webinar on Diversification in Aquaculture systems	Dr. Sunil Kumar Nayak Mr. Dhalongsaih Reang Mrs. Harsha Haridas	1 September, 2021 (ICAR-CIFE, Powarkheda)	38
Honourable Prime Minister, Scientist, Fish Farmar and Fisher Meet	Dr. Md Aklakur	28 September, 2021 (ICAR-CIFE, Motipur)	175
Hon'ble Prime Minister meet (Scientists, Fish farmers and Fishers' Meet)	Dr. Muralidhar. P Ande Dr. Karthireddy Syamala	28 September, 2021 (ICAR-CIFE, Kakinada)	85
Hon'ble Prime Minister-Scientists- Fish Farmers and Fishers Meet on Climate Resilient Agricultural Technologies and Methodologies	All scientist	28 September, 2021 (ICAR-CIFE, Kolkata)	44+10 = 54
Farmers scientists interface on Climate Resilient varieties, technologies and practices	Mr. Dhalongsaih Reang Mrs. Harsha Haridas	28 September, 2021 Platinum Hotel, Hoshangabad	102
World fisheries day celebration	Dr. Sunil Kumar Nayak Mr. Dhalongsaih Reang Mrs. Harsha Haridas	21 November, 2021 (ICAR-CIFE, Powarkheda)	40
National campaign webinar on Antimicrobial resistance in fish	Dr. Sunil Kumar Nayak Mr. Dhalongsaih Reang Mrs. Harsha Haridas	22 November, 2021 Online (ICAR-CIFE, Powarkheda)	30
Natural farming addressed by shri prime minister at pre vibrant Gujarat summit - 2021 Anand	Dr. Sunil Kumar Nayak Mr. Dhalongsaih Reang Mrs. Harsha Haridas	16 December, 2021 Online (ICAR-CIFE, Powarkheda)	39
Celebration of Kisan Diwas on Water management under Swachhta Pakhwada	Dr. Sunil Kumar Nayak Mr. Dhalongsaih Reang Mrs. Harsha Haridas	23 December, 2021 (ICAR-CIFE, Powarkheda)	42

4.6. Invited Lectures Delivered in other Universities/Institutes Including Invited Online Lectures

Name of the faculty	Title of lecture delivered	Name of university / place etc.	Date
Dr. K.A. Martin Xavier	Mince and Mince based products	KUFOS, Kochi	20 January, 2021
Dr. Md. Aklakur	Priciples and application of biofloc technology	Jharkhand Department of Fisheries	27 January , 2021
Dr. Kiran Rasal	Recent Advances in Fish Biotechnology to BFSc students	College of Fisheries, JAU, Veraval, Gujarat	28 January, 2021
Dr. K. Syamala	Mass culture techniques of live food for ornamental fish	ICAR-CIFE Kolkata Centre	06 February, 2021
Dr. Arpita Sharma	We Are Feeding the Nations That's Why She Matters' in the SHEsciences#GWB-21-Global Women's Breakfast-21	Sal College of Engineering, Ahmedabad	9 February, 2021
Dr. Shivaji Argade	Gender & livelihoods in agriculture	VAMNICOM, Pune	9 February, 2021
Dr. G. H. Pailan	Scientific Aquaculture practices	WBUAFS, Kolkata	10 February, 2021
Dr. G. Biswas	Overview of brackishwater aquaculture with reference to feed management (Bengal Fishermen Orientation and Exposure Meet 2021)	Minakhan, North 24 Parganas, West Bengal	18 February, 2021
Dr. Sunil Kumar Nayak	Basic of fishery, Shrimp farming, Feed and medicine, demonstration of good aquaculture	NGO at Bhopal, Madhya Pradesh, under Agri Clinics and Agri Business Centre Scheme, Manage, Hyderabad	18 February, 2021
Dr. Arpita Sharma	Convergence of Government Organisations, Community and Corporate Social Responsibility in Fisheries and Aquaculture for Sustainable Livelihood Development	KVK, ICAR-IVRI, Izatnagar	20 February, 2021
Dr K.K.Krishnani	Abiotic stresses and their management in aquaculture	ICAR-NIASM, Baramati	20 February, 2022
Dr. Shivaji Argade	Gender analysis tools in agriculture	ICAR-CIWA, Bhubaneswar	
Dr. Karan kumar R.	Ph.D. Disciplines in Fisheries Science and avenues	College of Fishery Science , Udgir	24 February, 2021
Dr. Sunil Kumar Nayak	Importance of fish biodiversity and their culture technology	Government Kusum College, Hoshangabad, Madhya Pradesh	26 February, 2021
Dr. BabithaRani. A.M	Refresher course on biofloc technology	Department of Fisheries, Govt. of Kerala, Kollam, Kerala	1 March, 2021

Dr. Arpita Sharma	Social Construction of Gender	Department of Fisheries, Government of India	8 March, 2021
Dr. Sunil Kumar Nayak	Machalipalan ki adhunik taknik	College of fisheries Science, NDVSU, Jabalpur, Madhya Pradesh	8 March, 2021
Dr. Sunil Kumar Nayak	*Machalike beej evam unke paribahansambandhi jankari*	College of fisheries Science, NDVSU, Jabalpur, Madhya Pradesh	10 March, 2021
Dr. Karankumar R.	PhD Disciplines in Fisheries Science and avenues	College of Fishery Science , Nagpur	10 March, 2021
Dr. Rupam Sharma	Nanotechnology: Biotechnological applications and Toxicity	VIT, Vellore	20 March, 2021
Dr. Kiran Rasal	Fish Genetics and Bioinformatics to BFSc students for JRF preparation	College of Fisheries, CAU, Tripura	22-26 March, 2021
Dr. Shivaji Argade	Mainstreaming gender in agriculture and allied areas	VAMNICOM, Pune	23 March, 2021
Dr. S. Munilkumar	Culture of fish food organisms and its role in fish seed production	College of Fisheries, CAU Tripura	25 March, 2021
Mr. Satya Prakash	Preparation strategies for Aquaculture section of ICAR-JRF entrance test (online mode)	College of Fishery Science- Jabalpur	28 March, 2021
Abuthagir Iburahim	Cracking JRF examination	College of Fisheries Lembucherra, Agartala	31 March - February, 2021
Dr. K. Syamala	PCR techniques in Aquaculture	Bvoc Fisheries, Ideal College, Kakinada, AP	3 April, 2021
Dr. Muralidhar P. Ande	Feed Formulation; Feed manufacturing & Feed storage	Bvoc Fisheries, Ideal College, Kakinada, AP	3 April, 2021
Dr. K.K.Krishnani	Biotechnological interventions for environmental and health management of Integrated Agri-aquaculture systems and culture based fisheries.	Birla Institute of Scientific Research (BISR), Jaipur	5 April, 2021
Dr. Sunil Kumar Nayak	Basic of fishery, Shrimp farming, Feed and medicine,demonstration of good aquaculture	NGO Bhopal, Madhya Pradesh	16 April, 2021
Dr. B. K. Mahapatra	Recent Advances in Fisheries & Aquaculture Technology for Sustainable Rural Development	WBUAFS, Kolkata and NADCL, Baramulla	25 May, 2021

Dr. N.P.Sahu	Invited a lecture on simple Technological intervention for enhanced utilization of Farm-made feed as a strategy for sustainable rural development	Online	28 May, 2021
Dr. G. H. Pailan	Feed and Feeding Strategies in Aquaculture	WBUAFS, Kolkata and NADCL, Baramulla	28 May, 2021
Dr. G. Biswas	Brackishwater aquaculture technologies and their contribution to blue economy	WBUAFS, Kolkata NADCL, Baramulla	3 June, 2021
Mr.Abuthagir Iburahim	Ecopreuneurship-A conservation based revenue approach	Dr.M.G.R. Fisheries College and Research Institute, Thalainayeru	8 June, 2021
Dr. Muralidhar P. Ande	Mangrove ecosystem: A rich biohabitat	Indian Coast Guard Station, Kakinada, AP	10 June, 2021
Dr. Sunil Kumar Nayak	Fresh water aquaculture-an overview	Pashu Vigyan Kendra, Sriganaga nagar, Bikaner	16 June, 2021
Dr. Md. AKLAKUR	Biofloc culture	College of Fishries Jabalpur	19 June, 2021
Dr. Sanath Kumar H	Casting into the future of aquaculture and fisheries	Centurion University of Technology and Management, Odisha	23 June, 2021
Dr. A. Pavan Kumar	Application of DNA markers for Sustainable Fisheries and Aquaculture	Centurian University of Technology and Management, Odisha	23 June, 2022
Dr. Mujahidkhan. A. P.	Fish Breeding Plans	Dr. MGR.FC&RI, TNFU	28 June, 2021
Dr. Pankaj Kumar Dr. Sreedharan K	White shrimp culture	Department of Fisheries, Government of Haryana, Siwani, Bhiwani, Haryana	4 July, 2021
Dr. Md. Aklakur	Ecosystem Management for Sustainable Fisheries	ICAR-CIFE, Motipur Centre	10 July, 2021
Dr. Paramita B. Sawant	The 3 C's (Conserve, Cultivate and Commercialize) perspective for promotion of native ornamental fishes	Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Dr. M.G.R. Fisheries College and Research Institute, Ponneri, Tamil Nadu	14 July, 2021
Dr. Kiran Rasal	Fundamentals of Biotechnology and Bioinformatics to BFSc students	College of Fisheries, AAU, Raha, Assam	14-16 July, 2021
Dr. Babitha Rani A.M	Biofloc technology and its applicability in North East India	NFDB, Guwahati Centre	15 July, 2021
	Biofloc Technology and its application in north eastern region of India	NFDB, Hyderabad	15 -16 July, 2021

Dr. K.V. Rajendran	Tilapia Lake Virus: An Update	Hawassa University, Ethiopia	15 July, 2021
Dr. B. K. Mahapatra	Some Commercial important Ornamental Fishes of India"	College of Fishery Science, NDVSU,Jabalpur	19 July, 2021
Dr. Sunil Kumar Nayak	Basics of fisheries and aquaculture Feed and disease management	CARD, NGO, Bhopal, Madhya Pradesh (under ACABC scheme, MANAGE)	3 August, 20 August, 31 August, 09 September, 13 October, 30 November
		Dr. MGR Fisheries College and Research Institute, Thalainayeru, Tamil Nadu	
Dr. Sunil Kumar Nayak	*Machali evam machalike beej ke lie paribahan prabandhan*	College of Fisheries Science, NDVSU, Jabalpur, Madhya Pradesh	4 August, 2021
Dr. Babitha Rani.A.M	Biofloc Aquaculture	Bharatidasan University, Thiruchirappally, Tamil Nadu	9 August, 2021
Mr. Abuthagir Iburahim	'JRF Mock Test Series 2021'	AIASA: Fisheries Chapter	10 August, 2021
Dr. Shivaji Argade	ARS tutorials on gender and empowerment	MPKV, Rahuri	12 August, 2021
Dr. Shivaji Argade	ARS tutorials on gender issues and development	MPKV, Rahuri	14 August, 2021
Dr.Suman Manna	Importance of Soil and Water quality parameters in sustainable aquaculture (online)	AIC- Bihar Vidyapith,	6 September, 2021
Dr. Kapil S. Sukhdhane	Cage Farming in Reservoirs	Agri Diskha Portal	6 September, 2021
Dr. Sunil Kumar Nayak	Fish production strategies and sustainable aquaculture	MSME, AIC, Bihar Vidyapith, supported by NITI aayog, GOI	7 September, 2021

Mrs. Shobha Rawat	Application of block chain technology in fisheries	Agri Diskha Portal	7 September, 2021
Dr. Gayatri Tripathi	Recombinant activity gene: An analysis of expression profile during development stages of Pterophyllum scalare	World Congress on Infectious Diseases, Rome, Italy.	7 September, 2021
Dr. BabithaRani.A.M	Biofloc technology in Aquafarming : The relevance in commercial aquaculture and research	Bharatidasan University, Thiruchirappally, Tamil Nadu.	9 September, 2021
Dr. Sanath Kumar H	Antimicrobial resistance in the food production environment: challenges and mitigation strategies (e-training on Advances in Aquatic Animal Health and Environment Management)	GADVASU, Ludhiana, Punjab, India	10 September, 2021
Dr. Saurav Kumar	Ecotoxicology: Scope and approaches	Agri-Diksha portal	14 September, 2021
Dr. Madhuri Pathak	Reproductive biology and reproduction behaviour in crab	Agri Diskha Portal	15 September, 2021
Dr. Shivaji Argade	Women entrepreneurship and collective actions: transforming gender relations	ICAR-CIWA, Bhubaneswar	17 September, 2021
Mr. Abuthagir Iburahim	Artificial Intelligence in Fisheries	Agri Diskha Portal	17 September, 2021
Dr. Megha Bedekar	Use of vaccination in fish	Conferentous Global Pvt Ltd , VCNMDD	20 September, 2021
Dr. Arpita Sharma	Circular Economy in Fisheries and Aquaculture	The World Fisheries Congress 2021 Sharing Our Oceans and Rivers Organised by Australian Government) Adelaide, Australia (Online)	20 September, 2021
Dr. Sreedharan K	Diagnostic procedures for the isolation of pathogenic bacteria from fish & shrimp (online mode)	St. Josephs College, Irinjalakuda, Kerala	21 September, 2021
Mr. Dayal Devadas	Ecosystem based fisheries management-Part 1	Agri Diskha Portal	21 September, 2021
Mrs. Vidhya.V	Ecosystem based fisheries management-Part-2	Agri Diskha Portal	21 September, 2021
Dr. K.V. Rajendran	Return of Tiger - Exploring Sustainability	Coastal Aquaculture Authority, Chennai	22 September, 2021
Dr. Balange A K	Utilization of low-cost fish for value addition (Lead Speaker)	College of Fisheries, Central Agricultural University, Lembucherra, Agartala	27 September, 2021

Dr. Karan Kumar R.	Aquatic Telemetry in fisheries management	Agri Diskha Portal	27 September, 2021
Dr. Babitha Rani.A.M	Biofloc Technology In Inland Aquaculture: A Sustainable Way Forward (online)	Tamil Nadu J Jayalalita Fisheries University, KVK, Nagapattinum	30 September, 2021
Mr. V. Harikrishna	Inland saline shrimp farming	DFTC Enakhera, Malout, Sri Muktsar Sahib, Punjab	4 October, 2021
Dr. Megha Bedekar	Opportunities and Advancement for Fish Vaccine Development: Special mention to vaccine delivery using nanoparticals	vaccine-2021@ eruditionsummit	19 October,2021
Dr. Megha Bedekar	Fundamentals of Fish Immunology	NDVSU, College of Veterinary Science; Animal Husbandry Department of veterinary microbiology, Mhow, Madhya Pradesh	26 October, 2021
Dr. K.A. Martin Xavier	Extraction of chitin and chitosan from crustacean waste and its derivatives and applications	Cochin University of Science and Technology, Kochi, Kerala	20 October, 2021
Dr. MD Aklakur	Biofloc technology based aquaculture	Bihar State Depatment of Fisheries	15-18 November, 2021

Dr. G. H. Pailan	Nutrition and feed management in Freshwater aquaculture	ICAR-CIBA, Kakdwip, W.B.	18 November,2021
Dr. B. K. Mahapatra	i.Ornamental Fish Farming ii.Post HarvestManagenent of Ornamental Fish	NCDC	24 November,2021
Dr. B. K. Mahapatra	New Dimension in Aquaculture Technology	Department of Fishery Sciences, Vidyasagar University	10 December,2021
Dr. K. V. Rajendran	Fish Microbiome and Immunome	ICAR-Central Marine Fisheries Institute, Kochi	20 December,2021
Dr. G. Biswas	Innovative Farming Technologies of Brackishwater Fishes	ICAR-CIBA, Kakdwip, W.B.	20 December,2021
Dr. G. Biswas	Nursery Rearing Technologies of Brackishwater Fishes	ICAR-CIBA, Kakdwip, W.B.	20 December, 2021
Shri. V. Harikrishna	Inland saline shrimp farming	Office of BDO, Kolayat, Bikaner, Rajasthan	21 December,2021
Dr. Paramita B. Sawant	Ocean and water pollution and cleanliness initiatives	Versova Welfare Association High School, Mumbai	22 December,2021
Dr. Babitha Rani.A.M	Biofloc technology in inland aquaculture	Regional Research centre of Taraporewala Marine Biolgical Research Station	24 December,2021
Dr. Babitha Rani. A. M	Biofloc adaptation for inland aquaculture	Webinar on The art and science of biofloc technology	24 December,2021
Dr. A. Pavan Kumar	Biotechnological Tools for Forensic Studies	Kendriya Vidyala Sangathan, Zonal Institute of Education & training (Online)	27 December, 2021
Dr. G. H. Pailan	Livelihood Opportunities in Freshwater Aquaculture for Marginal Farmers	South Asian Forum for Environment (SAFE)	28 December, 2021
Dr. B. K. Mahapatra	Selection of Fish species for Biofloc, RAS etc. Culture system and management of feed and fish health	Directorate of Fisheries, Govt. of West Bengal, Meen Bhavan, Pascim Medinipur	29 December, 2021
	Scientific Aquaculture practices to augment the income from small farming	WBUAFS, Kolkata	30 December, 2021

4.7. Technology Transfer, Consultancy and Advisory Services

1. Dr. K.K. Krishnani

As a mentor, has guided the following three incubatees for six months in 2021 in the field of environmental management of aquaculture (water reuse efficient aquaculture/aquafarming technologies),

- Mr. Birendra Choubey
- Dr Nishith Tyagi
- Mr. Vikash Choubey

2. Dr. Paramita Banerjee Sawant

Provided advisory and technical support to ornamental fish farmers / entrepreneurs at Mumbai physically as well as through Whatsapp and distributed hatchery bred high value ornamental fish seed to them.

3. Dr. Babitha Rani A. M.

- As a mentor, she has guided seven incubatees for six months in 2021. In the field of Biofloc technology in aquaculture.
- As technical advisory committee member, demonstrated the biofloc based aquaculture technology in association with the state fisheries department and KUFOS and KVK-IISR.

4. Post Harvest Technology Scientists

Installation of a Pilot plant for value added fish products preparation at Guijan, Tinsukia district, Assam on 08 October, 2021 with financial support under NEH Scheme of ICAR-CIFE, Mumbai. Technical support through conductance of 2 training programs of 2 days each during 03 October, 2021 to 06 October, 2021 benefitting 100 tribal hilly region women self help groups.

Installation of a Pilot plant for value added fish products preparation at Khairwe, Nandurbar district, Maharashtra on 16 September, 2021 with financial support under TSP Scheme of ICAR-CIFE, Mumbai. Technical support through conductance of 2 training programs of 2 days each during 17 September, 2021 to 20 September, 2021 benefitting 100 tribal fisher community.

Follow up action-Among the trained women SHG's, 4 SHG's are now actively involved in making their products under their own brand and the activity helped in doubling their income at both the places. Provided time to time Advisory to Department of Fisheries, Maharashtra on the policy of sustainable fishing as a member of the Expert Committee appointed by the Govt of Maharashtra

5. Dr. Gayatri Tripathi

A WhatsApp group of 40 tribal fish farmers of Nandurbar district was created to provide timely help and assistance whenever required. The detailed information about the tribal farmer community involved in fish farming, the pond size, water level, species stocked, feed, income generation etc. has also been recorded.

6. Dr. G. Rathi Bhuvaneswari

- Diagnostic services provided to an in-house vertical crab farming project at Bhuigaon village, Vasai, Maharashtra and provided advisory on water quality and heath management during November-December 2021.
- Water quality analysis of samples received from A.S. Agri Aqua LLP Company, Nashik during December 2021 were performed to check for the suitability of water for biofloc culture.

7. Dr. Pawan Kumar

DNA barcoding services for identification of fish species is provided to state fisheries department, Research labs and researchers.

8. Scientist of Kolkata Centre

Advisory	Scientist	Date	Beneficiaries
Brackishwater Polyculture as a Sustainable Livelihood Option for Small and Marginal Farmers	Dr. Gournaga Biswas	18September, 2021	179

10. Scientist of Kakinada Centre

S.No	Name of Farmer/ Entrepreneur	Place	Subject of guidance
1.	Mr. Kantha Raj	Banglore, Karnataka	*P. vannamei* culture in Freshwater
3.	Dr. Sreelatha	Yanam	Alternative species culture in Brackishwater ponds
5.	Sh. D. Divakar Reddy	Gollapalem, E G Dt, AP	*C. chanos* seed identification, nursery management and culture
7.	Sh. P. Jayaram	Kakinada	*C. magur* culture techniques
9.	Mr. T. Syam Sundar	Kakinada	*M. cephalus* culture

11. Scientist of Powerkeda Centre

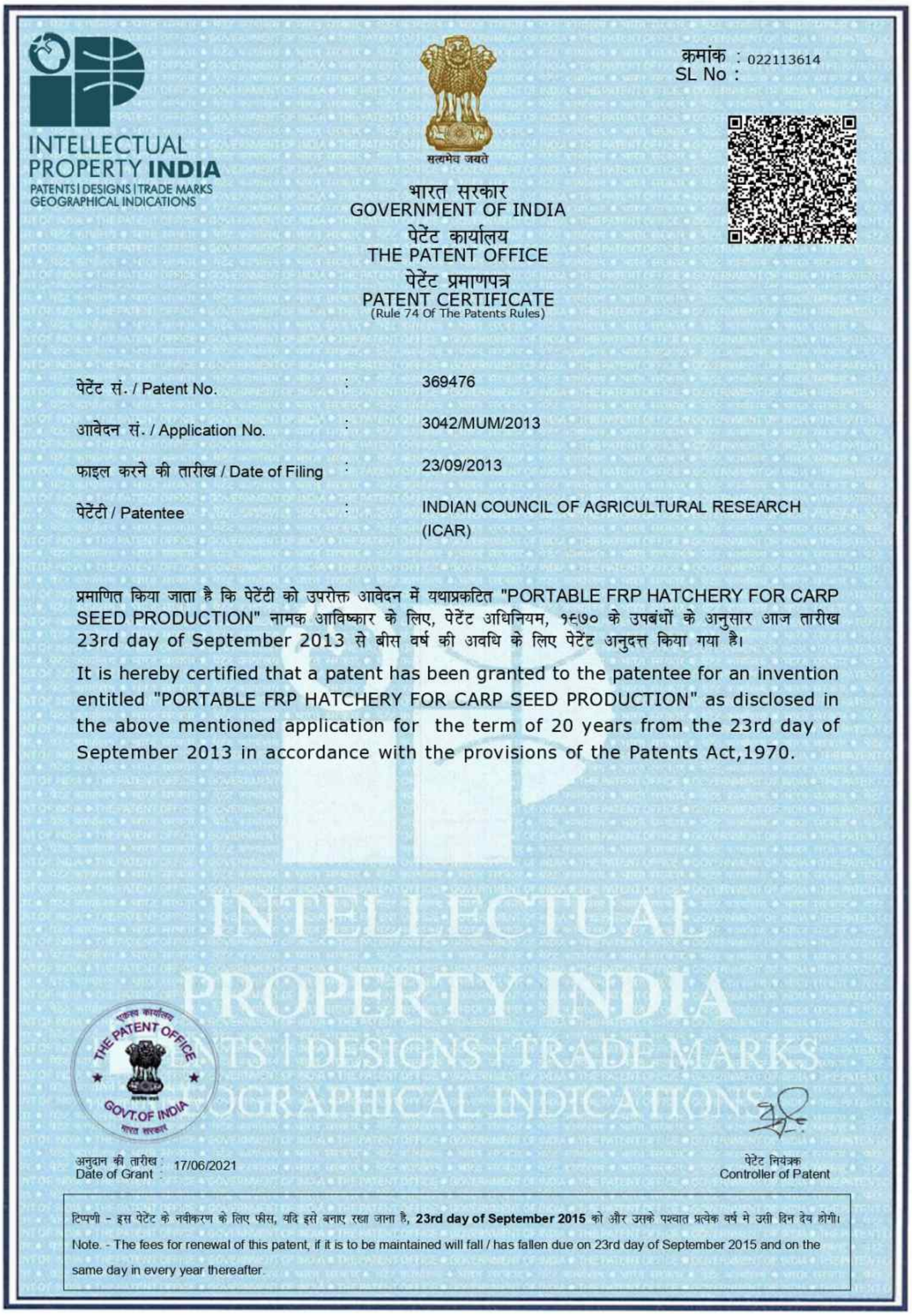
S.No	Name of Farmer/ Entrepreneur	Place	Subject of guidance
2.	Mr. Meena	Shivpur, Babai, Hoshangabad, Madhya Pradesh	Poly Culture of *Channa marulius* with carps

Technology Transfer

Patents Granted

Portable FRP Hatchery for Carp Seed Production

Application No : 3042/MUM/2013
Date of grant patent : 17/06/2021
Patent No : 369476



INTELLECTUAL PROPERTY INDIA
PATENTS | DESIGNS | TRADE MARKS
GEOGRAPHICAL INDICATIONS

सत्यमेव जयते

क्रमांक : 022113614
SL No :

भारत सरकार
GOVERNMENT OF INDIA
पेटेंट कार्यालय
THE PATENT OFFICE
पेटेंट प्रमाणपत्र
PATENT CERTIFICATE
(Rule 74 Of The Patents Rules)

पेटेंट सं. / Patent No.	:	369476
आवेदन सं. / Application No.	:	3042/MUM/2013
फाइल करने की तारीख / Date of Filing	:	23/09/2013
पेटेंटी / Patentee	:	INDIAN COUNCIL OF AGRICULTURAL RESEARCH (ICAR)

प्रमाणित किया जाता है कि पेटेंटी को उपरोक्त आवेदन में यथाप्रकटित "PORTABLE FRP HATCHERY FOR CARP SEED PRODUCTION" नामक आविष्कार के लिए, पेटेंट अधिनियम, १९७० के उपबंधों के अनुसार आज तारीख 23rd day of September 2013 से बीस वर्ष की अवधि के लिए पेटेंट अनुदत्त किया गया है।

It is hereby certified that a patent has been granted to the patentee for an invention entitled "PORTABLE FRP HATCHERY FOR CARP SEED PRODUCTION" as disclosed in the above mentioned application for the term of 20 years from the 23rd day of September 2013 in accordance with the provisions of the Patents Act,1970.

THE PATENT OFFICE
GOVT.OF INDIA

अनुदान की तारीख : 17/06/2021
Date of Grant :

पेटेंट नियंत्रक
Controller of Patent

टिप्पणी - इस पेटेंट के नवीकरण के लिए फीस, यदि इसे बनाए रखा जाना है, **23rd day of September 2015** को और उसके पश्चात प्रत्येक वर्ष मे उसी दिन देय होगी।

Note. - The fees for renewal of this patent, if it is to be maintained will fall / has fallen due on 23rd day of September 2015 and on the same day in every year thereafter.

Name of the technology

L. vannamei culture in salt affected inland saline water

Demonstrated at

Haryana, Punjab, Delhi, Rajasthan, Western UP region

Beneficiaries

Farmers & Entrepreneurs

Impact

Intensive technology demonstrations and trainings were given to farmers in the three extensively salt-affected states of Haryana, Punjab and Rajasthan in collaboration with their respective State Fisheries Departments. In addition, continual technical guidance and monitoring of each farm by ICAR-CIFE throughout the culture period gave enough confidence to farmers and the lure of big profit resulted in widespread adoption of shrimp farming by 2021. Our technology for shrimp farming in salt affected soils has been demonstrated in around 900 acres in the state of Punjab and 1000 acres in the state of Haryana with an average productivity of 2.8 tonnes/acre and a survival rate of 70%. Preliminary studies are going on in selected districts of Rajasthan and Uttar Pradesh. The wide spread adoption of the technology by farmers resulted in the huge production of *L. vannamei* over the years, generating in the cumulative revenue of around 200 crores.

District wise details of commercial inland saline shrimp farms demonstrated by ICAR-CIFE Rohtak Centre in 2021

State	Major districts covered
Haryana	Rohtak, Jhajjar, Bhiwani, Jind, Hisar, Fatehabad, Sirsa, Sonipat, Gurugram, Charki Dadri, Rewari
Delhi	South West Delhi
Punjab	Sri Muktsar Sahib, Fazilka, Batinda, Mansa
Rajasthan	Churu, Hanumangarh, Jhunjhunu, Ganganagar Nagaur, Barmer, Bikaner, Jhodpur, Jaipur (Preliminary trials going on)
Western UP	Agra, Mathura (Preliminary trials are going on)

Name of the technology

Poly Culture of *Channa marulius* with carps in earthen ponds

Demonstrated at

village-Shivpur, Tehsil-Babai, Dist-Hoshangabad, State- Madhya Pradesh

Beneficiaries

Farmers & Entrepreneurs

Impact

Human resource development

Technology Adoption

4.8. TV Talk / Radio Talk / YouTube Videos, Print Media

TV channel

Staffs of ICAR-CIFE, Rohtak Centre
"Rohtak Centre's Role in Vannamei Farming"
Janta TV (Video documentary), 13 December, 2021

All India Radio

Dr. Neha Wajahat Qureshi
"Radio Talk on World Fisheries Day"
Programme: Hit and Hot Programme, Rainboow FM 107.1, 21 November 2021

Youtube channel

Off season seed production & quality improvement
Dr. S. Munilkumar & Dr. S. Dasgupta
Programme: Online Training Programme under ICAR-DoF Convergence, Kolkata Centre
05 January, 2021

Management of soil & water quality in Aquaculture
Dr. S. Datta & Dr. Suman Manna
Programme: Online Training Programme under ICAR-DoF Convergence, Kolkata Centre
13 January, 2021

Winter breeding & culture of ornamental fish
Dr. B. K. Mahapatra
Programme: Online Training Programme under ICAR-DoF Convergence, Kolkata Centre
18 January, 2021

Feed and feeding methods in aquaculture
Dr. Dilip Kumar Singh
Programme: Online Training Programme under ICAR-DoF Convergence, Kolkata Centre
22 January, 2021

Diversification in aquaculture
Dr. S. Munilkumar & Dr. S. Dasgupta
Programme: Online Training Programme under ICAR-DoF Convergence, Kolkata Centre
30 January, 2021

Health management of finfish & shellfish
Dr. Ashok Biswas & Ms. HusneBanu
Programme: Online Training Programme under ICAR-DoF Convergence, Kolkata Centre
02 February, 2021

Live feed culture and feeding technique of ornamental fish
Dr. S. Munilkumar & Dr. K. Syamala
Programme: Online Training Programme under ICAR-DoF Convergence, Kolkata Centre
06 February, 2021

Farm made fish feed
Dr. Parimal Sardar
Programme: Online Training Programme under ICAR-DoF Convergence, Kolkata Centre
12 February, 2021

Peri-urban aquaculture
Dr. S. Munilkumar& Dr. S. Dasgupta
Programme: Online Training Programme under ICAR-DoF Convergence, Kolkata Centre
20 February, 2021

Use of chemicals and their effect in aquaculture
Dr. S. Datta & Dr. Suman Manna
Programme: Online Training Programme under ICAR-DoF Convergence, Kolkata Centre
27 February, 2021

Ornamental fish diseases and their management
Dr. Gayatri Tripathi & Mrs. Husne Banu
Programme: Online Training Programme under CAR-DoF Convergence, Kolkata Centre
06 March, 2021

Functional fish feed
Dr. Dilip Kumar Singh & Dr. Md Aklakur
Programme: Online Training Programme under ICAR-DoF Convergence, Kolkata Centre
12 March, 2021

Multi-trophic Aquaculture
Dr. Gouranga Biswas
Programme: Online Training Programme under ICAR-DoF Convergence, Kolkata Centre
20 March, 2021

Application of drugs and chemicals in aquaculture
Mrs. Husne Banu
Programme: Online Training Programme under ICAR-DoF Convergence, Kolkata Centre
27 March, 2021

Freshwater Pearl Culture Technology
Mrs. Sweta Pradhan
Programme: Online Training Programme under ICAR-DoF Convergence, Kolkata Centre
06 April, 2021
https://www.youtube.com/watch?v=cT-w_Vsjv1E

Pilot plant for value added fish products
Dr. A K Balange
Programme: Value added fish products, Public mirror You Tube channel, September 2021
https://www.youtube.com/watch?v=aY-v8dFF-Lk&authuser=0

Pilot plant for value added fish products
Dr. A K Balange
Programme: Value added fish products, DD Sahyadri News You Tube channel, October 2021

https://www.youtube.com/watch?v=AtWbwTqwUn4&authuser=0

Print Media

(Title/News Paper/Date/Language)

1. ***Matsyachash: Kamalpur Karmashala***
   Department of Information and broadcasting, Govt of Tripura
   09 February, 2021
   Bengali

2. ***Misti Jole Machchash Karmoshalaanusthito***
   Daily newspaper, Tripura
   16 February, 2021
   Bengali

3. ***Machli utpadankar ban sakte hain aatmnirbhar***
   Prabhat Khabar
   04 March, 2021
   Hindi

4. ***Mithe Pani Me Matsypalan Ki Adhuniktam Takniki Se Rubaru Hua Anusuchit jati Ke Matsy Krishak***
   Purbanchal Surya
   12 March, 2021
   Hindi

5. ***Shobhivant masyachi Paidas : ek Joddhanda***
   Ambegaon News
   15 March, 2021
   Marathi

6. ***Chepala royyala viluva aadharitha uthpathula tayyari pai shikshana***
   Andhra Prabha , Eenadu, Praja Shakthi, Kakatiya
   Date: 16 March,2021
   Telugu

7. ***Aqua vantakalatho upaadhi***
   Eenadu , Andhra Prabha ,Kakatiya
   20 March 2021
   Telugu

8. ***Aquaculture padhathulalo pradhamika amshalu***
   Kakatiya
   21 March, 2021
   Telugu

9. ***Shobhivant masyachi Paidas : ek Joddhanda***
   Samna
   22 March, 2021
   Marathi

10. ***Aquaculture as a Potential Livelihood Option for Tribal Communities***
    Agrowon Sakal
    28 March, 2021
    Marathi

दैनिक भास्कर
बीकानेर ज़िला 22-12-2021

खारे पानी में झींगा मछली पालन से बढ़ेगी आय

भास्कर न्यूज़ | कोलायत

क्षेत्र में खारे पानी से किसान परेशान है, लेकिन झींगा मछली पालन के लिए यह पानी काफी उपयोगी है। झींगा मछली के पालन कर प्रत्येक माह 1 लाख तक की आमदनी की जा सकती है। इसको लेकर मंगलवार को पंचायत समिति सभागार में एक दिवसीय प्रशिक्षण आयोजित किया गया।

केंद्रीय मत्स्य संस्थान मुम्बई के रोहतक केंद्र प्रभारी डॉ. हरिकृष्णा ने बताया कि क्षेत्र में खारा पानी है। ऐसे में काफी किसान खेती में पूरी आमदनी प्राप्त नहीं कर पाते। परंतु ऐसे पानी मे झींगा मछली का पालन संभव है, जिससे प्रत्येक माह अच्छी आय प्राप्त की जा सकती है। इस दौरान उन्होंने झींगा मछली पालन के तकनीकी पहलुओं के बारे में बताया। सूरतगढ़ मत्स्य विकास अधिकारी मोहम्मद इरशाद खान ने कहा कि 1 हेक्टेयर में जलहौज बनाकर झींगा मछली का व्यवसाय शुरू किया जा सकता है। इसके लिए सरकार 60 प्रतिशत अनुदान भी देती है। क्षेत्र के गड़ियाला व गजनेर का पानी जांचा गया है जो झींगा पालन के लिए उपयुक्त है। झींगा मछली के पानी की उपयोगिता के लिए पानी का सेम्पल जांचा जाता है। कार्यक्रम के दौरान एसडीएम प्रदीप चाहर ने कहा कि क्षेत्र में किसानों के खेतों में पानी खारा है। ऐसे में मत्स्य पालन अच्छा विकल्प है। बीडीओ दिनेश सिंह भाटी ने झींगा मछली के भविष्य की उपयोगिता को लेकर प्रकाश डाला। इस अवसर पर सरपंच, ग्राम विकास अधिकारी मौजूद थे।

अॅग्रोवन

‘आदिवासींना मत्स्य शेती हा उदरनिर्वाहाचा उत्तम पर्याय’

अॅग्रोवन वृत्तसेवा

पुणे : ‘‘गेल्या काही दिवसांपासून मत्सशेतीचे महत्त्व वाढत आहे. त्यामुळे शेतकऱ्यांसह, अनेक व्यावसायिक व्यक्ती, संस्था याकडे वळत आहेत. आदिवासी समाजासाठी मत्सशेती उदरनिर्वाहाचा एक उत्तम पर्याय आहे,’’ असे मत केंद्रीय मत्स्य शिक्षण संस्थेचे विस्तार प्रमुख डॉ. एस. एन. ओझा यांनी व्यक्त केले.

केंद्रीय मत्स्य शिक्षण संस्था आणि नारायणगाव कृषी विज्ञान केंद्रातर्फे आदिवासी उपयोजनेअंतर्गत एकदिवसीय मत्स्य शेती, जनजागृती, सह-प्रदर्शन कार्यक्रम नुकताच झाला. डॉ. कपिल सुखधने, डॉ. शिवाजी अरगडे, डॉ. अंकुश कांबळे, केव्हीकेचे प्रमुख प्रशांत शेटे, धनेश पडवळ, डॉ. करण रामटेके यांच्यासह ११० आदिवासी शेतकरी उपस्थित होते.

डॉ. ओझा म्हणाले, ‘‘तळागाळातील सर्व आदिवासी समाजासाठी उदरनिर्वाहाचा स्रोत म्हणून मत्स्यपालनास प्रोत्साहित करणे व मत्स्यशेती वाढीस लागणे या दृष्टीने कार्यक्रमाचे आयोजन केले आहे. आदिवासी समाजाला गोड्या पाण्यातील मत्स्य पालन, त्यासाठी योग्य जातींची निवड, शेततळ्याची निर्मिती व काळजी, माशांचे खाद्य व्यवस्थापन तसेच त्या संदर्भातील विविध योजना आहेत.’’

शेटे म्हणाले, ‘‘मत्स्य शेतीसाठी केव्हीकेतर्फे मस्त्यबीज निर्मिती करून उत्तम प्रतीच्या मस्त्यबीजाचा पुरवठा केला जाईल. त्याचा फायदा आदिवासी शेतकऱ्यांसह इतर शेतकऱ्यांनी घ्यावा. त्यामुळे शेतकऱ्यांच्या उत्पन्नात वाढ होईल.’’ डॉ. शिवाजी अरगडे यांनी सूत्रसंचालन केले. डॉ. अंकुश कांबळे यांनी आभार मानले.

Pune, Main
28/03/2021 Page No. 5

11. ***Mithepani main machaliutpadankaisen Karen:* Dr. Sunil Kumar**
Hansal News, Sriganganagar, Rajasthan
16 June, 2021
Hindi

12. ***Mithepani main machaliutpadankaisen Karen: Dr. Sunil Kumar***
Simantrakhyak news, Suratgarh, Rajasthan
16 June, 2021
Hindi

13. ***Mithepani main machaliutpadankaisen Karen: Dr. Kumar***
Aahutisamachar, Sriganaganagar, Rajasthan
16 June, 2021
Hindi

14. ***Pradesh main matashyapalanki apar sambhabanayen: Dr. Tiwari***
Pradesh Today, Jabalpur, MP
05 August, 2021
Hindi

15. ***Matashyapalan main yuvayonke lie rojgarki sambhabanayen***
Naidunia, Jabalpur, MP
05 August, 2021
Hindi

13. ***Training and input distribution to cyclone "Yash" affected farmers of Sandehskhali***
Ekdin
12 September, 2021
Bengali

14. ***Training programme and distribution of inputs to cyclone "Yash" influenced fish farmers of Sandeshkhali***
Ek Bangla
12 September, 2021
Bengali

15. मूल्यवर्धित मतस्यपदार्थ तैयार करण्याच्या प्रकल्पाचा खेरवे येथे शुभारम्भ
Lokmat
22 September, 2021
Marathi

16. ***New species of blind freshwater eel discovered from Mumbai well***
The Hindu
01 October, 2021
English

17. ***New species of swamp eel discovered in Mumbai***
The Indian Express
01 October, 2021
English

18. ***Training program on value added fish products preparation from freshwater fish at Guijan, Tinsukia, Assam***
Pratikshan
05 October, 2021
Assamese

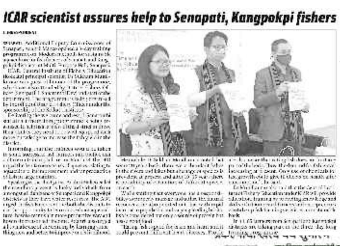
19. ***Training on value added fish products preparation at Tinsukia***
The Assam Tribune
05 October, 2021
English

20. ***Fish processing plant set up: Training program conducted***
The Sentinal
06 October, 2021
English

21. ***Pilot plant inaugurated for value added fish products preparation***
Local News paper
09 October, 2021
English

22. ***SDP on modern methods of freshwater aquaculture gets underway***
The Dawnlit Post
24 November, 2021
English

23. ***Kharepani me JhingaPalan se Badhegiaay***
DainikBhaskar
22 December, 2021
Hindi


ICAR scientist assures help to Senapati, Kangpokpi fishers


Training Programme on Modern methods for Sustainable Aquaculture begins

Our Correspondent

SENAPATI, Mar 16: 3 days training programme on Modern Methods for Sustainable Aquaculture for fish farmers of Senapati and Kangpokpi districts began today at Multi-Purpose Hall, Senapati organised by the District Fishery Officer, Senapati under the sponsorship of ICAR, Central Institute of Fishery Education.

The inaugural programme was attended by Additional Deputy Commissioner, Senapati Adahrii Maheo, MCS and Dr Sukham Munilkumar, Principal Scientist, ICAR, Central Institute of Fishery Education, Kolkata as the presidium members.

L Sanatombi Devi, District Fishery Officer, Senapati and staff of the department also attended the programme.

In her welcome note, L Sanatombi stated that the programme is being organised for the welfare of the fish farmers considering the emergent need for the fish farmers of the district to be well equipped with more knowledge to produce more fish products.

The trainees would reportedly be taken to visit some successful fish farmers and biofloc fish culture unit in Imphal on March 18, she added.

Further she appealed to all fish farmers to feel free in asking queries relating to aquaculture and its improvement and for production of fish in large quantity.

Speaking as the chief guest, Adahrii Maheo urged the fish farmers of both the districts to avail the opportunity to learn more about aquaculture, how to rear fish in more productive way thereby generating more income.

Dr Sukham Munilkumar stated that one of the fastest growing sectors in agriculture is fishery and aquaculture and enumerated the benefits of consuming fish.

He continued that the Central Institute of Fishery Education under ICAR is to provide education and training thereby enhancing knowledge and skill so that interested farmers and entrepreneurs can take up fish farming activities for long term sustainability.

65 farmers from Senapati and Kangpokpi districts are participating in the 3 days training programme.


SEAWEED
INDIA 2021

CERTIFICATE OF PARTICIPATION

THIS CERTIFICATE IS PRESENTED TO ***CENTRAL INSTITUTE OF FISHERIES EDUCATION (ICAR-CIFE), MUMBAI***, FOR PARTICIPATING IN THE TWO DAYS VIRTUAL INTERNATIONAL CONFERENCE & EXHIBITION, SEAWEED INDIA 2021 ON 26TH -27TH AUGUST 2021.

Pravash Pradhan

PRAVASH PRADHAN
CONVENOR, SEAWEED INDIA 2021,
CHIEF EDITOR, SMART AGRIPOST & AQUA POST

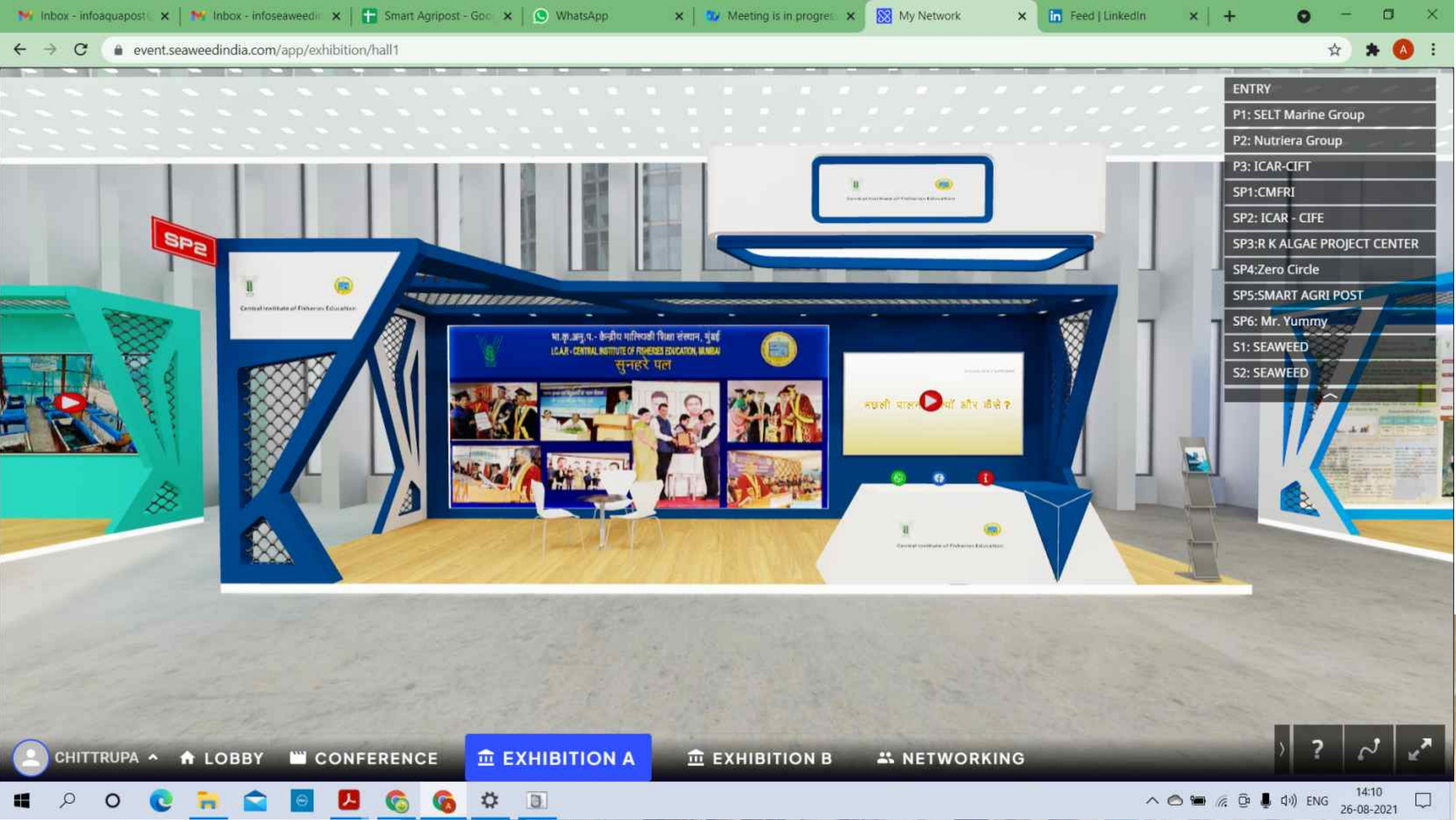
Participation in Exhibitions

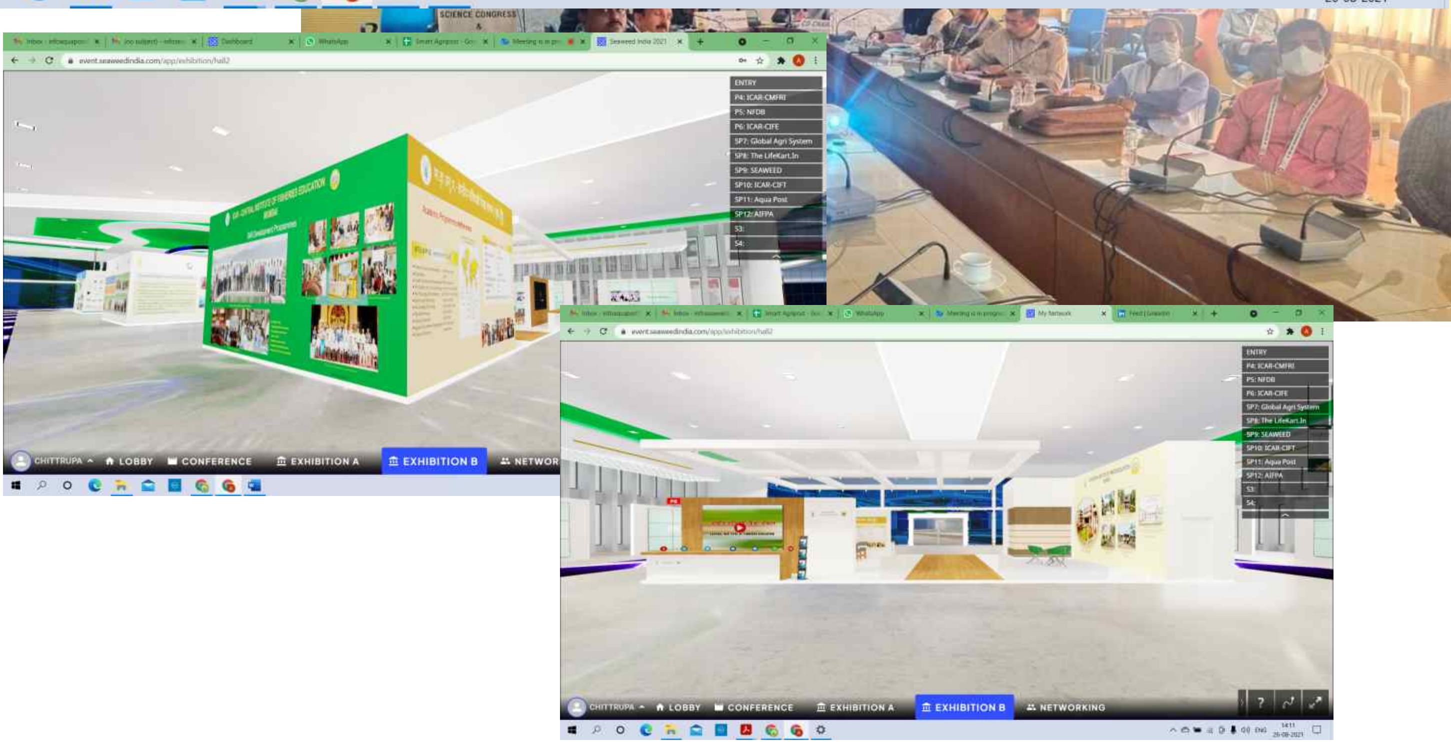
ICAR-CIFE Exhibition at BHU, Varanasi, UP

XV Agricultural Science congress and ASC Expo held at BHU, Swatantrata Bhawan from 13–16 November 2021. ICAR-CIFE participated in it. A spiritual city, Varanasi is endowed with the large campus of Banaras Hindu University (1300 acres). 1500 delegates from several universities and institutes participated in it in offline and virtual modes, but it was mainly an ICAR show. In the congress fisheries session was also held, and the fisheries theme was concluded in the valedictory function. At the ICAR-CIFE stall, Dr. Punjab Singh Ex-DG, ICAR, and Dr. Trilochan Mahapatra, DG-ICAR, visited the stall and appreciated the efforts of ICAR-CIFE.

Offline

Sr. No	Date	Name of Expo	Organized by
1.	26 -27 August 2021	International Conference & Expo on Seaweed Farming Seaweed India 2021	P2C Communications, New Delhi
2.	13-16 November, 2021	XV Agricultural Science, Congress & ASC EXPO, BHU, Varanasi	NAAS New Delhi & BHU, Varanasi





Participation in Exhibitions

Virtual

Sr. No	Date	Name of Expo	Organized by
1.	6-15 Feburary, 2021	Smart Aqua Expo India, 2021	P2 Communications, New Delhi
2.	16-22 March, 2021	MOCI-CII EduExpo 2021 (ciihive.in)	Association of Indian Universities, Delhi with Ministry of Commerce and Industries and Confederation of Indian Industries

05

HRD


भा.कृ.अनु.प.-केन्द्रीय मात्स्यिकी शिक्षा संस्थान,मुंबई
ICAR-CENTRAL INSTITUTE OF FISHERIES EDUCATION

5.1. Faculty & Staff

CIFE Head Quarters, Mumbai

RMP

Director

Dr. Gopal Krishna (upto 03.11.2021)
Dr. N.P. Sahu, Director(I/C) (wef. 04.11.2021)

Joint Director

Dr. N.P. Sahu (wef 27.04.2021)

Scientific Staff

Heads of Division

Dr. N.P. Sahu (Acting) (upto 26.04.2021)
Dr. S.N. Ojha (Acting)
Dr. K.V. Rajendran (Acting)
Dr. B.B. Nayak (upto 14.07.2021) & (Acting)
Dr. N.K.Chadha (Acting) (wef 20.05.2021)
Dr. Kishore K. Krishnani (Acting) (upto 19.05.2021)
Dr. Aparna Chaudhari (Acting)
Dr. Parimal Sardar (Acting) (wef 04.05.2021)

Principal Scientists

Dr. Naresh S. Nagpure
Dr. Geetanjali Deshmukhe
Dr. K. Pani Prasad
Dr. P.K. Pandey (upto 12.05.2021)
Dr. S. Jahageerdar
Dr. Arpita Sharma
Dr. P.P. Srivastava (on deputation)
Dr. R.P. Raman
Dr. Gayatri Tripathi
Dr. Satya Prakash Shukla
Dr. Ashok Kumar Jaiswar
Dr. Rupam Sharma
Dr. Swadesh Prakash
Dr. Subodh Gupta
Dr. Mukunda Goswami
Dr. Ashutosh D. Deo
Dr. Manoj Pandit Brahmane
Dr. Ananthan P.S.
Dr. Megha Kadam Bedekar
Dr. Sanath Kumar H.
Dr. A.K. Balange
Dr. Paramita Banerjee Sawant

Senior Scientists

Dr. Zeba Jaffer Abidi
Dr. Asha T. Landge
Dr. Ajit Kumar Verma
Dr. Vidya Shree Bharti
Dr. Babita Rani A.M.
Dr. Sonwane Arvind Asaram
Dr. A. Pavan Kumar
Dr. Kundan Kumar

Scientists

Dr. Vinod Kumar Yadav
Dr. Ankush Lala Kamble
Dr. Manjusha L.
Dr. Sukham Monalisha Devi
Dr. Martin Xavier K.A.
Dr. Arun Sharma
Dr. Thongam Ibemcha Chanu
Dr. Sikendra Kumar
Dr. Jeena K.
Dr. Saurav Kumar
Dr. Tincy Verghese
Dr. Mujahidkhan Ajamalkhan Pathan
Dr. Shashi Bhushan
Dr. Shamna N.
Dr. Dhamotharan K.
Dr. Karankumar K. Ramteke
Dr. Kiran Dashrath Rasal
Dr. Rathi Bhuvaneswari G.
Dr. Shivaji Dadabhau Argade
Dr. Layana P
Dr. Manish Jayant
Dr. Neha Wajahat
Dr. Sukhdhane Kapil Sukhdeo
Mr. Angom Lenin Singh
Dr. Upasana Sahoo
Dr. Madhuri Pathak
Mrs. Shobha Rawat
Mr. Abuthagir Iburahim S.
Mrs. V. Vidhya
Mr. Dayal Devadas

Technical Staff

Chief Technical Officers (T-9)

Dr. S.K. Pandey
Dr. M.K. Chouksey
Mr. S.S. Kamat
Mr. Ram Singh
Mr. Dasari Bhoomaiah
Mr. P.K. Das
Dr. Nalini Poojary

Asst. Chief Technical Officers (T-7/8)

Dr. Chandrakant M.H.
Mr. Subhash Chand
Ms. Revati B. Dhongde
Mrs. Rekha Nair

Sr. Technical Officers (T-6)
Mrs. Rajani H. Khandgale
Mr. Sanjeevan Kumar
Mr. S. Maity

Technical Officers (T-5)
Mr. B.G. Mandhare
Mr. B.J. Rathod
Mr. N.K. Aglave
Mr. S.R. Bandkar
Mrs. Bharati Ghagare
Mr. Avinash Sable
Mr. Suryakant L. Koli
Mr. B.T. Phande
Mr. Anil Kumar Kulsange
Mr. Sagar Suresh Sawant
Mr. Rajarshee Moitra
Dr. Pawan Kumar

Sr. Technical Assistants (T-4)
Mr. Yogesh Jadhao
Mr. Mohd. Baqar
Mr. K.V. Rajendran
Mr. Arun Puri Gosavi
Mr. R.D. Deshmukh
Mrs. Reshma K. Raje
Mr. Dhanpat Singh Rawat
Mr. V.K. Bhave

Sr. Technicians (T-2)
Sh. Pranaya Kumar Biswal
Mr. Mohd Sadiq M. Mulla
Mr. Abhijeet Vijay Jadhav
Mr. T.G.Gaikwad

Technician (T-1)
Mr. G.B. Kamble

Non-Ministerial Staff (Cook)
Mr. S. Kamaraju

Administrative Staff

Chief Administrative Officer (SG)
Mr. K.L. Meena (wef 22.09.2021 to 18.12.2021)
Mr. G.G. Harakangi (wef 29.12.2021)

Chief Finance & Accounts Officer
Mr. Prashant Sharma (upto 04.10.2021)

Sr. Administrative Officers
Mr. P.J. Davis (upto 30.04.2021)
Mr. B.L. Kokkula (wef 31.12.2021)

Administrative Officer
Mrs. Poonam N. Behl

Finance & Accounts Officer
Mr. S.V. Kasabe

Asst. Director (Official Language)
Mr. Devendra Kumar Dharam

Asst. Finance & Accounts Officer
Mr. Deepak M. Bhokse

Asst. Admin. Officers
Mrs. F.G. Fernandes
Ms. C.S. Khundol
Mr. D.S. Ingale
Mrs. Swati S. Koli
Mr. V.S. Kuveskar
Mr. Suraj Gupta

Private Secretary
Mr. P.R. Ninawe
Mrs. Pragati R. Gadre

Stenographer (Grade – III)
Mr. Amey A. Sakpal

Assistants
Mr. D.V. Raorane
Mrs. A.U. Joshi
Mr. A.G. Kolambkar
Mrs. S.V. Pawar (upto 24.04.2021)
Mrs. Sanyuja S. Parab
Mr. B.P. Chauhan
Mr. N.L. Ghane
Mr. P.G. Angne
Mr. M.B. Waghela

Upper Division Clerks
Mrs. C.C. Raut
Mrs. Anu Grover
Mr. S.H. Bhosale
Mr. Shirish P. Malvankar
Mr. Prasenjit P. Sonawane
Mr. R.N. Kamble
Mr. Ram A. Shinde

Lower Division Clerks
Mr. Ninad V. Kandalgaonkar
Mr. Sambhaji S. Shelke
Ms. Ujjawala V. Tiwari

Skilled Support Staff

Mr. G.G. Zendekar
Mr. Surajbali R. Jaiswar
Mr. Ashok R. More
Mr. D.B. Gaikwad
Mr. Sitaram B. Padyal
Mr. J.K. Makwana
Mr. Bandu R. Chavan
Mr. Ankush R. Dore
Mr. M.P. Kotian
Mr. Ashok R. Shingade
Mr. Jagdish N. Dhanu
Mr. Vasant N. Ondkar
Mr. Arvind M. Lavande
Mr. Vinod Kumar Yadav
Mrs. R.H. Chavan
Mr. Ankush N. Joyashi
Mr. Ganesh N. Zendekar
Mr. Anil D. Sonawane
Mrs. Reshma Naik
Mrs. Sabita Devi

CIFE Kakinada Centre

Scientific Staff

Officer Incharge / Senior Scientist
Dr. Muralidhar P. Ande

Scientist
Dr. Karthireddy Syamala

Technical Staff

Chief Technical Officer (T-9)
Dr. P. Srinivas Rao

Asst. Chief Technical Officer (T-7/8)
Mr. R.R.S. Patnaik

Technical Assistants (T-3)
Mr. A. Gurraiah
Mrs. Usharani Maradana

Sr. Technicians (T-2)
Mr. V. Shivaji

Technicians
Mr. Sheikh Valisha
Mr. G.V.V. Satyanarayana

Administrative Staff

Asst. Administrative Officer
Mr. B. Laxmana Rao

Upper Division Clerk
Mrs. M. Rama Mani

Skilled Support Staff

Mr. O. Veera Raju
Mr. T. Satyanarayana
Mr. P.V.K. Reddy
Mr. P.D. Reddy
Mr. S.S. Reddy
Mr. Y. Buchilingam
Mr. M. Govindu
Mr. Kurru Suresh
Mr. M. Kondala Rao

CIFE Kolkata Centre

Scientific Staff

Officer Incharge / Principal Scientist
Dr. G.H. Pailan

Principal Scientists
Dr. B.K. Mahapatra
Dr. Shubendu Dutta
Dr. S. Munil Kumar
Dr. S. Das Gupta

Senior Scientists
Dr. Gouranga Biswas
Dr. Sujata Sahoo

Scientists
Dr. Dilip Kumar Singh
Dr. Suman Manna
Mrs. Husne Banu
Mrs. Sweta Pradhan
Dr. Hanjabam Mandakini Devi

Technical staff

Chief Technical Officer (T-9)
Dr. Asok Biswas

Technical Officers (T-5)
Mrs. G. Aruna Devi
Mr. Prakash Kumar Behera
Mr. Tapas Kumar Ghosh

Administrative Staff

Asst. Admin. Officer
Mr. C.N. Sahani

Private Secretary
Ms. Kaberi Biswas

Upper Division Clerks
Mr. Kishore Bose
Mr. Ram Milan Singh

Skilled Support Staff

Mrs. Suman Pandey
Mr. Rajesh Mahato

CIFE Powerkheda Centre

Scientific Staff

Officer Incharge/ Scientist
Dr. Sunil Kumar Nayak

Scientists
Mr. Dhalongsaih Reang
Mrs. Harsha Haridas

Technical Staff

Asst. Chief Technical Officer
Mr. L.P. Bamalia
Mr. Hasan Javed

Technical Officer (T-5)
Mr. Gurubachan Singh

Technical Assistant (T-3)
Mr. Raghuvir Prasad

Technician (T-1)
Mr. S. Prajapati

Administrative Staff

Asst. Admin. Officer
Mrs. Asha Dhurve

Skilled Support Staff

Mr. Lallu Prasad
Mr. Vishnu Lal
Mr. Mangli Prasad
Mr. Sambhu Dayal
Mr. Hari Singh
Mr. Manohar Lal
Mr. Ram Swarup
Mr. Deepak Kumar Kushwaha

CIFE Rohtak Centre

Scientific Staff

Officer Incharge/ Scientist
Mr. Hari Krishna

Scientists
Dr. Arun Sudhagar S.
Dr. Pankaj Kumar
Dr. Sreedharan K.
Mr. Satya Prakash (study leave wef 1.04.2021)

Technical Staff

Sr. Technical Officer (T-7/8)
Mr. Ashok Kumar

Technical Officer (T-5)
Mr. Lokesh Kumar

Sr. Technical Assistant (T-4)
Mr. Satyendra Singh
Mr. Krishan Kumar

Sr. Technician (T-2)
Mr. Kuldeep Singh

Technician (T-1)
Mr. Lavesh Kumar

Skilled Support Staff

Mr. Gyani Ram
Mr. Gyan Chand

CIFE Motipur Centre

Scientific Staff

Officer Incharge/ Scientist
Dr. Md. Aklakur

Technical Staff

Technical Assistant (T-3)
Dr. Parmanand Prabhakar

5.2. Appointments and Promotions

Appointments

S.No.	Name of the Officials	Designation	Date of Joining
1	Dr. Ankush Lala Kamble	Scientist	15 January, 2021
2	Dr. Gouranga Biswas	Sr. Scientist	1 February, 2021
3	Mrs. Sweta Pradhan	Scientist	1 February, 2021
4	Mrs. Harsha Haridas	Scientist	12 February, 2021
5	Dr. Sonwane Arvind Asaram	Sr. Scientist	15 March, 2021
6	Dr. Monalisha Sukham Devi	Scientist	12 April, 2021
7	Dr. Narottam Prasad Sahu	Joint Director Director (I/C)	27 April, 2021 4 November, 2021
8	Mrs. Hanjabam Mandakini Devi	Scientist	14 June, 2021
9	Mr. K.L. Meena	Chief Admin. Officer (SG)	22 September, 2021
10	Mrs. Usharani Maradana	Technical Assistant	28 September, 2021
11	Dr. Parmanand Prabhakar	Technical Assistant	1 October, 2021
12	Mr. Kuldeep Singh	Sr. Technician	1 October, 2021
13	Mr. S.V. Kasabe	Finance & Accounts Officer	25 November, 2021
14	Mr. G.G. Harakangi	Chief Admin. Officer (SG)	29 December, 2021
15.	Mr. B.L. Kokkula	Sr. Admin. Officer	31 December, 2021

Promotions

Scientific Staff

S. No.	Name of the Employee	From	To	w.e.f.
1	Dr. Paramitta B. Sawant	Sr. Scientist	Principal Scientist	1 January, 2020
2	Dr. Sujata Sahoo	Scientist	Senior Scientist	15 December, 2018
3	Dr. Kundan Kumar	Scientist	Senior Scientist	23 December, 2018
4	Dr. Mujahidkhan Pathan	Scientist	Scientist (SS)	17 February, 2018
5	Dr. Saurav Kumar	Scientist	Scientist (SS)	27 February, 2018
6	Dr. Tincy Varghese	Scientist	Scientist (SS)	16 April, 2018
7	Dr. Shivaji D. Argade	Scientist	Scientist (SS)	1 July, 2018
8	Dr. Shamna N.	Scientist	Scientist (SS)	14 November, 2018
9	Dr. Rathi Bhuvneshwari	Scientist	Scientist (SS)	1 January, 2019
10	Dr. Jeena K.	Scientist	Scientist (SS)	1 January, 2019
11	Dr. Pankaj Kumar	Scientist	Scientist (SS)	1 January, 2019
12	Dr. Karan Kumar Ramteke	Scientist	Scientist (SS)	1 January, 2019
13	Dr. Neha Wajahat Qureshi	Scientist	Scientist (SS)	13 March, 2019

Administrative Staff

S.No.	Name of the Employee	From	To	w.e.f.
1	Mrs. Poonam N. Behl	Asst. Admin. Officer	Administrative Officer	5 November, 2021
2	Mr. B. Laxmana Rao	Assistant	Asst. Admin Officer	25 June, 2021
3	Mr. Vijay S. Kuveskar	Assistant	Asst. Admin. Officer	25 June, 2021
4	Mr. C. N. Sahani	Assistant	Asst. Admin. Officer	25 June, 2021
5	Mr. Suraj Gupta	Assistant	Asst. Admin. Officer	6 July, 2021
6	Mr. Ram Shinde	LDC	UDC	25 June, 2021

Technical Staff

S. No.	Name of the Employee	From	To	w.e.f.
1	Mr. D. Bhoomaiah	Asst. Chief Tech. Officer (T-7/8)	Chief Technical Officer (T-9)	4 December, 2017
2.	Mr. P.K. Das	Asst. Chief Tech. Officer (T-7/8)	Chief Technical Officer (T-9)	15 October, 2018
3	Dr. Nalini Poojary	Asst. Chief Tech. Officer (T-7/8)	Chief Technical Officer (T-9)	17 December, 2018
4	Mr. Hasan Javed	Sr. Technical Officer (T-6)	Asst. Chief Tech. Officer (T-7/8)	1 January, 2021
5	Mr. Rajarshee Moitra	Sr. Tech. Assistant(T-4)	Technical Officer (T-5)	24 February, 2020
6	Mr. Lokesh Kumar	Sr. Tech. Assistant (T-4)	Technical Officer (T-5)	21 July, 2020
7	Dr. Pawan Kumar	Sr. Tech. Assistant (T-4)	Technical Officer (T-5)	7 August, 2020
8	Mrs. Guruaibam Aruna Devi	Sr. Tech. Assistant (T-4)	Technical Officer (T-5)	16 August, 2020
9	Mr. Prakash Kumar Behara	Sr. Tech. Assistant (T-4)	Technical Officer (T-5)	26 August, 2020
10.	Mr. Tapas Kumar Ghosh	Sr. Tech. Assistant (T-4)	Technical Officer (T-5)	29 June, 2021
11	Mr. Vishwanath K. Bhave	Technical Assistant (T-3)	Sr. Tech. Assistant (T-4)	1 August, 2020
12	Mr. Krishan Kumar	Technical Asstt. (T-3)	Sr. Tech. Assistant (T-4)	13 April, 2020

Financial upgradation for Staff

S. No.	Name of the Employee	From (Grade Pay)	To (Grade Pay)	w.e.f.
1	Mr. Sambhu Dayal, SSS	2000	2400	16 April, 2020
2	Mr. S.S. Reddy, SSS	2000	2400	18 July, 2020
3	Mr. Y. Bhuchilingam, SSS	2000	2400	18 July, 2020
4	Mr. M. Govindu, SSS	2000	2400	18 July, 2020
5	Mr. Mahesh P. Kotian, SSS	2000	2400	18 July, 2020
6	Mr. Ram Milan Singh, UDC	2400	2800	27 August, 2020
7	Mr. Ram Shinde, LDC	1900	2000	6 September, 2020
8	Mr. Bharat P. Chauhan, Assistant	4200	4600	25 September, 2020
9	Mrs. Rupawanti Chavan, SS	1900	2000	28 October, 2020
10	Mrs. Anu Grover, UDC	2800	4200	3 January, 2021
11	Mr. Pravin R. Ninawe,PS	4600	4800	19 February, 2021
12	Mr. Pradeep G. Angne, Assistant	4200	4600	6 May, 2021
13	Mr. Manoharlal , SSS	2000	2400	25 June, 2021
14	Mr. Ramswarup, SSS	2000	2400	6 July, 2021
15	Mrs. M. Ramamani, UDC	2800	4200	3 September, 2021
16	Mr. Ganesh N. Zendekar, SSS	1900	2000	11 September, 2021

Retirements

S. No.	Name of the Employee	Date of Retirement
1	Mr. Ram Singh, Chief Tech. Officer	31 January, 2021
2	Mr. K.V. Rajendran, Sr. Technical Officer	28 February, 2021
3	Dr. Rama Sharma, Principal Scientist	31 March, 2021
4	Mrs. Sujata V. Pawar, Assistant	24 April, 2021 (VRS)
5	Mr. P.J. Davis, Sr. Administrative Officer	30 April, 2021
6	Mr. Dilip S. Ingale, Asst. Admin. Officer	5 July, 2021 (VRS)
7	Dr. Zeba Jaffer Abidi, Sr. Scientist	30 June, 2021
8	Mr. Mangli Prasad, SSS, Powarkheda Centre	30 June, 2021
9	Mr. Hari Singh, SSS, Powarkheda Centre	31 July, 2021
10	Dr. Asok Biswas, CTO, Kolkata Centre	31 July, 2021
11	Mr. R.R.S. Patnaik, ACTO, Kakinada Centre	31 August, 2021
12	Mr. B.T. Phande, Tech. Officer	31 August, 2021
13	Mr. Lallu Prasad, SSS, Powarkheda Centre	31 August, 2021
14	Mr. Vishnu Lal, SSS, Powarkheda Centre	31 October, 2021

Transfers from CIFE

S. No.	Name of the Employee	Transfer to	Date of Relieving
1	Dr. Arun Sudhagar S. Scientist	ICAR-NBFGR-Regional Centre, Kochi	31 January, 2021
3	Mr.Prashant Sharma CFAO	ICAR-NBPGR, New Delhi	4 October, 2021
5	Mr. Amey Avinash Sakpal Steno Gr. III	Commissioner of Customs, Mumbai	21 December, 2021

Obituary

Sl. No.	Name of the Officials	Designation	Date of Death
1	Mr. Gurubanchan Singh	Technical Officer	3 February, 2021

5.3. Training & Capacity building of Faculty & Staff

Name of the faculty	Name of the Training Programmes/ Summer school etc. attended	Organiser/Place	Date (Period)
Dr. Neha Wajahat Qureshi	DST sponsored training programme on "Natural Resource and Environmental Management"	Indian Institute of Forest Management (IIFM), Bhopal, Madhya Pradesh	18-20 January, 2021
Dr. A. Pavan Kumar	Master Trainers Programme on Academic Management System (AMS)	ICAR-IASRI, New Delhi (Online)	4 February, 2021
Dr. Gayatri Tripathi	Basic and Advanced Computational Tools for Molecular Genetics	ICAR-CIFE, Mumbai	16-22 February, 2021
Dr. Gayatri Tripathi	Introduction to Bioinformatics Microbial-omice	Online (Meeting Platform)	22–26 March, 2021
Dr. Mukunda Goswami	Hand-on Laboratory Course on CRISPR-Cas Gene Editing	SGT University and Alliance of Biodiversity and CIAT, New Delhi (Online)	23–27 March, 2021
Dr. Saurav Kumar	Training in Agri-Diksha Web Education Channel	ICAR- IASRI, New Delhi (Online)	15 June, 2021
Mr. Abuthagir Iburahim. S	Programming of Web & Mobile Applications using Low-code Platforms	ICAR-NAARM Hyderabad (Online)	07-12 July, 2021

Mrs. Sweta Pradhan Dr. Muralidhar P. Ande Dr. Karthireddy Syamala Dr. Suman Manna Mrs. Sweta Pradhan & Dr. Arun Sharma	Gender, Poverty and Employment	V.V. Giri National Labour Institute, Noida (Online)	12-16, July, 2021
Dr. Saurav Kumar	Training programme on entrepreneurship development in fisheries sector	ICAR-NAARM, Hyderabad & ICAR-CIFE, Mumbai (Online)	17 July, 2021
Dr. Jeena K.	FAO training course on Surveillance and monitoring of antimicrobial resistance in Aquaculture	FAO Regional Office for Asia and the Pacific (Online)	26-30 July, 2021
Dr. Hanjabam Mandakini Devi	Designing new age foods of animal origin	College of Veterinary Science and Animal Husbandry, Mhow (Online)	2-16 August, 2021
Dr. Neha Wajahat Qureshi & Dr. Kapil S. Sukhdhane	Parangat – Hindi	Hindi Vibhag, Govt. of India (Online)	7 August– 18 November, 2021
Dr. Sreedharan K.	Awareness camp for whiteleg shrimp culture	Sirsa, Haryana	8 August, 2021
Dr. Ashutosh D. Deo	Training programme on Leadership and management in higher education	Aima's Vice-Chancellor's Council (Online)	26-27 August, 2021
Dr. Vinod Kumar Yadav	Data analytics & machine learning in geosciences	GeoVigyan (Online)	28 -29 August, 2021
Dr. Shamna N.	Training on recent advances in aquatic animal health & environment management for sustainable aquaculture	GADVASU, Ludhiana, Punjab (Online)	31 August- 10 September, 2021
Dr. Jeena K.	Application of Bioinformatics in agricultural research and education	ICAR-NAARM Hyderabad (Online)	20 -24 September, 2021
Dr. A. Pavan Kumar	Training on education management and academic leadership	ICAR-NAARM Hyderabad (Online)	23 -28 September, 2021
Mrs. Vidhya V.	110 th FOCARS, Professional Attachment Training	ICAR-CMFRI, Mandapam Regional Centre	4 October- 2 January, 2022
Mr. Abuthagir Iburahim S. & Mr. Dayal Devadas	110 th FOCARS, Professional attachment training	ICAR-CIFRI, Barrackpore, West Bengal	3 October- 2 January, 2022
Dr. V. Harikrishna & Mr. Satyendar Singh	Training camp for fish farming	DFTC Enakhra, Malout, Sri Muktsar Sahib, Punjab	4 October, 2021
Mrs. Shobha Rawat	110 th FOCARS, Professional attachment training	ICAR-CMFRI, Kochi	8 October- 6 January, 2022

Dr. Arun Sharma	Management Development Programme (MDP) on priority setting, Monitoring and Evaluation (PME) of agricultural research projects	ICAR-NAARM Hyderabad (Online)	25-30 October, 2021
Dr. Vinod Kumar Yadav	Winter school in geospatial science and technology	Multidisciplinary Centre for Geoinformatics, Delhi Technological University, New Delhi, India (Online)	15 November - 9 December, 2021
Dr. Asha T. Landge	Training programme on developing concepts for climate projects: Essentials for government executives	Bankers Institute of Rural Development, Lucknow (Online)	8 -10 December, 2021
Dr. Arpita Sharma	Management development programme on leadership development	ICAR-NAARM Hyderabad (Online)	13 -24 December, 2021
Dr. V. Harikrishna Mr. Satyendar Singh	Training cum awareness programme on shrimp culture	Office of BDO, Kolayat, Bikaner, Rajasthan	21 December, 2021

06

Publications

182
Total publication

130
International

52
National

48
NAAS >10

97
NAAS 6.0-10.0

37
NAAS<6.0

37
Popular Articles

02
Books

25
Chapters in Book

03
Reports

English : 07
Hindi: 03
Hindi/English: 01
Bengali: 01
Hindi/Marathi: 01
Hindi/English/Marathi: 02
English/Hindi/ Bengali: 01
Marathi: 02

English: 10
Hindi: 02
Bengali: 01
Marathi: 01

6.1 International Journals

(Peer reviewed publications with NAAS;Impact Factor)

Affarin TDM, Xavier KMA, Nayak BB, Harikrishna V, Krishna G, Balange AK (2021) Comparative evaluation of patties prepared from Pacific white shrimp (*Litopenaeus vannamei*) grown in inland saline water and brackish water regimes during frozen storage. ***Journal of Aquatic Food Product Technology*** 30(7): 826-834. (7.77; 1.767)

Ajima MAO, Kumar K, Poojary N, Pandey PK (2021) Sublethal diclofenac induced oxidative stress, neurotoxicity, molecular responses and alters energy metabolism proteins in Nile tilapia, *Oreochromis niloticus*. ***Environmental Science and Pollution Research*** 28(32):44494-504. (10.22; 4.223)

Ajina SM, Gladston Y, SriHari M, Kiruba-Sankar R, Pavan-Kumar A, Roy SD, Jaiswar AK (2021) New distributional record of Blacklash scorpionfish, *Pontinus nigerimum* Eschmeyer, 1983 from Andaman Waters, Eastern Indian Ocean. ***Thalassas: An International Journal of Marine Sciences*** 6:1-5. (6.64; 0.64)

Anagha T, Gupta S, Sahu NP, Srivastava PP, Varghese T, Chanu TI, Ciji A (2021) Titanium dioxide nanoparticles alter reproductive and thyroid hormones of *Labeo rohita* females: Amelioration through Vitamin E and folic acid. ***Aquaculture*** 539:736633. (10.24; 4.24)

Anand K, Subhasmita B, Mani S, Sreedharan K, Suresh B, Reddy GBM, Madhusudan H (2021) Monoclonal antibodies against foot-and-mouth disease virus RNA polymerase for detection of virus infection. ***Microbiology and Immunology***, 65(2): 95-98. (7.96; 1.955)

Anjana S, Abhilash S, Varghese B, Sabu S, Sunooj KV, Xavier KAM (2021) Performance evaluation of ultraviolet assisted vertical re-circulating depuration system on microbial, heavy metal reduction and composition of Black clam (*Villorita cyprinoides*). ***LWT-Food Science and Technology*** 138: 110628 https://doi.org/10.1016/j.lwt.2020.110628. (9.714; 3.714)

Apang T, Xavier KM, Lekshmi M, Kannuchamy N, Layana P, Balange AK (2021) *Garcinia* spp. extract incorporated icing medium as a natural preservative for shelf life enhancement of chilled Indian mackerel (*Rastrelliger kanagurta*). ***LWT-Food Science and Technology*** 133:110086. (9.714; 3.714)

Aralappanavar VK, Bharti VS, Mukhopadhyay R, Prakash S, Harikrishna V, Bhuvaneswari GR, Tripathi G, Krishna G, Sarkar B (2021) Inland saline aquaculture increased carbon accumulation rate and stability in pond sediments under semi-arid climate. ***Journal of Soils and Sediments*** 75(1): 1-10 (9.31; 3.308)

Azeez PA, Rohit P, Shenoy L, Jaiswar AK, Raman M, Koya KM, Vase VK, Damodaran D (2021) Species composition and spatio-temporal variation of bycatch from mid-water trawlers operating in the Arabian Sea along north-west coast of India. ***Regional Studies in Marine Science*** 43: 101692. (7.18; 1.624)

Baitha R, Manna SK, Koushlesh SK, Das N, Bera AK, Prasad KP (2021) Occurrence, morpho-histopathological characterization, and infection dynamics of *Posthodiplostomum* sp. (Strigeidida: Diplostomidae) in cyprinid fish of the Ganga River. ***Folia Biologica*** 69(3): 113-120. (6.69; 0.432)

Bhat IA, Dar JY, Ahmad I, Mir IN, Bhat H, Bhat RA, Ganie PA, Sharma R (2021) Testicular development and spermatogenesis in fish: insights into molecular aspects and regulation of gene expression by different exogenous factors. ***Reviews in Aquaculture*** 13: 2142-2168. (16.59; 10.592)

Bhat RAH, Thakuria D, Dubey MK, Tandel RS, Sharma P, Khangembam VC, Dash P, Tripathi G, Sarma D (2021) Lethal dose and histopathological alterations induced by *Aeromonas salmonicida* in experimentally challenged common carp, *Cyprinus carpio*. ***Microbial Pathogenesis*** 158(1): 105110-105120. (9.74; 3.738)

Biswal A, Srivastava PP, Krishna G, Paul T, Pal P, Gupta S, Varghese T, Jayant M (2021) An integrated biomarker approach for explaining the potency of exogenous glucose on transportation induced stress in *Labeo rohita* fingerlings. ***Scientific Reports*** 11: 5713. https://doi.org/10.1038/s41598-021-85311-5. (10.38; 4.38)

Biswal A, Srivastava PP, Pal P, Gupta S, Varghese T, Jayant M (2021) A multi-biomarker approach to evaluate the effect of sodium chloride in alleviating the long-term transportation stress of *Labeo rohita* fingerlings. ***Aquaculture*** 531: 735979. https://doi.org/10.1016/j.aquaculture.2020.735979. (10.24; 4.24)

Biswas C, Chakraborty S, Munilkumar S, Gireesh-Babu P, Sawant PB, Chadha NK, Krishna G, Dasgupta S (2021) Effect of high temperature during larval and juvenile stages on masculinization of common carp *(Cyprinus carpio, L). **Aquaculture** 530:735803. doi.org/10.1016/j.aquaculture.2020.735803* (10.24; 4.242)

Chintada B, Ranjan R, Santhosh B, Mahajan S, Ghosh S, Babitha Rani AM (2021) Effect of stocking density and algal concentration on production parameters of calanoid copepod *Acartia bilobate*. ***Aquaculture Reports*** 21:100909 DOI: 10.1016/j.aqrep.2021.100909 (9.16; 3.16)

Chuphal N, Sardar P, Sahu NP, Shamna N, Harikrishna V, Maiti MK, Mannur VS, Jana P, Paul M, Krishna G (2021) Effects of graded dietary lipid levels on growth, feed utilization, body composition and metabolism in juvenile white leg shrimp, *Penaeus vannamei* (Boone, 1931) reared in inland saline water of 10 g/L salinity. ***Aquaculture Nutrition*** 27(6): 1811-1824. (9.50; 3.50)

Chuphal N, Singha KP, Sardar P, Sahu NP, Shamna N, Kumar V (2021) Probiotics and antimicrobial proteins scope of Archaea in fish feed: a new chapter in aquafeed probiotics? ***Probiotics and Antimicrobial Proteins*** 13(11): 28-37. (10.61; 4.61)

Daniel N, Muralidhar AP, Srivastava PP, Jain KK, Prasad KP, Ranjan A (2021) Effect of vitamin C on immune and stress responses in striped catfish, *Pangasianodon hypophthalmus* juveniles under pre- and post-challenge with *Aeromonas hydrophila*. ***Aquaculture Research*** DOI: 10.111/are.15509 (8.02; 2.082)

Das SK, Kumar SH, Nayak BB, Lekshmi M (2021) Isolation and Identification of *Cronobacter* spp. from fish and shellfish sold in retail markets. ***Current Microbiology*** 78(5):1973-1980. (7.74; 1.74)

Dash P, Tandel RS, Bhat RA, Sarma D, Pandey N, Sawant PB, Chadha NK (2021) Spawning substrate preference and spawning behavior of chocolate mahseer, *Neolissochilus hexagonolepis*. ***Animal Reproduction Science*** 233:106847. doi.org/10.1016/j.anireprosci.2021.106847 (8.15; 2.04)

Dash P, Tandel RS, Pandey N, Sawant PB, Sarma D, Rawat KD, Chadha NK (2021) Effects of rearing temperature on egg incubation, growth, standard metabolic rate, and thermal tolerance of chocolate mahseer, *Neolissochilus hexagonolepis*. ***Journal of Thermal Biology*** 98: 102942. (8.90; 2.902)

Dayakar B, Xavier KAM, Das O, Porayil L, Balange AK, Nayak BB (2021) Application of extreme halophilic archaea as biocatalyst for chitin isolation from shrimp shell waste. ***Carbohydrate Polymer Technologies and Applications*** 2: 100093. https://doi.org/10.1016/j.carpta.2021.100093.

Deepitha RP, Xavier KAM, Layana P, Nayak BB, Balange AK (2021) Quality improvement of pangasius fillets using aqueous seaweed (*Padina tetrastromatica*) extract. ***LWT-Food Science and Technology*** 137: 110418. (10.952; 4.952)

Devi MS, Xavier KAM, Singh AS, Edwin L, Singh VV, Shenoy L (2021) Environmental pressure of active fishing method: A study on carbon emission by trawlers from north-west Indian coast. ***Marine Policy*** 127:104453. (10.173; 4.173)

Dhanabalan V, Xavier KM, Eppen S, Joy A, Balange A, Asha KK, Murthy LN, Nayak BB (2021) Characterization of chitin extracted from enzymatically deproteinized Acetes shell residue with varying degree of hydrolysis. ***Carbohydrate Polymers*** 253: 117203. doi.org/10.1016/j.carbpol.2020.117203 (15.37; 9.37)

Dorothy M, Harikrishna V, Sudhagar A, Reddy AK, Babitha Rani AM (2021) Growth, body composition and antioxidant status of *Litopenaeus vannamei* juveniles reared at different stocking densities in the biofloc system using inland saline groundwater. ***Aquaculture Research*** 52(2): 56-61. DOI: 10.1111/are.15493 (8.08: 2.08)

Droma D, Kumar S, Paul T, Pal P, Saharan N, Kumar K, Poojary N (2021) Biomarkers for assessing chronic toxicity of carbamazepine, an anticonvulsants drug on *Pangasianodon hypophthalmus* (Sauvage, 1878). ***Environmental Toxicology and Pharmacology.*** doi.org/10.1016/j.etap.2021.103691 (10.86; 4.86)

Ferosekhan S, Turkmen S, Pérez-García C, Xu H, Gómez A, Shamna N, Afonso JM, Rosenlund G, Fontanillas R, Gracia A, Izquierdo M, Kaushik S (2021) Influence of genetic selection for growth and broodstock diet n-3 LC-PUFA levels on reproductive performance of Gilthead Seabream, *Sparus aurata*. ***Animals*** 11:519 (8.75; 2.75)

Garg CK, Sahu NP, Maiti MK, Shamna N, Deo AD, Sardar P (2021) Dietary *Houttuynia cordata* leaf extract and meal enhances the immunity and expression of immune genes in *Labeo rohita* (Hamilton, 1822). ***Aquaculture Research*** 52(1):381-394. (8.08; 2.08)

Gita S, Shukla SP, Deshmukhe G, Choudhury TG, Saharan N, Singh AK (2021) Toxicity evaluation of six textile dyes on growth, metabolism and elemental composition (C, H, N, S) of microalgae *Spirulina platensis*: The environmental consequences. ***Bulletin of Environmental Contamination Toxicology*** 106(2): 302–309. (8.25; 2.25)

Gita S, Shukla SP, Deshmukhe G, Singh AR, Choudhury TG, Singh A (2021) Adsorption–biodegradation coupled remediation process for the efficient removal of a textile dye through chemically functionalized sugarcane bagasse. ***Water Environment Research*** *93(10*): 2223-2236. (7.946; 1.946)

Gore SB, Xavier M, Nayak BB, Shitole SS, Tandale AT, Balange AK (2021) Effects of cod liver oil fortification on the quality aspects of mince sausages from Indian Major Carp (*Labeo rohita*). ***Journal of Food Processing and Preservation*** 45(7): 15596. (8.190; 2.190)

Goswami M, Yashwanth BS, Trudeau V, Lakra WS (2021) Role and relevance of fish cell lines in advanced in vitro research. ***Molecular Biology Reports*** https://doi.org/10.1007/s11033-021-06997-4 (8.361; 2.361)

Gupta G, Srivastava PP, Gangwar M, Varghese T, Chanu TI, Gupta S, Ande MP, Krishna G, Jana P (2021) Extra-Forttification of Zinc Upsets Vitellogenin Gene Expression and Antioxidant status in female of *Clarias magur* brooders. ***Biological Trace Element Research*** https://doi.org/10.1007/s 12011-021-02793-0 (9.74; 3.738)

Gupta G, Srivastava PP, Kumar M, Varghese T, Chanu TI, Gupta S (2021) The modulation effects of dietary zinc on reproductive performance and gonadotropins (FSH and LH) expression in threatened Asian catfish, *Clarias magur* (Hamilton, 1822) broodfish. ***Aquaculture Research*** 52(5):2254-65. (8.08; 2.08)

Gurjar UR, Xavier KM, Shukla SP, Deshmukhe G, Jaiswar AK, Nayak BB (2021) Incidence of microplastics in gastrointestinal tract of golden anchovy (*Coilia dussumieri*) from north east coast of Arabian Sea: The ecological perspective. ***Marine Pollution Bulletin*** 169:112518. (11.553; 5.553)

Gurjar UR, Xavier M, Nayak BB, Ramteke K, Deshmukhe G, Jaiswar AK, Shukla SP (2021) Microplastics in shrimps: a study from the trawling grounds of the North eastern part of Arabian Sea. ***Environmental Science and Pollution Research*** 28(35):48494-504. (10.223; 4.223)

Haque R, Sawant PB, Sardar P, Xavier KM, Varghese T, Chadha NK, Pattanaik SS, Jana P, Naik VA (2021) Synergistic utilization of shrimp shell waste-derived natural astaxanthin with its commercial variant boosts physio metabolic responses and enhances colouration in discus (*Symphysodon aequifasciatus*). ***Environmental Nanotechnology, Monitoring & Management*** 15:100405. (11.647; 5.647)

Haridas H, Chadha NK, Sawant PB, Deo AD, Ande MP, Syamala K, Sontakke R, Lingam SS (2021) Growth performance, digestive enzyme activity, non-specific immune response and stress enzyme status in early stages of grey mullet reared in a biofloc system. ***Aquaculture Research*** DOI: 10.111/are.15326 (7.75; 2.082)

Hussain N, Kumar S, Sardar P, Varghese T, Maiti MK, Srivastava PP (2021) Green pea, *Pisum sativum* leaf meal with supplemented exogenous cellulose and xylanase can completely replace de-oiled ricebran (DORB) in the diet of *Labeo rohita* (Hamilton, 1878) fingerlings. ***Aquaculture Reasearch*** 52(7): 3186-3197. (8.08; 2.08)

Jahan I, Tiwari VK, Pavan Kumar A, Verma AK, Harikrishna V, Babitha Rani AM, Chadha NK, Anand G (2021) The Effect of Inland Saline Groundwater on Growth, Maturation, and Osmoregulation of Common Carp. ***North American Journal of Aquaculture*** *83(1): 15-25* (7.72; 1.717)

Jana P, Sahu NP, Sardar P, Shamna N, Varghese T, Deo AD, Harikrishna V, Paul M, Panmei H, Gupta G, Nanda C, Krishna G (2021) Dietary protein requirement of white shrimp, *Penaeus vannamei* (Boone, 1931) juveniles, reared in inland ground water of medium salinity. ***Aquaculture Research*** 52(6):2501-2515. (8.08; 2.08)

Javith MA, Balange AK, Xavier M, Hassan MA, Sanath Kumar H, Nayak BB, Krishna G (2021) Comparative studies on the chemical composition of inland saline reared *Litopenaeus vannamei*. ***Journal of Culinary Science & Technology*** 31:1-4. (6.71; 0.71)

Jayant M, Sahu NP, Deo AD, Garg CK, Yadav R, Gupta S (2021) Effective valorization of agro-waste of castor oil extraction industry as feedstock for sustainable fish production Biofuel. ***Bioproducts and Biorefining*** 15: 1126-1140. (10.10; 4.10)

Jayant M, Sahu NP, Deo AD, Gupta S, Rajendran KV, Garg CK, Meena DK, Wagde MS (2021) Effective valorisation of bio-processed castor kernel meal based fish feed supplements concomitant with oil extraction processing industry: A prolific way towards greening of landscaping/environment. ***Environmental Technology & Innovation*** https://doi.org/10.1016/j.eti.2020.101320. (11.26; 5.26)

Jayasimhan P, Thackrey T, Mohapatra A, Pavan-Kumar A (2021) *Rakthamichthys mumba*, a new species of Hypogean eel (Teleostei: Synbranchidae) from Mumbai, Maharashtra, India. ***Aqua International Journal of Ichthyology*** 27 (3); 93-102. (-; -)

John VC, Verma AK, Krishnani KK, Chandrakant MH, Bharti VS, Varghese T (2021) Optimization of potassium (K^+) supplementation for growth enhancement of *Spinacia oleracea* L. and *Pangasianodon hypophthalmus* (Sauvage, 1878) in an aquaponic system. ***Agricultural Water Management*** **261: 107339.** https://doi.org/10.1016/j.agwat.2021.107339 (10.52; 4.516)

Karnatak G, Das BK, Puthiyottil M, Tayung T, Kumari S, Lianthuamluaia L, Sarkar UK, Behera BK, Tiwari VK, Chadha NK, Das AK (2021) Environmental parameters and stocking density influence growth, feed utilization and economics of butter catfish, *Ompok bimaculatus* (Bloch, 1794) production in floating net cages in a large tropical reservoir, India. ***Environmental Science and Pollution Research*** 28(42): 59720-59730. (10.22; 4.22)

Kesavan S, Xavier KM, Deshmukhe G, Jaiswar AK, Bhusan S, Shukla SP (2021) Anthropogenic pressure on mangrove ecosystems: Quantification and source identification of surficial and trapped debris. ***Science of the Total Environment*** 794: 148677. https://doi.org/10.1016/j.scitotenv.2021.148677 (13.963; 7.963)

Khot M, Chinnaesakki S, Bara SV, Ravi PM, Jaiswar AK (2021) Baseline radionuclide concentration in commercially important brachyuran crabs around Mumbai and Sindhudurg of Maharashtra, India. ***Journal of Radioanalytical and Nuclear Chemistry*** 327(3): 1055-62. (7.14; 1.373)

Khot M, Jaiswar AK (2021) Three new records of brachyuran species (Crustacea: Decapoda) from Maharashtra, India, Central Eastern Arabian Sea. ***Thalassas: An International Journal of Marine Sciences*** doi:10.1007/s41208-021-00314-3 (- ;0.64)

Krishnan R, Jeena K, Prasad KP (2021) Nervous necrosis virus induced oxidative imbalance and host associated antioxidant response in Asian seabass brain. ***Aquaculture*** *531: 735809.* (10.42; 4.242)

Krishnani KK, Choudhary K, Veera BM, Moon DH, Meng X (2021) Heavy metals biosorption mechanism of partially delignified products derived from mango (*Mangifera indica*) and guava (*Psidium guiag*) barks. ***Environmental Science and Pollution Research*** 28: 32891–32904. (10.22; 4.22)

Kumar CB, Kumar A, Paria A, Kumar S, Prasad KP, Rathore G (2021) Effect of spatio-temporal variables, host fish species and on-farm biosecurity measures on the prevalence of potentially pathogenic *Aeromonas* species in freshwater fish farms. ***Journal of Applied Microbiology*** doi.org/10.1111/jam.15330 (9.77; 3.772)

Kumar GP, Xavier KM, Nayak BB, Sanath Kumar H, Gudipati V, Senapathi SR, Balange AK (2021) Physicochemical and microbiological changes during salt fermentation of pangasius steaks. ***Journal of Culinary Science & Technology*** 5:1-7. (6.71; 0.71)

Kumar M, Goswami M, Nayak SK, Gireesh-Babu P, Chaudhari A (2021) Evaluation of the binding affinity of a gonadotropin-releasing hormone analogue (GnRH-a) buserelin through in silico and in vivo testing in *Clarias magur*. **Current Proteomics** https://doi.org/10.2174/1570164618666210426090916 (6.837; .837)

Kumar M, Gupta G, Varghese T, Shankregowda AM, Srivastava PP, Bhushan S, Shukla SP, Krishna G, Gupta S (2021) Synthesis and characterisation of super-paramagnetic iron oxide nanoparticles (SPIONs) for minimising *Aeromonas hydrophila* load from freshwater. ***Current Nanoscience*** DOI:10.2174/ 1573413717 666210531153107 (7.82; 1.82)

Kumar N, Bhushan S, Gupta SK, Kumar P, Chandan NK, Singh DK, Kumar P (2021) Metal determination and biochemical status of marine fishes facilitate the biomonitoring of marine pollution. ***Marine Pollution Bulletin*** 170:112682. (11.55; 5.55)

Kumar N, Singh DK, Bhushan S, Jamwal A (2021) Mitigating multiple stresses in *Pangasianodon hypophthalmus* with a novel dietary mixture of selenium nanoparticles and Omega-3-fatty acid. ***Scientific Reports*** 11(1):1-20. (10.38; 4.37)

Kumar P, Wisdom KS, Ram RK, Gireesh-Babu P, Nayak SK, Nagpure NS, Sharma R (2021) Gonadotropin inhibitory hormone receptors (GnIHRs): Molecular characterization and synergistic effect of different drugs in Indian major carp, *Labeo catla*. ***General and Comparative Endocrinology*** 314:113904. (8.43; 2.822)

Kumar R, Kumar PS, Rao M, Prasad KP, Raman RP, Mothadaka MP (2021) Antibiotic resistance of culturable heterotrophic bacteria isolated from shrimp (*Penaeus vannamei*) aquaculture ponds. ***Marine Pollution Bulletin*** 172: 112887 (10.55; 5.553)

Kumar S, Paul T, Shukla SP, Kumar K, Karmakar S, Bera KK (2021) Biomarkers-based assessment of triclosan toxicity in aquatic environment: A mechanistic review. ***Environmental Pollution***, doi.org/10.1016/j.envpol.2021.117569 (14.07; 8.071)

Kumari P, Kumar S, Deo, K. V. Rajendran, and R. P. Raman (2021) Antiparasitic potentiality of ethanol and methanol extracts of *Azadirachta indica* leaf for eggs and copepodid stage of *Argulus japonicus*: in vitro study. ***Journal of Parasitic Diseases*** . https://doi.org/10.1007/s12639-021-01355-4. (5.95; -)

Kumari S, Harikrishna V, Surasani VKR, Balange AK, Rani AB (2021) Growth, biochemical indices and carcass quality of red tilapia reared in zero water discharge based biofloc system in various salinities using inland saline ground water. ***Aquaculture*** 540: 736730.https://doi.org/10.1016/j.aquaculture. 2021.736730. (10.24; 4.242).

Lal DM, Sreekanth GB, Shivakrishna A, Kumar R, Nayak BB, Abidi ZJ (2021) Ecosystem health status and trophic modeling of an anthropogenically impacted small tropical estuary along India's west coast. ***Environmental Science and Pollution Research***, 1-21 (10.22; 4.22).

Lekshmi M, Kumar SH, Rajendran KV, Nayak BB (2021) Development of a reverse transcription (RT) polymerase chain reaction (PCR) method for the detection of human norovirus in bivalve molluscs. ***Water Science and Technology*** 83(5): 1103-1107. (7.53; 1.53)

Lekshmi S, Xavier KM, Kumar S, Balange AK (2021) The preservative impact of the brown seaweed (*Padina tetrastromatica*) extract on the quality of tilapia (*Oreochromis mossambicus*) during chilled storage. ***Journal of Food Processing and Preservation*** 45(11): 15931. (8.190; 2.190)

Leya T, Ahmad I, Rajendran KV, Kurcheti PP, Tripathi G, Sharma R, Bedekar MK (2021) Development of species-specific IgM antibodies and elevation of mucosal immune response in *Labeo rohita* using recombinant bicistronic nano DNA vaccine priming. ***Fish & Shellfish Immunology*** 113(1): 185-195. (10.58; 4.58)

Leya T, Rajendran KV, Tripathi G, Prasad KP, Bedekar MK (2021) Expression of polymeric immunoglobulin receptor (pIgR) and immunoglobulin (IgM) gene in mucosal-associated lymphoid tissues (MALT) of *Labeo rohita* fingerlings immunized with pDNA (pGPD-IFN) vaccine. ***Aquaculture*** *535: 736343*. https://doi.org/10.1016/j.aquaculture.2021.736343 (10.24; 4.242)

Mallik A, Xavier KM, Naidu BC, Nayak BB (2021) Ecotoxicological and physiological risks of microplastics on fish and their possible mitigation measures. ***Science of the Total Environment*** 779:146433. (13.963; 7.963)

Moorthy AK, Bhuvaneswari GR, Shukla SP, Kumar K, Bharti VS (2021) Acute toxicity of textile dye Methylene blue on growth and metabolism of selected freshwater microalgae. ***Environmental Toxicology and Pharmacology*** 82:103552. (10.86; 4.86)

Mudulin C, Tripathi G, Prasad KP, Kumar K, Rathore G (2021) Virulence potential of *Aeromonas hydrophila* isolated from apparently healthy freshwater food fish. ***Biologia*** 76: 1005-1015. (7.35; 1.350)

Munilkumar S, Rameshori Y, Mangang WR, Kamei M, Chinglemba Y, Pavan-Kumar A, Mahapatra BK, Das A, Hanif MA, Siddik MA (2021) Length-weight relationships of six Nemacheilid fish species (Teleostei: Cypriniformes) from different rivers of Manipur, India. ***Journal of Applied Ichthyology*** 37(2):356-8. (6.89; 0.892)

Nageswari P, Verma AK, Gupta S, Jeyakumai A, Chandrakant MH (2021) Haematological, serum biochemical, and antioxidative enzymes responses of sutchi catfish (*Pangasianodon hypophthalmus*) against *Aeromonas hydrophila* using various carbon sources in biofloc system. ***Aquaculture Research*** 00: 1-11. https://doi.org/10.1111/are.15713(8.08; 2.082)

Nath K, Munilkumar S, Patel AB, Kamilya D, Pandey PK, Sawant PB (2021) Lamellidens and Wolffia canopy improves growth, feed utilization and welfare of *Labeo rohita* (Hamilton, 1822) in integrated multi-trophic freshwater aquaculture system. ***Aquaculture*** 534:736207. (10.24; 4.242)

Ngairangbam D, Das BK, Prasad KP, Tripathi G (2021) Characterisation and validation of housekeeping genes for qRT- S PCR expression analysis in *Pterophyllum scalare.* ***Aquaculture International*** DOI: 10.1007/s10499-021-00754-x (8.24; 2.235)

Nissa MU, Pinto N, Parkar H, Goswami M, Sanjeeva S (2021) Proteomics in fisheries and aquaculture: An approach for food security. ***Food Control*** 127: 108125 (11.548; 5.548)

Nuwansi KKT, Verma AK, Chandrakant MH, Prabhath GPWA, Peter R M (2021) Optimization of stocking density of koi carp (*Cyprinus carpio var. koi*) with gotukola (*Centella asiatica*) in an aquaponic system using phytoremediated aquaculture wastewater. ***Aquaculture*** 532: 735993. https://doi.org/10.1016/j.aquaculture.2020.735993. (10.24; 4.242)

Pattanaik SS, Sawant PB, KA MX, Srivastava PP, Dube K, Sawant BT, Chadha NK (2021) Dietary carotenoprotien extracted from shrimp shell waste augments growth, feed utilization, physio-metabolic responses and colouration in Oscar, *Astronotus ocellatus* (Agassiz, 1831). ***Aquaculture*** 534:736303. (10.24; 4.242)

Paul A, Mohanty J, Rajendran KV, Tripathi G, Sahoo PK (2021) First report of *Dactylogyrus scorpius* infection in Indian major carp, *Labeo rohita* from India: Host specificity and kinetics of immune gene expression in gills. ***Aquaculture*** 536(1): 453-462. (9.22; 4.242)

Phulia V, Sardar P, Jawal A, Kumar V, Shamna N, Fawole FJ, Sanap B, Gupta S (2021) Identification of best detoxification strategies for sustainable valorization of waste from Jatropha-based biodiesel industry: Compounding the benefits of plant-based vehicular fuel. ***Environmental Technology & Innovation*** 24:101911. DOI: 10.1016/j.eti.2021.101911 (11.26; 5.26)

Prabhakar P, Lekshmi M, Joseph TC, Balange AK, Nayak BB, Kumar SH (2021) Performance evaluation of a selective-enrichment-isolation protocol for *Salmonella enterica* from seafood. ***Journal of Microbiological Methods*** 180:106120. doi: 10.1016/j.mimet.2020.106120. (8.36; 2.36)

Priyadarshini MB, Xavier KM, Dhanabalan V, Nayak BB, Balange AK (2021) Development of ready-to-cook shrimp analogue from surimi: Effect of natural plant extracts on the chemical quality during refrigerated storage. ***LWT-Food Science and Technology*** 135: 110239. (10.952; 4.952)

Rajendran KV, Stentiford GD, Bass D (2021) The rise of syndrome sub-optimal growth disorders in farmed shrimp. ***Reviews in Aquaculture*** 13(4):1888-1906. (16.59; 10.592)

Ramya VL, Behera BK, Das BK, Krishna G, Pavankumar A, Pathan MA (2021) Stock structure analysis of the endemic fish, *Barbodes carnaticus* (Jerdon 1849), for conservation in a biodiversity hotspot. ***Environmental Science and Pollution Research*** 28(39):55277-89. (10.22; 4.223)

Ranjan A, Kumar S, Sahu NP, Jain KK, Deo AD (2021) Strategies for maximising de-oiled rice bran (DORB) in the fish feed. ***Aquaculture International*** 1-16.DOI: 10.1007/s10499-021-00791-6 (8.24; 2.24)

Rao M, Kumar SH, Kumar S, Bedekar MK, Tripathi G, Rajendran KV, (2021) Microbiological investigation of Tilapia lake virus-associated mortalities in cage-farmed *Oreochromis niloticus* in India. ***Aquaculture International*** 29(2):511-522. (8.24; 2.24)

Rasweefali MK, Sabu S, Sunooj KV, Sasidharan A, Xavier KM (2021) Consequences of chemical deacetylation on physicochemical, structural and functional characteristics of chitosan extracted from deep-sea mud shrimp. *Carbohydrate* ***Polymer Technologies and Applications*** 2: 100032.doi.org/10.1016/j.carpta.\2020. 100032. (-;-)

Rathinam RB, Banu H, Ghode GS, Bhushan S, Bhuvaneswari R, Tripathi G (2021) High prevalence of *Aeromonas* and *Pseudomonas* infections among cage cultured Pangas catfish from the reservoirs of Maharashtra, India. ***The Israeli Journal of Aquaculture-Bamidgeh*** doi.org/10.46989/001c.29633 (6.28; 0.28)

Rathinam RB, Iburahim SA, Ramanan SS, Tripathi G (2021) A scientometric mapping of research on *Aeromonas* infection in fish across the world (1998–2020). ***Aquaculture International*** 91(1): 1-23. (8.23; 2.235)

Sabu S, Xavier KAM, Sasidharan A (2021) Efficacy of pomegranate phenolic extract and chitosan as edible coating for shelf life extension of Indian white shrimp (Penaeus indicus) during refrigerated storage. ***Journal of Packaging Technology and Research*** https://doi.org/10.1007/s41783-021-00109-0 (6.00; -)

Sandeep KP, Avunje S, Dayal JS, Balasubramanian CP, Sawant PB, Chadha NK, Ambasankar K, Vijayan KK (2021) Efficiency of different microalgae as monospecific and bispecific diets in larval rearing of *Penaeus indicus* with special reference to growth, nutrient composition and antimicrobial activity of microalgae. ***Aquaculture Research*** 00, 1–9. https://doi. org/10.1111/are.15382. (8.08; 2.08)

Saravanan K, Kiruba-Sankar R, Khan MJ, Hashmi AS, Velmurugan A, Haridas H, Prakasan S, Deepitha RP, Laxmi MNV (2021) Baseline assessment of marine debris with soil, sediment, and water quality characteristics from the fish landing centres of South Andaman, Andaman archipelago, India. ***Marine Pollution Bulletin*** 172: 112879. https://doi.org/10.1016/j.marpolbul.2021.112879 (11.55; 5.55)

Saseendran S, Dube K, Chandrakant MH, Babitha Rani AM (2021) Enhanced growth response and stress mitigation of genetically improved farmed Tilapia in a biofloc integrated aquaponic system with bell pepper. ***Aquaculture*** 533(25):736200. (10.24; 4.24)

Sathish C, Nakhawa AD, Bharti VS, Jaiswar AK, Deshmukhe G (2021) Estimation of extent of the mangrove defoliation caused by insect *Hyblaea puera* (Cramer, 1777) around Dharamtar creek, India using Sentinel 2 images. ***Regional Studies in Marine Science*** 48:102054. (7.18; 1.624)

Selvam K, Xavier KM, Shivakrishna A, Bhutia TP, Kamat S, Shenoy L (2021) Abundance, composition and sources of marine debris trawled-up in the fishing grounds along the north-east Arabian coast. ***Science of The Total Environment*** 751: 141771. (13.963; 7.963)

Shameena SS, Kumar K, Kumar S, Kumari P, Krishnan R, Karmakar S, Kumar HS, Rajendran KV, Raman RP (2021) Dose-dependent co-infection of *Argulus* sp. and *Aeromonas hydrophila* in goldfish (*Carassius auratus*) modulates innate immune response and antioxidative stress enzymes. ***Fish & Shellfish Immunology*** 114:199-206. (10.58; 4.581)

Shameena SS, Kumar S, Kumar K, Raman RP (2021) Role of temperature and co-infection in mediating the immune response of goldfish. ***Microbial Pathogenesis***. 156:104896.https://doi.org/10.1016/ j.micpath.2021.104896. (9.37; 3.738)

Shamna N, Sahu NP, Sardar P, Fawole FJ (2021) Effects of nutraceutical conglomerate on growth and antioxidant status of *Labeo rohita* fingerlings. ***Animal Feed Science and Technology*** 280 (1):115045 (9.25; 3.25)

Shamna N, Sahu NP, Sardar P, Fawole FJ, Kumar S (2021) Changes in weight gain, digestive and metabolic enzyme activities in *Labeo rohita* fingerlings in response to multiple stress exposure and dietary nutraceutical. ***Tropical animal Health and Production*** 53 (5):509-514. (7.56; 1.56)

Silpa S, Srihari M, Pavan-Kumar A, Roul SK, Russell BC, Jaiswar AK (2021) Mistaken by dots: Revealing the misidentification of *Saurida lessepsianus* (Actinopterygii: Aulopiformes: Synodontidae) along the west coast of India (eastern Arabian Sea). ***Acta Ichthyologica et Piscatoria*** 7(51): 185-191. (6.93; 0.93)

Singh R, Das R, Jain KK, Srivastava PP, Deo AD (2021) Combined effect of L-carnitine and ractopamine supplementation on growth and nutritional composition of *Labeo calbasu* (Hamilton,1822). ***Aquaculture Nutrition*** 4:1-9.Doi No.:10.1111/anu.13412. (9.50; 3.50)

Singh R, Prasad KP, Tiwari A, Pathak A, Srivastava PP (2021) Molecular docking and Simulation study to identify antiviral agents by targeting MX protein against Betanodavirus causing viral nervous necrosis in Barramundi. ***Research Journal of Pharmacy and Technology*** 14(3):1405-1411. (7.20; 1.203)

Singh S, Mishra A, Pavan-Kumar A, Bidyasagar Singh S, Radhakrishnan KV, Nagpure NS, Chaudhari A (2021) Characterization of the complete mitochondrial genome of *Neolissochilus hexastichus* (McClelland, 1839). ***Mitochondrial DNA*** Part B, 6(9): 2461-2463. (6.66; 0.68)

Singha KP, Shamna N, Sahu NP, Sardar P, Harikrishna V, Thirunavukkarasar R, Chowdhury DK, Maiti MK, Krishna G (2021) Optimum dietary crude protein for culture of genetically improved farmed tilapia (GIFT), *Oreochromis niloticus* (Linnaeus, 1758) juveniles in low inland saline water: Effects on growth, metabolism and gene expression. ***Animal Feed Science and Technology*** 271: 114713. (9.25; 3.247)

Soman M, Chadha NK, Madhu K, Madhu R, Sawant PB, Francis B (2021) Optimization of temperature improves embryonic development and hatching efficiency of false clown fish, *Amphiprion ocellaris* Cuvier, 1830 under captive condition. ***Aquaculture*** 536:736417. doi.org/10.1016/j.aquaculture.2021. 736417 (10.24; 4.242)

Sontakke R, Tiwari VK, Prasad KP, Asanaru BR, Kutty M, Muralidhar A (2021) Yam-based biofloc system improves the growth, digestive enzyme activity, bacterial community structure and nutritional content in milkfish *(Chanos chanos).* ***Aquaculture Research*** 52(7): 3460-3474 (7.75; 1.376)

Sreekanth GB, Chakraborty SK, Jaiswar AK, Zacharia PU, Mohamed KS (2021) Modeling the impacts of fishing regulations in a tropical Indian estuary using Ecopath with Ecosim approach. ***Environment, Development and Sustainability*** 5: 1-19. (8.19; 2.95)

Srihari M, Bhushan S, Nayak BB, Pavan Kumar A, Abidi ZJ (2021) Spatial Variations in the Stocks of Randall's Threadfin Bream, *Nemipterus randalli* Russell 1986 Along the Indian Coast Inferred Using Body and Otolith Shape Analysis. ***Thalassas: An International Journal of Marine Sciences*** 37(2):883-90. (6.64; 0.64)

Srihari M, Silpa S, Pavan-Kumar A, Bhushan S, Nayak BB, Abidi ZJ (2021) Stock characterization of Greater Lizardfish, Saurida tumbil (Bloch, 1795) along the west coast of India using morphological and molecular markers. ***Marine Biology Research*** 17(2):107-19. (7.29; 1.29)

Srihari M, Silpa S, Pavan-kumar A, Tikochinski Y, Golani D, Nayak BB, Bushan S, Abidi ZJ (2021) Characterization of genetic diversity of an invasive Lessepsian Migrant, *Nemipterus randalli* Russell, 1986 from its native and non-native regions using mitochondrial DNA marker. ***Mediterranean Marine Science*** 22(1), 73-78. (- ; 2.319)

Sushila N, Das BK, Prasad KP, Tripathi G (2021) Characterisation and validation of housekeeping genes for qRT-PCR expression analysis in *Pterophyllum scalare*. ***Aquaculture International*** 29(6): 2387–2402. (8.23; 2.235)

Susmita M, Manjusha L, Parvathi A, Nayak BB, Kumar SH (2021) Survival of the blaNDM-harbouring *Escherichia coli* in tropical seawater and conjugative transfer of resistance markers. ***Archives of Microbiology*** 203(7):4273-4279. (7.6; 1.6)

Talukdar A, Deo AD, Sahu N P, Sardar P, Md Aklakur, Prakash S (2021) Effect of suboptimal dietary protein levels on growth, nutrient utilisation, and physio-metabolic status of *Anabas testudineus* fingerlings in inland saline water. ***Aquaculture Nutrition*** 27 (6): 2673-2689. (9.50; 3.497)

Talukdar A, Deo AD, Sahu NP, Sardar P, Aklakur M, Harikrishna V, Prakash S, Shamna N, Jana P (2021) Effects of different levels of dietary protein on the growth performance, nutrient utilization, digestive enzymes and physiological status of white shrimp, *Litopenaeus vannamei* juveniles reared in inland saline water. ***Aquaculture Nutrition*** 27(1): 77-90. (9.50; 3.497)

Tandel RS, Dash P, Bhat RA, Thakuria D, Sawant PB, Pandey N, Chandra S, Chadha NK (2021) Anti-oomycetes and immunostimulatory activity of natural plant extract compounds against *Saprolegnia spp*.: Molecular docking and in-vitro studies. ***Fish & Shellfish Immunology*** 114: 65-81. (10.58; 4.43)

Thirunavukkarasar R, Kumar P, Sardar P, Sahu NP, Harikrishna V, Singha KP, Shamna N, Jane J, Krishna G (2021) Protein-sparing effect of dietary lipid: Changes in growth, nutrient utilization, digestion and IGF-I and IGFBP-I expression of Genetically Improved Farmed Tilapia (GIFT), reared in inland ground saline water. ***Animal Feed Science and Technology*** 284:115150. DOI: 10.1016/j.anifeedsci.2021. 115150 (9.25; 3.25)

Thomas RM, Verma AK, Krishna H, Prakash S, Kumar A, Peter RM (2021) Effect of salinity on growth of Nile tilapia (*Oreochromis niloticus*) and spinach (*Spinacia oleracea*) in aquaponic system using inland saline groundwater. ***Aquaculture Research*** 52: 6288-6298. (8.08; 2.082)

Uchoi D, Lekshmi M, Ghag A, Thakur A, Kishore P, Nayak BB (2021) Quality changes in Indian mackerel (*Rastrelliger kanagurta*) during preservation with saturated brine fermentation technique. ***Journal of Food Processing and Preservation*** doi.org/10.1111/jfpp.15996 (8.20; 2.190)

Upadhyay A, Swain HS, Das BK, Ramteke MH, Kumar V, Krishna G, Mohanty BP, Chadha NK, Das AK (2021) Stocking density matters in open water cage culture: Influence on growth, digestive enzymes, haemato-immuno and stress responses of *Puntius sarana* (Ham, 1822). ***Aquaculture*** 547: 737445. (10.24; 4.242)

Vandana VR, Poojary N, Tripathi G, Pavan-Kumar A, Pratapa MG, Sanil NK, Rajendran KV (2021) A novel myxozoan parasite, *Ellipsomyxa boleophthalmi* sp. nov. (Myxozoa: Ceratomyxidae) in the brackishwater fish, *Boleophthalmus dussumieri* Valenciennes, 1837 (Perciformes: Gobiidae) from India. ***Parasitology Research*** *120(4) :* 1269-1279. (7.64;1.641)

Vandana VR, Poojary N, Tripathi G, Pavan-Kumar A, Sanil NK, Rajendran KV (2021) Hepatic microsporidiosis of mudskipper, *Boleophthalmus Dussumieri* valenciennes, 1837 (Perciformes: Gobiidae), due to *Microgemma* sp. ***Journal of Parasitic Diseases*** 20(1): 1-14. (5.95 ; -)

Varela MF, Jerusha S, Lekshmi M, Ojha M, Wenzel N, Sanford LM, Hernandez AJ, Parvathi A, Kumar SH (2021) Bacterial Resistance to Antimicrobial Agents. ***Antibiotics*** 10(5): 593. (9.89; 3.89)

Wilson JM, Ignatius B, Santhosh B, Sawant PB, Chadha NK (2021) Induced quiescence in eggs of the tropical calanoid copepod *Acartia tropica*: Effect of different storage conditions. ***Aquaculture Research*** 00: 1–8. https://doi.org/10.1111/are.15588 . (8.08; 2.08)

Wilson JM, Ignatius B, Sawant PB, Santhosh B, Chadha NK (2021) Productivity of the calanoid copepod *Acartia tropica* in response to different salinities and multigenerational acclimatization. ***Aquaculture*** 531:735818. doi.org/10.1016/j.aquaculture.2020.735818 (10.24; 4.242)

Wilwet L, Shakila RJ, Sivaraman B, Nayak BB, Kumar HS, Jaiswar AK, Ratrey VP, Jeyasekaran G (2021) In-house and on-field validation of the multiplex PCR assay developed for authentication of three commercially important shrimp species. ***LWT Food Science and Technology*** 148: 111701.(10.952; 4.952)

Wilwet L, Shakila RJ, Sivaraman B, Nayak BB, Kumar HS, Jaiswar AK, Jeyasekaran G (2021) Rapid detection of fraudulence in seven commercial shrimp products by species-specific PCR assays. ***Food Control*** 124: 107871. doi.org/10.1016/j.foodcont.2021.107871 (11.55; 5.548)

Yadav SR, Chavan BR, Chadha NK, Naik SD, Krishnani KK, Sawant PB (2021) Effect of stocking density on growth performance, plankton abundance, body composition and haematological parameters of *Etroplus suratensis* (Bloch, 1790) in the biofilm-based rearing system. ***Aquaculture Research*** 52(10):4752-66. (8.08; 2.08)

Zaffar I, Varghese T, Dasgupta S, Sahu NP, Srivastava PP, Harikrishna V, Mushtaq Z, Dar SA, Prakash S, Krishna G (2021) Dietary potassium partially compensates the requirement of aqueous potassium of *P. vannamei* reared in medium saline inland groundwater. ***Aquaculture Research*** 52(9): 4094-4104. (8.08; 2.082)

6.2 National Journals

(Peer reviewed Publications with NAAS;Impact Factor)

Balange AK, Xavier KA, Javith S, Chattopadhyay K, Das P, Reddy R (2021) Functional properties of surimi powder prepared from Croaker fish (*Otolihoides biauritus*). ***Fishery technology*** 53(1): 1-5. (5.82: -)

Bhendarkar MP, Gaikawad BB, Ramteke K, Joshi HD, Ingole NA, Brahmane MP, Gupta N (2021) Anticipating the impact of the COVID-19 lockdowns on the Indian fisheries sector for technological and policy reforms. ***Current Science*** 121(6): 1-8. (7.10;1.102)

Bhutia TP, Yadav VK, Qureshi NW, Kesavan S (2021) Fish of choice-an analytical hierarchy process to determine fish consumption in West Bengal. ***Indian Journal of Economics and Development*** 17(3): 693-699. (5.15; -)

Chakravarty S, Chadha NK, Mahapatra BK, Sawant PB, Dasgupta S (2021) Temperature accelerates photoperiod mediated testicular maturity in *Clarias magur* (Hamilton, 1822). ***International Journal of Current Microbiology and Applied Sciences*** https://doi.org/10.20546/ijcmas.2021.1008.xx. (5.51; -)

Gogoi P, Ahirwal SK, Chaktraborty SK, Bhattacharjya BK, Jaiswar AK, Singh J, Behera PR (2021) Investigations on age, growth and mortality parameters of *Ailia coila* (Hamilton, 1822) (Siluriformes: Ailiidae) from Brahmaputra river system of Assam, India. ***Indian Journal of Fisheries*** 68 (2): 8-14. (6.5; 0.5)

Gurjar UR, Takar S, Sawant MS, Pawar RA, Nirmale VH, Pawase AS, Chakraborty SK, Ramteke KK, Kumawat T (2021) Preliminary observation on the sustainability of white sardine, *Escualosa thoracata* (Valenciennes, 1847), exploited from the central west coast of India. ***The Journal of Basic and Applied Zoology*** 82(1):1-7. (-;-)

Haridas H, Chadha NK, Sawant PB, Deo AD, Ande MP, Syamala K, Sontakke R, Lingam SS (2021) Different carbon sources influences the growth and digestive enzyme activity of grey mullet (*Mugil cephalus)* in biofloc based nursery rearing system. ***Journal of Environmental Biology*** 42: 1249-1256. (6.78;0.78)

Harsha H, Sontakke R, Soman C (2021) Advances in climate resilient aquafarming practices. ***Journal of the Indian Society of Coastal Agricultural*** *Research* 39 (1): 17-24. (5.17; -)

Javith SMA, Xavier KAM, Nayak BB, Kumar HS, Harikrishna V, Balange AK, Krishna G (2021) Effect of different rearing conditions on the shelf-life of Pacific white shrimp (*Litopenaeus vannamei*) during ice storage. ***Journal of Environmental Biology*** 42(3): 652-658. (6.78; 0.781)

Joshua NE, Sharma A, Gopan A (2021) Impact of tsunami relief measures on the socio-economic condition of fishers in Tamil Nadu and Kerala. ***Multilogic in Science*** XI(38): 1953-1956. (4.51; -)

Katre N, Ojha SN, Arpita S, Sharma R, Dubey S, Yadav VK (2021) Alternative livelihood opportunities for fishers of Bargi Reservoir, Madhya Pradesh. ***Journal of Indian Fisheries Association*** 47(2): 78-84. (4.6; -)

Kharatmol BR , Shenoy L, Landge AT, Mohite AS and Rathod RH (2021) Study of fish catch and discard rate of trawling off Sindhudurg coast of Maharashtra, India. *Journal of Experimental Zoology* Vol. 24, No. 1, 595-600 (5.25;-)

Kiranmayi D, Sharma A, Prasad KP, Sharma R, Sharma SK (2021) Development of an android-based application system for fish farmers. ***Agricultural Research*** 3(4): 1-9. (5.95; -)

Kohli V, Vaidhyanathan R, Balange AK, Nayak BB, Kumar HS (2021) Distribution of *Vibrio parahaemolyticus* in farmed shrimp *Penaeus vannamei*, farm water and sediment. ***Journal of Pure and Applied Microbiology*** 15(3): 1608-17. (5.05; -)

Krishnani KK (2021) Finfish based bioaugmentation technology for enhancing shrimp grower's income and livelihood. ***Agricultural Research*** https://doi.org/10.1007/s40003-020-00530-y. (5.95;-)

Kumar A, Pradhan PK, Mohindra V, Tiwari VK, Chadha NK, Sood N (2021) Early weaning of Asian stinging catfish, *Heteropneustes fossilis* (Bloch) larvae. ***Indian Journal of Animal Research*** DOI:10.18805/IJAR.B-4452. (6.48; 0.48)

Kumari S, Jaiswar AK, Jahageerdar S, Abidi ZJ, Chakraborty SK, Kumar T, Sarkar UK (2021) Inter and intra variation of sciaenid fishes (Teleostei: Perciformes: Sciaenidae) through osteological and morphological approach from north west coast of Indian waters, Arabian sea. ***Journal of Experimental Zoology, India*** 24(2): 1409-1421. (5.25; -)

Kumari S, Sharma A (2021) Gender differentials in performance of self-help groups in fisheries sector at Raipur, Chhattisgarh. ***Indian Journal of Extension Education*** 57(1): 12-16. (5.95; -)

Kumari S, Sharma A, Choudhary AK, Ananthan PS, Ojha SN, Sharma R, Landge A (2021) Assessment of cage culture practices in Chandil Reservoir, Jharkhand. **Asian *Journal of Agricultural Extension, Economics & Sociology*** 39(9): 21-30. (4.86; -)

Kumawat T, Saravanan R, Vinod K, Jaiswar AK, Deshmukhe G, Shenoy L (2021) Fisher perceptions on impacts of jellyfish swarming on fishing operations along the Gujarat coast, India. ***Journal of Marine Biology Association, India*** 62(2):62-65 doi:10.6024/ jmbai. 2021.63.1.2272-0x (-; -)

Mamatha D, Verma AK, Chandrakant MH, Peter RM (2021) Performance of an integrated zero water exchange system for hatching of eggs of rohu (*Labeo rohita*). ***Journal of Experimental Zoology, India*** 24(2): 961-965. (5.25;-)

Muduli C, Rathore G, Srivastava R, Singh RK, Tripathi G, Prasad KP, Kumar K (2021) Immuno-pathological changes in Indian catfish *Clarias magur* (Hamilton, 1822) upon experimental challenge with *Aeromonas hydropila*. ***Indian Journal of Fisheries*** 68(3): 77-85. (6.5; 0.5)

Munilkumar S, Mangang WR, Devi GA, Ail S, Sundaray J (2021) Coastal ornamental aquaculture as livelihood option and its vulnerability to climate change. Journal of ***Indian Society of Coastal Agricultural Research*** 39(1):1-6. (5.17; -)

Muralidhar AP, Kohli MPS, Prasad KP, Syamala K, Prusty AK (2021) Effect of dietary supplementation of green seaweed, *Ulva lactuca* on growth performance, digestive enzymes and histo-architectural changes of *Labeo rohita* (Hamilton, 1822) fingerlings. ***Journal of Indian Fisheries Association*** 48(1): 34-43. (4.14;-)

Nair SM, Gangan SS, Raut S, Raghavan R, Kumar AP, Singh LK, Jaiswar AK (2021) Otoliths as taxonomic tool to identify catfishes of the genus *Mystus* (Teleostei: Bagridae) from India. ***Indian Journal of Fisheries*** 68(1): 32-36. (6.5; 0.5)

Pathak, Bhutia RN, Bhushan S, Deshmukhe G, Jaiswar AK (2021) Discrimination of five Gobid species (Family: Gobiidae) based on otolith morphometry. ***Indian Journal of Animal Research*** doi:10.18805/IJAR.B-4458. (6.48; 0.48)

Patil SV, Sharma A (2021) Constraints faced and test of agreement among shrimp farmers of Palghar district in Maharashtra. ***Journal of Krishi Vigyan*** 9(2): 22-28. (4.55; -)

Patil SV, Sharma A (2021) Understanding the Constraints of fisheries extension personnel, in shrimp aquaculture sector, Maharashtra. ***Journal of Community Mobilization and Sustainable Development*** 16(3): 627-632. (5.67; -)

Patro D, Srivastava PP, Varghese T, Gupta S, Kumar P, Prabhakaran A (2021) Evaluation of growth and biochemical responses of *Cyprinus carpio* reared in freshwater and inland saline water. ***Journal of Marine Biological Assessment of India*** 63(1): 25-30. (5.40; -)

Paul M, Sardar P, Sahu NP, Varghese T, Shamna N, Harikrishna V, Jana P, Singha KP, Krishna G (2021) Optimal dietary protein requirement of juvenile GIFT Tilapia (*Oreochromis niloticus*) reared in inland ground saline water. ***Journal of Environmental Biology*** 43(2): 15-21. (6.56; 0.56)

Peter RM, Verma AK, Chandrakant MH, Mamatha D (2021) Effect of different potassium (K^+) doses on growth of tomato (*Solanum lycopersicum*) with pearlspot (*Etroplus suratensis*) in a recirculating aquaponic system. ***Journal of Experimental Zoology, India*** 24(2): 951-959. (5.25;-)

Peter RM, Verma AK, Saharan N, Tiwari VK, Chandrakant MH, Thomas RM (2021) Effect of hydraulic loading rate on production of tomato (*Solanum lycopersicum*) with Pearlspot (*Etroplus suratensis*) in recirculating aquaponic system. ***Journal of Agricultural Engineering*** 58(3); 300-308. (4.79; -)

Prasad SM, Ande MP, Syamala K, Chadha NK, Sawant PB, Xavier B, Babu PB (2021) Effect of different dietary protein levels on physio-metabolic response during stunting of milkfish, *Chanos chanos* (Forsskal, 1775) reared under pond conditions. ***Indian Journal of Animal Research*** DOI: 10.18805/IJAR.B-4813. (6.48; 0.48)

Prusty S, Sharma A (2021) Perceptions of fisheries professionals with reference to change in minimum qualification for agricultural research services. ***Asian Journal of Agricultural Extension, Economics & Sociology*** 39(11): 161-167. (4.86; -)

Rajeshwaran M, Argade S, Ojha SN, Ananthan PS (2021) A scale to measure the fisher's attitude towards Small scale fisheries. ***Journal of Indian Fisheries Association*** 48 (1): 62-67. (4.15; -)

Rajeshwaran M, Ojha SN, Ananthan PS, Argade S, Meharoof M, Fernando H (2021) Case study on country's first community radio station for marine fishermen. ***Multilogic in Science*** 10(36): 1585-1589. (5.20; -)

Ratre D, Ojha SN, Sharma A, Ramasubramanian V, Yadav R (2021) An analysis of relationship between gender and opinion leadership among the fish farmers of Chhattisgarh. ***Indian Journal of Extension Education*** 57(4): 93-96. (5.95; -)

Raul C, Prakash S, Lenka S, Bharti VS (2021) Sugarcane bagasse biochar: A suitable amendment for inland saline pond water productivity. ***Journal of Environmental Biology*** 42(5):1264-1273. (6.78; 0.781)

Renjith RK, Jaiswar AK, Chakraborty SK, Landge AT, Sreekanth GB, Ramteke KK (2021) Facial sexual dimorphism in largescaled terapon *Terapon theraps* Cuvier, 1829, with special reference to geometric morphometry. ***Indian Journal of Fisheries*** 68(2):127-31. (6.29; 0.5)

Sathya G, Qureshi NW, Velumani T, Ananthan PS (2021) A scientometric assessment on the use of bioeconomic modeling in fisheries. ***Journal of Agricultural Development and Policy*** 31(1): 14-25. (3.61; -)

Shamna N, Somashekhar L, Sridhar N, Parthipan S, Arangasamy A, Dasgupta S, Sahu NP, Fawole FJ, Selvaraju S (2021) Morphometry and molecular characterisation of semen in four carp species. ***Indian Journal of Fisheries*** 68(2):76-85. (6.50; 0.5)

Shivakrishna A, Ramteke KK, Akhilesh KV, Pavan Kumar A, Chellappan A, Nayak BB, Abidi ZJ (2021) New distributional record of *Triacanthus nieuhofii* Bleeker, 1852 (Tetraodontiformes: Triacanthidae) from Maharashtra, North West Coast of India. ***Indian Journal of Animal Research*** 1:1-5. (6.48; 0.48)

Shivakrishna A, Ramteke KK, Kesavan S, Prasad P, Naidu BC, Dhanya M, Abidi ZJ (2021) Monitoring of current land use pattern of Ramsar designated Kolleru wetland, India using geospatial technologies. ***Journal of Environmental Biology*** 42(1): 106–111. (6.78; 0.78)

Singh SK, Tiwari VK, Munilkumar S, Prakash C, Chadha NK, Biswas P (2021) Effect of dietary synbiotic on serum biochemistry and anti-oxidative function of *Labeo rohita* fingerlings exposed to sub-lethal nitrite stress. ***Indian Journal of Animal Health*** 60(2): 253-261. (5.25; -)

Sreekanth GB, Jaiswar AK, Akhliesh KV (2021) Feeding ecology of giant guitarfish, *Glaucostegus* cf. *granulatus* (Glaucostegidae: Rhinopristiformes) from Eastern Arabian Sea. ***National Academy Science Letters*** 45(1):19-24. (6.42; 0.788)

Suresh-Babu PP, Rao SP, Krishnaprasad J, Sharma R, Babitha Rani AM, Biju IF (2021) Observations on impact of stunting on breeding performance of farmed rohu (*Labeo rohita*) (Hamilton, 1822). ***Indian Journal of Fisheries*** 68(1): 12-16. (6.5; 0.5)

Tandel RS, Chadha NK, Dash P, Sawant PB, Pandey N, Chandra S, Bhat RAH, Thakuria D (2021) An *in vitro* study of Himalayan plant extracts against oomycetes disease saprolegniasis in rainbow trout (*Oncorhynchus mykiss*). ***Journal of Environmental Biology*** 42:1008-1018. (6.781; 0.781)

Velumani T, Ananthan PS, Sarkar UK, Argade S (2021) Climate variability and fisheries vulnerability: a case study of Thanjavur district, Tamil Nadu. ***Journal of Indian Fisheries Association***, 48 (1): 81-93. (4.15; -)

Wanjari RN, Ramteke KK, Raut S, Gupta N (2021) Length–weight relationship of *Charybdis callianassa* Herbst, 1789 (Decapoda: Brachyura) in relation to sex and carapace length along the Mumbai coastal water, India. ***The Journal of Basic and Applied Zoology*** 82(1): 21–26. (-;-)

Yadav R, Chadha NK, Saini VP, Yadav R, Sawant PB, Ojha ML, Jayant M, Sharma BK (2021) Current status and future prospects of Rajasthan fisheries. ***Journal of Indian Fisheries Association*** 47(2): 52-60. (3.12;-)

Yadav R, Ojha SN, Ananthan PS, Vinod VK, Yadav R (2021) Gender role in fisheries value chain in Asia's second largest artificial lake - Jaisamand, Rajasthan. ***Indian Journal of Extension Education*** 57(1), 20-25. (5.95; -)

Yadav VK, Jahageerdar S, Adinarayana J (2021) Forecasting quarterly landings of total fish and major pelagic fish and modelling the impacts of climate change on Bombay duck along India's North-western coast. ***Indian Journal of Geo-Marine Science*** 50(7): 557-565. (6.48; 0.48)

6.3 Popular Articles

Argade S, Pathan MK, Pathak M, Varghese T, Jayant M, Qureshi NW, Banu H, Singh AL, Krishna G (2021) *Sahyadria denisonii* (Miss Kerala) culture: Challenges, livelihood potential and way forward. **Aqua Star** 2: 96-98.

Argade S, Pathan MK, Pathak M, Varghese T, Jayant M, Qureshi NW, Banu H, Lenin A (2021) Miss Kerala – a potential livelihood generating ornamental fish. **Aqua Star** 6: 90-96.

Balange AK, Deepitha RP (2021) Importance of fish value chain in maintaining fish quality and its implementation in India. **Meenakshi** 2: 45-47.

Balange AK (2021) Scope of entrepreneurship development in value added fish products in North Eastern region of India. **Proceedings- National Seminar on agribusiness with special reference to Tripura** 202: 52-58.

Balange AK, Snehal S (2021) Technology development in fish processing sector. **Sampada** 3: 30-33

Chanu TI, Sharma A, Krishna G, Jahageerdar S (2021) Culture of desi magur, *Clarias magur*. **Aqua Star** 2: 93-97.

Chattopadhyay K, Xavier KAM (2021) Biopackaging: A sustainable tool for food quality enhancement. **Sasthra –The Indian Journal of Science and Technology** 3: 27-30.

Chattopadhyay K, Xavier KAM (2021) Fish silage: A functional waste by-product. **Biotica Research Today** 3(4): 216-219.

Das R, Xavier KAM, Ghosh SK (2021) Fraudulent in fish and fisheries products: An overview. **Biotica Research Today** 3(6): 541-543.

Dhanabalan VLV, Manivannan M, Xavier KAM (2021) Fish processing by-products derived protein hydrolysates and it's potential as antioxidants. **Biotica Research Today** 3(4): 276-278.

Dhanabalan VLV, Xavier KAM (2021) Carbon footprint: An assessment approach for the environmental impacts of seafood production. **Biotica Research Today** 3(3): 149-150.

Dhanalakshmi M, Ramteke KK, Wanjari RN (2021) Impact of cyclone on fisheries sector in India. **Biotica Research Today** 3(10): 886–888.

Dhenuvakonda K, Sharma A (2021) MatsyaKiran app: A mobile based solution for fish farmers of Telangana. **Aquapost** 4: 1-7.

Iburahim AS, Bezawada CN, Meenatchi S, Chellamanimegalai P, Dhanalakshmi M, Kumari A, Mallik A, Landge AT (2021) Fisheries news updates 2021. **Food and Scientific reports** 12-28.

Jacob J, Shaikh N, Chatterjee NS, Banerjee K, Krishnani KK (2021) Seafood authentication: Role of analytical instruments and need for ecolabelling. **MPEDA News Letter IX** 8: 24-27.

Kamble AL, Bhalerao AK, Ananthan PS, Argade S (2021) Sustainable fisheries in Bhima River of Maharashtra: Status and measures. **AgriCos e-Newsletter**, 2(09): 21-23.

Kamble AL, Bhalerao AK, Ananthan PS, Ojha SN (2021) Prospects and challenges of fish farming in farm ponds in Maharashtra. **AgriCos e-Newsletter** 2(08): 125-126.

Kamble AL, Bhalerao AK, Argade S, Qureshi N (2021) Prospects of developing fish processing industry near Bhima River. **AgriCos e-Newsletter** 2(08): 122-124.

Kamble AL, Bhalerao AK, Shinoji KC, Argade S (2021) Effect of flood in Western Maharashtra on production and profitability of Sugarcane. **Harit Dhara** 4(1): 20-21.

Kamble AL, Bhalerao AK, Shinoji KC, Argade S (2021) Prospects of transforming farm ponds into water bank: Approach to enhance resilience against drought. **AgriCos e-Newsletter** 2 (07): 100-101.

Krishnan M, Dinesh N, Qureshi NW (2021) Volumes, values and markets for Indian shrimp: A success story that need constant care. **Aqua Asia Magazine** 5: 18-27

Krishnani K K (2021) Fish slime: Unexplored reservoir for bioprospecting and one health concept. **NAAS News** 21(2): 15-17.

Krishnani KK, Tripathi G, Chadha NK, Krishna G (2021) *Kisano dwara abhigrahan hetu shrimp jalkrishi pranali me jaiv sanvardhan ke liye aharit jal pradyogiki.* **Jalchari** 19-20: 26-28.

Kumar P (2021) *Matsya palan mein vaekalpik aahaar pranali rannitiyon ka vyavharik mahatva*. **Krishi Jagran** 2(1): 24-26.

Kumara R, Ande MP, Syamala K, Sawant PB, Chadha NK (2021) Phage therapy for disease control in aquatic organisms. **Aqua Star** 3: 78-85.

Lingam SS, Sawant PB, Chadha NK, Muralidhar PA, Syamala K, Anand S (2021) Stunted fingerlings, the seeds for future Aquaculture. **World Aquaculture** 3: 55-57.

Manivannan M, Dhanabalan VLV, Xavier KAM (2021) Merits of chitosan over food applications. **Biotica Research Today** 3(4): 270-272.

Moorthy AK, Rani V, Bhuvaneswari RG (2021) Plastic eating bacteria: A solution to plastic pollution? **Aqua International**. 53-56.

Patil SV, Sharma A (2021) Prioritization of training needs of shrimp farmers using scientific training need assessment model. **Vigyan Varta** 2(4): 57-60.

Paul T, Kumar S, Biswal A, Debroy S (2021) Bisphenol a (BPA) occurrence, fate and toxicity in aquatic environment. **Aquaculture spectrum** 4: 31-38.

Ramteke KK, Wanjari R, Nandagawli K (2021) Integrated fish culture systems in the hill. **Aqua Star** 3: 27-30.

Reang D, Nayak SK, Sharma A, Krishna G (2021) Anchor worm and the role of its Anchor in taxonomic identification. **Aqua Star** 7: 51-53.

Shamna N, Sahu NP, Gyandeep G, Munish K (2021) Pearl spot (*Etroplus suratensis*) culture: potentials & constraints. **Aqua Star** 1(4): 18-21.

Sharma A, Kumar SK, Reang D, Krishna G (2021) Anchor worm and the role of its anchor in taxonomic identification. **Aqua Star** 51-53.

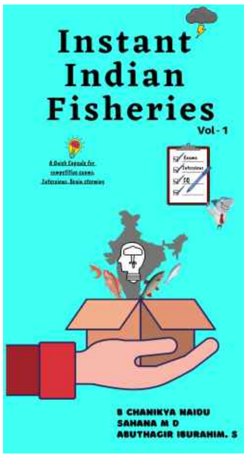
Suman S, Saurabh S, Pradhan S, Pavan-Kumar A, Das R, Krishna G (2021) Freshwater pearl culture practices and challenges in India. **Aquaculture Asia** 25(4): 19-22.

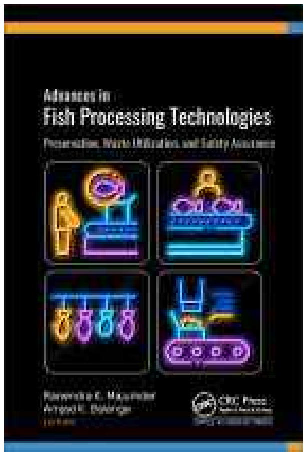
Thejaswini, Sahu U, Shamna N, Babita Rani AM (2021) Tubifex: A forever nutritious jewel in aquaculture. **World Aquaculture** 12: 65-67

Tripathi G, Rathinam B (2021) *Meethe paani ke pinjare me hone wale machali paalan ke machaliyo ke rog*. **Jalchari** 18-19: 74-83.

6.4 Books and Book Chapters

Books





Naidu CB, Sahana MD, Iburahim AS (2021) Instant Indian Fisheries-Volume 1. Amazon Kindle pp. 60

Majumder RK, Balange AK (2021) Advances in Fish Processing Technologies: Preservation, Waste Utilization, and Safety Assurance. CRC Press, Taylor & Francis Group pp.455 ISBN: 9781774911075

Chapters in Books

Balange AK, Deepitha RK (2021) Utilization of low-cost fish through restructured product-based technologies. In: *Advances in Fish Processing Technologies: Preservation, Waste Utilization, and Safety Assurance*; (Eds. Majumder RK, Balange AK). CRC Press, Taylor & Francis Group. ISBN: 9781774911075

Argade S (2021) Promoting women's aquapreneurship through collective actions: Transforming gender relations promoting women agripreneurship through crop-livestock-fisheries technologies. (Eds. Das L, Phand S, Tanuja S, Kumar N) [E-book], Published by ICAR-CIWA, Bhubaneswar-& MANAGE, Hyderabad.

Argade S, Mhatre C, Bhalerao A (2021) Integrating gender perspective in information and communication technology for empowering women in agriculture. In: *Extension Approaches and Strategies for Rural Transformation*. (Eds. Chaudhary KP, Prasad A, Ram D), Biotech Books PP. 127-143.

Argade S, Sarkar A, Mhatre C (2021) Building gender transformative agricultural extension system: a seed for change. In: *Extension Approaches and Strategies for Rural Transformation*. (Eds. Chaudhary KP, Prasad A, Ram D), Biotech Books PP. 24-37.

Garima, Rawat S (2021) Jalvayu kushal machli palan. In: *Jalvayu Parivartan Aur Bhartiya Krishi: Chunautiya, Anukualan Aur Shaman Radhnitiya*. Pp. 230-247. publisher ICAR-NAARM

Gayatri Tripathi and Dhanshree Kadam (2021). Therapeutics in Aquaculture. In: Model Question Bank A to Z of Fisheries. (Eds. Pandey PK, Choudhury TG) (Edition 2)/ Narendra Publication House, Delhi. pp. 209-216.

Kumar D, Munilkumar S (2021) Feeding cities through urban and peri-urban aquaculture. In: *The Basics of Human Civilization* (Ed. Nath P). pp. 541-563. CRC Press, ISBN 9781032159041

Kumar K, Kumar S (2021) Fish and Shellfish Pathology. In: *Model Question Bank A to Z of Fisheries*. (Eds. Pandey PK, Choudhury TG) (Edition 2)/ Narendra Publication House, Delhi pp. 185-193. ISBN: 9789390309672

Kumar K, Kumar S (2021) Fish Toxicology. In: *Model Question Bank A to Z of Fisheries*. (Eds. Pandey PK, Choudhury TG (Edition 2)/ Narendra Publication House, Delhi pp. 217-223. ISBN: 9789390309672

Kumar P, Jain KK, Munilkumar S (2021) Research on responses of digestive and metabolic enzymes to different feeding strategies with sub-optimal protein level in *Labeo rohita* fingerlings. In: *Current Advances in Chemistry and Biochemistry* Vol. 2,/(Eds. Fawzy M, Hassanien R). Publisher B P International, India pp. 55-65

Kumar S, Kumar K (2021) Soil and water quality. In: *Model Question Bank A to Z of Fisheries.* (Eds. Pandey PK, Choudhury TG) (Edition 2)/ Narendra Publication House, Delhi pp.247-255. ISBN: 9789390309672

Kumar S, Kumar K (2021) Aquatic pollution and coastal zone management. In: *Model Question Bank A to Z of Fisheries.* (Eds. Pandey PK, Choudhury TG) (Edition 2)/ Narendra Publication House, Delhi pp. 279-289. ISBN: 9789390309672

Kumar S, Kumari P (2021) Advances in management methods for argulosis in aquaculture. In: *Biotechnological Advances in Aquaculture Health Management*. (Eds. Gupta SK, Giri SS) pp. 407-430. https://doi.org/10.1007/978-981-16-5195-3_11 Springer, Singapore, ISBN: 978-981-16-5195-3

Lakra WS, Krishnani KK (2021) Perspectives of circular bioeconomy for stress resilient fisheries and aquaculture. In: *Circular Bioeconomy: Technologies for Biofuels and Biochemicals in the Biomass, Biofuels, Biochemicals*. (Eds. Varjani S, Pandey A, Bhaskar T, Mohan SV, Tsang DCW). Elsevier Publisher pp. 481-516.

Layana P, Deepitha RP, Martin Xavier KA, Balange AK (2021) Edible packaging for fish preservation: fundamentals and applications. In *Advances in Fish Processing Technologies: Preservation, Waste Utilization, and Safety Assurance*; CRC Press, Taylor & Francis Group, pp 450. ISBN: 9781774911075

Xavier KAM, Kasturi C (2021) Bioactive and functional nutraceuticals from shrimp processing wastes. In *Advances in Fish Processing Technologies: Preservation, Waste Utilization, and Safety Assurance*, CRC Press, Taylor & Francis Group, pp 450 ISBN. 9781774911075

Meena DK, Jayant M, Sahoo AK, Satvik K, Sarkar UK, Swain HS, Das BK (2021) Fish feed and feeding management in enclosure system: status and prospectus. In: *Recent advances in Reservoir Fisheries of India*. Satish Serial Publishing House, Delhi Pp.182-203. ISBN: 978-93-90660-11-7/ E-ISBN: 978-93-90660-12-4.

Rasal KD, Dixit S, Vasam M, Sundaray JK (2021) Emerging role of small non-coding (micrornas) during regulation of endocrine function in fishes. In: *Recent Updates in Molecular Endocrinology and Reproductive Physiology of Fish*. Springer, Singapore. https://doi.org/10.1007/978-981-15-8369-8_14 pp 193-201

Sahoo S, Banu H, Prakash A, Tripathi G (2021) Immune system of fish: An evolutionary perspective. In: *Antimicrobial Immune Response, Maria del Mar Ortega-Villaizan and Veronica Chico*. Publisher Intech Open, pp. 1-21 DOI: 10.5772/intechopen.99541

Sharma R (2021) Genotoxicity. In: *A Textbook of Fish Toxicology*, (Eds. Bhat IA, Bhat RAH, Yousuf DJ). pp. 165–176. Narendra Publishing House, Delhi, India pp. 165-176. ISBN 13 : 9789390309320

Shinogi KC, Srivastava S, Rashmi I, Jayaraman S, Sinha NK, Gurav PP, Kamble AL (2021) Socioeconomic challenges and prospects in the adoption of conservation agriculture practices in India. In: *Conservation Agriculture: A Sustainable Approach for Soil Health and Food*. (Eds. Jayaraman S et al.,) Publisher Springer, Singapore https://doi.org/10.1007/978-981-16-0827-8_29

Shinogi KC, Srivastava S, Rashmi I, Jayaraman S, Sinha NK, Gurav PP, Kamble AL (2021) Socioeconomic Challenges and Prospects in the Adoption of Conservation Agriculture Practices in India. In: *Conservation Agriculture: A Sustainable Approach for Soil Health and Food*. (Eds. Jayaraman S et al.,) publisher Springer, Singapore. https://doi.org/10.1007/978-981-16-0827-8_29

Singh SK, Munilkumar S, Pawar NA, Biswas P (2021) Prebiotic–synbiotic nexus: Critical dietary role in aquaculture. In: *Biotechnological Advances in Aquaculture Health Management*. (Eds. Gupta SK, Giri SS) pp. 237-267. https://doi.org/10.1007/978-981-16-5195-3_11 Springer, Singapore, ISBN: 978-981-16-5195-3

Sontakke R, Haridas H (2021) Biofloc based aquaculture system: Research status and developments. In: *Research Trends in Fisheries and Aquatic Sciences*. (Eds. Sundaray JK, Bhat RA). Pp. 241-261. AkiNik Publications, Dehli

Soottawat B, Avtar S, Thanasak SL, and Balange AK (2021) Endogenous Enzymes: Their Roles in Quality of Fish/Shellfish and Their Products *Advances in Fish Processing Technologies: Preservation, Waste*; CRC Press, Taylor & Francis Group. ISBN: 9781774911075

Yadav VK, Bharti VS, Jahageerdar S (2021) Projecting short-term and long-term total marine fish production and catch potential in India's North-Western Coast under the climate change scenario. In: *Impact of Climate Change on Hydrological Cycle, Ecosystem, Fisheries and Food Security*. (Eds. Kurup BM, Boopendranath MR, Harikrishnan, Shibu AV). Copyright © 2021, Narendra Publishing House, Delhi, India

6.5 Training Manuals

English

Balange AK (2021) Preparation of Value-added Fish Products from Freshwater Fish. pp 30.

Chaudhari A, Nagpure N, Pathan MA (2021) Application of Zebrafish as a Vertebrate Model for Biomedical Studies. ICAR-CIFE, Mumbai. pp.157.

Pailan GH, Mahapatra BK, Datta S, Munilkumar S, Dasgupta S, Biswas G, Sahoo S, Singh DK, Banu H, Manna S, Pradhan S (2021) PGDIFUAM Training Manual on Fishery Biology and Resource Management. ICAR-CIFE, Kolkata Centre. pp. 287.

Pailan GH, Mahapatra BK, Datta S, Munilkumar S, Dasgupta S, Biswas G, Sahoo S, Singh DK, Banu H, Manna S, Pradhan S (2021) PGDIFUAM Training Manual on Aquaculture. ICAR-CIFE, Kolkata Centre. pp. 504.

Pailan GH, Mahapatra BK, Datta S, Munilkumar S, Dasgupta S, Biswas G, Sahoo S, Singh DK, Banu H, Manna S, Pradhan S (2021) PGDIFUAM Training Manual on Fisheries Regulation and Management. ICAR-CIFE, Kolkata Centre. pp. 315.

Pailan GH, Mahapatra BK, Datta S, Munilkumar S, Dasgupta S, Biswas G, Sahoo S, Singh DK, Banu H, Manna S, Pradhan S (2021) PGDIFUAM Training Manual on Fisheries Engineering and Technology. ICAR-CIFE, Kolkata Centre. pp. 317.

Pailan GH, Pradhan S, Biswas G, Munilkumar S, Singh DK (2021) Modern Methods of Carp Seed Rearing and Culture. ICAR-CIFE, Kolkata Centre. pp. 25.

Shukla SP, Bhuvanesvari GR, Kumar S (2021) Technical knowhow of Spirulina Biomass Production and Utilization. ICAR-CIFE, Mumbai. pp. 34.

Chaudhari A, Brahmane MP, Pavan Kumar A, Rasal K (2021) Basic and Advanced Computational Tools for Molecular Genetics. ICAR-CIFE, Mumbai. pp. 150

Chaudhari A, Pavan Kumar A, Rasal K (2021) Molecular Taxonomy. ICAR-CIFE, Mumbai. pp. 100

Hindi

Aklakur M, Bhushan S (2021) *Machhali Palan ke Unnat Taknik*. ICAR-CIFE, Motipur Centre. Pp. 137

Pailan GH, Pradhan S, Biswas G, Munilkumar S, Singh DK, Manna S, Behera PK (2021) *Carp Beej Palan aur Matsya Palan Ke Adhunik Tarike.* ICAR-CIFE, Kolkata Centre. pp. 30.

Bengali

Pailan GH, Pradhan S, Biswas G, Munilkumar S, Singh DK, Manna SK, Behera PK (2021) *Adhunik Paddhatir Pona Machher Bijpalan o Chash.* ICAR-CIFE, Kolkata Centre. pp. 25

Marathi

Balange AK (2021) Preparation of Value-added Fish Products from Freshwater Fish. pp.26

6.6 Technical Bulletins/Extension Materials

English

Banu H, Pailan GH, Biswas G (2021) Health Management in Aquaculture. ICAR-Central Institute of Fisheries Education, Kolkata Centre pp. 6

Muralidhar PA, Syamala K, Xavier KAM (2021) Fish Cutlet Preparation. ICAR-Central Institute of Fisheries Education, Kakinada Centre Pp. 2

Muralidhar PA, Syamala K, Xavier KAM (2021) Fish/Prawn Pickle Preparation. ICAR-Central Institute of Fisheries Education, Kakinada Centre Pp. 2

Muralidhar PA, Syamala K, Xavier KAM (2021) Fish Papad. ICAR-Central Institute of Fisheries Education, Kakinada Centre Pp. 2

Sahu N, Tripathi G, Bedekar M, Pathan M (2021) Rights and Laws against Sexual Harassment. ICAR-Central Institute of Fisheries Education, Mumbai pp. 2

Sharma R, Bhushan S, Kumar S, Shamna N, Bhoomaiah D (2021) Warismriti– Souvenir on Alumni meet. ICAR-Central Institute of Fisheries Education, Mumbai pp. 120

Sharma R, Bhushan S, Kumar S, Shamna N, Bhoomaiah D (2021) Alumni Directory. ICAR-Central Institute of Fisheries Education, Mumbai pp. 150

Hindi

Sahu NP, Tripathi G, Bedekar M, Balange AK, Bharti VS, Sharma A, Rasal K, Jayant M (2021) Better Management Practices in Aquaculture. ICAR-Central Institute of Fisheries Education, Mumbai pp. 4

Singh DK, Pailan GH, Munilkumar S, Sahoo S, Devi A, Behera PK (2021) मत्स्य लार्वा को खिलाने के लिए आर्टेमिया नुप्ली उत्पादन तकनीक. ICAR-Central Institute of Fisheries Education, Kolkata Centre pp. 6

Tripathi G (2021) Good Aquaculture Practices with Special Reference to Environment. ICAR-Central Institute of Fisheries Education, Mumbai pp. 4

Bengali

Pailan GH, Manna S, Sahoo S, Datta S (2021) *Samanwit Mach Chas*. ICAR-Central Institute of Fisheries Education, Kolkata Centre pp. 25

Hindi/English

Aklakur M (2021) Biofloc Technology Based Aquaculture. ICAR-Central Institute of Fisheries Education, Motipur Centre Pp. 6

English/Hindi/ Bengali

Manna S, Datta S, Pradhan S, Pailan GH (2021) Pond Management for Sustainable Aquaculture. ICAR-Central Institute of Fisheries Education, Kolkata Centre pp. 2

Marathi

Tripathi G (2021) *Maashyanche Samanya Rog va Tyanche Upachaar*. ICAR-Central Institute of Fisheries Education, Mumbai pp. 1-18

Tripathi G (2021) Skill and Knowledge Development for Fish Health Management in Freshwater Fish Culture System from Selected Tribal Region of Maharashtra. ICAR-Central Institute of Fisheries Education, Mumbai pp. 4

Hindi/Marathi

Krishnani KK, Chadha NK, Ojha SN, Krishna G (2021) Green Water Technology for Bioaugmentation of Shrimp Aquaculture System for Adoption by the Farmers. ICAR-Central Institute of Fisheries Education, Mumbai pp. 4

Hindi/English/Marathi

Krishnani KK, Chadha NK, Ojha SN, Krishna G (2021) Circular Economy Applied to Integrated Agri-aquaculture for Doubling Farmers Income. ICAR-Central Institute of Fisheries Education, Mumbai pp. 6

Krishna G, Krishnani KK, Chadha NK, Rawat KD (2021) Culture Based Fisheries in Reservoirs for Enhancing Livelihood of Farmers. ICAR-Central Institute of Fisheries Education, Mumbai pp. 6

6.7 Reports

Sahu NP, Tripathi G, Kumar S, Kumar S, Xavier KAM, Poojary N, Dasari B (2021). ICAR-CIFE Annual Report, 2020 ICAR-Central Institute of Fisheries Education, Mumbai. 200p

Bedekar MK, Poojary N (2021). Annual Progress Report of Strengthening and Development Grant to Agricultural Universities 2019-2020. ICAR-Central Institute of Fisheries Education, Mumbai. 38p.

Sahu NP, Kumar S, Sharma R, Bedekar MK, Pavankumar A, Kumar K, Poojary N (2021) University Ranking Document 2020, ICAR-Central Institute of Fisheries Education, Mumbai . 300p.

07

HONOURS & AWARDS

Ranked 7th among
67 Agricultural Univerities

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Ranking of Agricultural Universities 2020

This is to certify that

ICAR-Central Institute of Fisheries Education, Mumbai

is ranked Number 7 amongst Agricultural Universities

7th RANK

(R.C. Agrawal)
Dy Director General (Ag. Edn)

3 December 2021, New Delhi

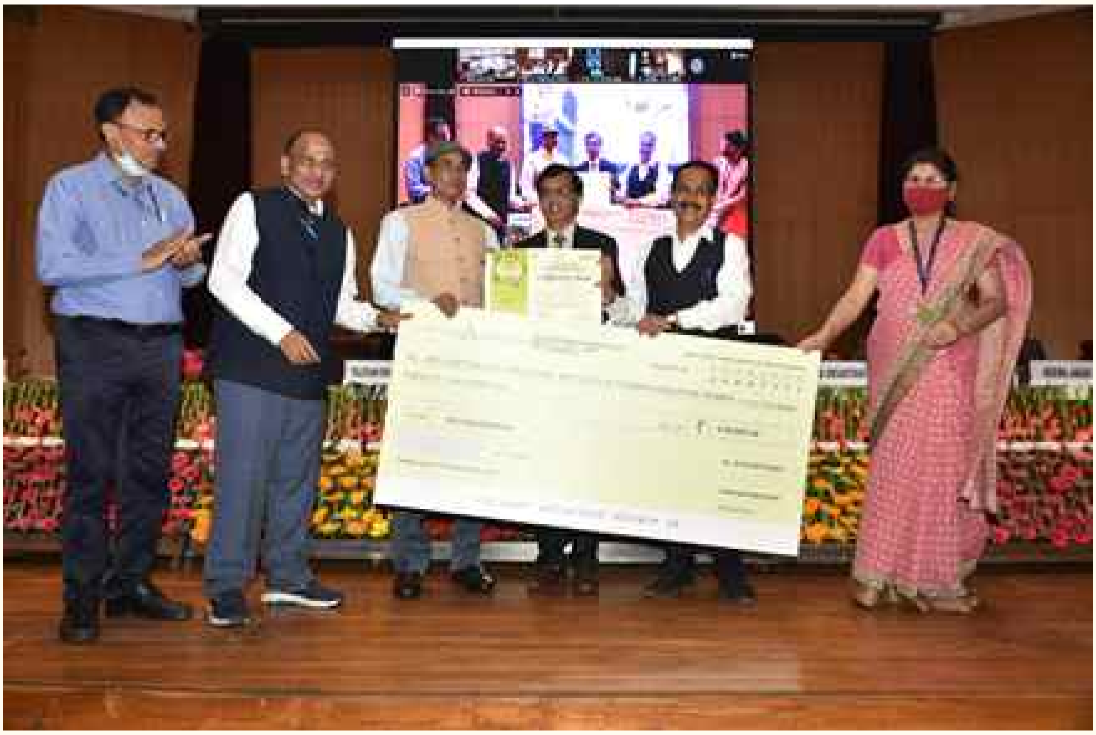
(Trilochan Mohapatra)
Secretary, DARE & DG, ICAR

ICAR-Central Institute of Fisheries Education, Mumbai was conferred 7th rank among the 66 State Agricultural Universities (SAUs) of the country. Based on several performance indicators related to academic, research and extension achievements, the Education Division, Indian Council of Agricultural Research ranks Universities annually.

Won 3rd Prize for being a Green and Clean Campus

Green & Clean Campus Award 2021

ICAR–Central Institute of Fisheries Education, Mumbai, was bestowed with the "Green and Clean Campus Award- 3rd Position". The award was announced in the presence of the Honorable Prime Minister of India (online) on the occasion of the Vice-Chancellors' Conference held on 28 September, 2021 at A. P. Shinde Auditorium, NASC Complex, New Delhi. The award constitutes Rs. 6.0 Lakh cash and was sponsored by the National Agricultural Higher Education Project (NAHEP) and handed over to the Director, ICAR-CIFE & PI of the NAHEP, by the Secretary, DARE and DG, ICAR, and witnessed by the DDG Education, ICAR and other dignitaries. This initiative of awarding a green and clean campus is to promote sustainable and eco-friendly practices in the University campus. CIFE promotes and adopted eco-friendly activities e.g. conservation of water resources through rain water harvesting, open well, waste water utilization for aquaculture purpose ; optimisation of energy through solar street light, LED bulbs, adoption of green building concepts, operational mobile fish cooler; waste management and compositing, decentralised segregation of hazardous waste; maintaining the greenery and diversity of plants through plantation of indigenous species, no single use plastic inside the campus. In award documents the green campus concept offers an opportunity to institutions to take the lead in redefining their environmental culture. All AUs partnering for NAHEP were the applicants for the "Green and Clean Campus Award" and the shortlisted AUs were asked to submit their accomplishments to the award committee.



Annual Institutional Awards (Year 2019-20)

Inorder to recognize the significant contributions by the faculty, staff members and students of the institute to reward talent and promote team spirit, provide encouragement and inspiration for improved performances, ICAR-CIFE released annual institutional awards and list of winners are as following in various categories.

S.No	Awards	Awards
1	Best Scientist Award	Dr. A. K. Balange
2	Best Extension Scientist	Dr. Gayatri Tripathi
3	Best Division Award	CIFE Powerkheda Centre
4	Best Technical Staff	Mr. Dasari Bhoomaiah
5	Best Administrative staff award	Mr. Prasenjit Sonawane
6	Award for Institutional Building	Dr. Megha Kadam Bedekar
7	Award for overall Best M.F.Sc. Dissertation	Ms. Abhilipsa Biswal
8	Award for Patent/IPR/Technology Generation	Dr. Subhendhu Datta
9	Award for Best School-going Child X	Master Aman Verma
10	Award for Best School-going Child XII	Ms. Saniya Jaiswar
11	Best Supporting Staff	Mr. Ankush N. Joyashi
12	Best Publication of the Year Award	Paul T, Kumar S, Shukla SP, Pal P, Kumar K, Poojary N, Biswal A, Mishra A (2020) A multi-biomarker approach using integrated biomarker response to assess the effect of pH on triclosan toxicity in *Pangasianodon hypophthalmus* (Sauvage, 1878). Environmental Pollution. doi.org/10.1016/j.envpol.2020.114001
13	Award for Overall Best Ph.D. Thesis	Dr. Manish Jayant

Annual institutional awards (Year 2020-2021)

S.No	Awardee	Awards
1	Best Scientist Award	Dr. Martin Xavier
2	Best Extension Scientist	Dr. Sunil Kumar Nayak
3	Best Division Award	Fisheries Resource Harvest and Post Harvest Management Division
4	Best Technical Staff	Dr. M.D.Chandrakanth
5	Best Administrative Staff Award	Mr. Ninad V. Kandalgaonkar
6	Award for Institutional Building	Dr. Ashutosh D. Deo
7	Award for overall Best M.F.Sc. Dissertation	Mr. Chanikya Naidu
8	Award for Patent/IPR/Technology Generation	Dr. A. K. Verma
9	Award for Best School-going Child X	Master Prithviraj Bhawesh Sawant
10	Award for Hindi Publication	Dr. Pankaj Kumar
11	Award for Best School-going Child XII	Mr. Soubhik Pailan
12	Best Young Scientist for Field Oriented Work	Mr. Dhalongsaih Reang
13	Best Publication of the Year Award	Dhanabalan V, Xavier KAM, Eppen S, Joy A, Balange A, Asha KKL, Murthy N, Nayak BB (2020) Characterization of chitin extracted from enzymatically deproteinized Acetes shell residue with varying degree of hydrolysis. Carbohydrate Polymers doi.org/10.1016/j.carbpol.2020.117203

Endowment Awards - 2021

Dr. C. V. Kulkarni Best Young Scientist Award

Dr. Kundan Kumar, Senior Scientist, AEHM Division received the Dr. C.V. Kulkarni Best Young Scientist Award 2020 (on all India basis) from ICAR-CIFE, Mumbai

Dr. Hiralal Chaudhari Award for the Best Young Scientist

Dr. Saurav Kumar, Scientist, AEHM Division received the Dr. Hiralal Chaudhuri Best Young Scientist Award 2020 (on all India basis) from ICAR-CIFE, Mumbai

National Award

Dr. Megha Kadam Bedekar, Principal Scientist, Aquatic Environment & Health Management Division, received Dr. APJ Abdul Kalam Lifetime Achievement National Award for her remarkable achievements in the field of Teaching, Research and Publications from National Institute for Socio Economic Development (NISED), Bangalore on 31 October, 2021.

Letter of Appreciation

Dr. Balange A.K., Principal Scientist, Fisheries Resource Harvest and Post Harvest Management Division received an appreciation letter for dissemination of low cost fish products technologies to the women self help groups in Assam and Maharashtra during the year 2021.

Dr. Babitha Rani. A. M., Senior Scientist, Aquaculture Division received an appreciation letter for her significant contribution towards implementation of biofloc technology in the state of Kerala from the Fisheries Secretary, Govt. of Kerala.

Oral Presentation Award

Dr. Sikendra Kumar, Scientist, Fish Nutrition, Biochemistry and Physiology Division awarded with Best oral presentation for the topic entitled "Replacement of de-oiled rice bran with raw or fermented water hyacinth leaf meal in the diet of Cyprinus carpio fingerlings" on 3rd International conference (Hybrid mode) on Food Agriculture and Innovations held on 24-26 December, 2021, Ranchi, Jharkhand.

Dr. Vinod Kumar Yadav, Scientist, Fisheries Economics and Extension Division, received Second Best oral presentation award for the topic "Trend analysis of future projection of Climatic Parameters and their possible impact of vulnerability on fishing communities: A case study of Dimbe and Bhavanisagar reservoir of Maharashtra and Tamil Nadu respectively" on World Environment Summit 2021 organized by Environment and Social Development Association (ESDA) Delhi during 1-3 October, 2021.

08

Linkages and Collaborations

8.1. Linkages

The Institute maintains linkages and collaborations with various national and international institutions and agencies for education, research and development.

Government of India Organizations r

- Fishery Survey of India, Mumbai
- Central Institute of Fisheries Nautical and Engineering Training, Kochi
- Marine Products Export Development Authority, Kochi
- Zoological Survey of India, Kolkata
- Indian Institute of Technology, Kharagpur
- Department of Earth Sciences, New Delhi
- Department of Science and Technology, New Delhi
- Department of Biotechnology, New Delhi
- Indian National Center for Ocean Information Services, Hyderabad
- Satellite Application Centre, Ahmedabad
- Bhabha Atomic Research Centre, Mumbai
- Tata Cancer Research Center, Mumbai
- Indian Institute of Foreign Trade, Kolkata
- Tata Institute of Fundamental Research, Mumbai
- Krishi Vigyan Kendra, Banswara, Rajasthan
- Nuclear Power Corporation of India Limited, Mumbai
- National Bank for Agriculture and Rural Development, Mumbai

ICAR Institutes r

- ICAR-Central Marine Fisheries Research Institute, Kochi
- ICAR-Central Institute of Brackishwater Aquaculture, Chennai
- ICAR-Central Institute of Freshwater Aquaculture, Bhubaneshwar
- ICAR-Central Inland Fisheries Research Institute, Barrackpore
- ICAR-Central Institute of Fisheries Technology, Kochi
- ICAR-National Bureau of Fish Gentic Resources, Lucknow
- ICAR-Directorate of Coldwater Fisheries Research, Bhimtal
- ICAR - Central Coastal Agricultural Research Institute, Goa
- ICAR Research Complex for Eastern Region, Patna
- ICAR Research Complex for North-Eastern Hill Region, Barapani
- ICAR-Indian Agricultural Research Institute, New Delhi
- ICAR-Central Institute of Agricultural Engineering, Bhopal

CSIR Institutes r

- Central Drug Research Institute, Lucknow
- Central Institute of Medicinal and Aromatic Plants, Lucknow
- Central Food Technological Research Institute, Mysore
- National Institute of Oceanography, Goa
- Centre for Cellular and Molecular Biology, Hyderabad
- Institute of Genomics and Integrative Biology, New Delhi
- Indian Institute of Integrative Medicine, Jammu
- Indian Institute of Chemical Biology, Kolkata

International

- University of Idaho, Idaho, USA
- University of Kentucky, Lexington, KY, USA
- Curtin University, Australia

Universities

- Cochin University of Science and Technology, Kochi
- Annamalai University, Chidambaram
- Acharya N. G. Ranga University, Guntur
- B. S. Konkan Krishi Vidyapeeth, Dapoli
- Maharana Pratap University of Agriculture and Technology, Udaipur
- Jawaharlal Nehru University, New Delhi
- Mangalore University, Mangalore
- Bhartiyar University, Coimbatore
- West Bengal University of Animal & Fishery Sciences, Kolkata
- Mumbai University, Mumbai
- Bidhan Chardra Krishi Viswa Vidyalaya, Nadia, West Bengal
- Kalyani University, Kalyani, West Bengal
- Barkatullah University, Bhopal
- Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur
- Chhattisgarh Kamdhenu Vishwavidyalya, Chhattishgarh
- Babasaheb Bhimrao Ambedkar University, Lucknow
- Centre of Agriculture University, Imphal

State Governments

Department of Fisheries of the following states:
Maharashtra, Haryana, Uttar Pradesh, Bihar, Tamil Nadu, Andhra Pradesh,Tripura, Arunachal Pradesh, Madhya Pradesh, Meghalaya, Nagaland, Assam, Manipur, Mizoram, Sikkim, Punjab and Telangana

NGOs:

- Yusuf Meherally Centre, Kutch, Gujarat
- United Artists' Association, Ganjam, Odisha

Other Organizations r

- Haryana Kishan Ayog, Chandigarh
- State Institute of Fisheries Technology, Kakinada
- Action Aid International, Port Blair
- M. S. Swaminathan Research Foundation, Chennai
- The Seafood Exporters Association of India, Kolkata
- Nezami Rekha Sea Foods Pvt. Ltd., Kolkata
- IFB Agro Industries Ltd., Aquatic & Marine Products Div., Kolkata
- Shimpo Exports, Kolkata
- Coreline Exports, Kolkata
- Digha Sea Food Exports, Kolkata
- NSZA Sea Food Pvt. Ltd, Kolkata
- Central Calcutta Science and Culture Organization for Youth, Kolkata
- APC Nutrient, Mumbai
- Godrej Agrovet Pvt. Ltd., Vijayawada
- Maharashtra Machimar Kriti Samiti, Mumbai
- Akhil Bhartiya Machimar Sanghatna, Mumbai
- Madhya Pradesh Fish Federation
- CPWD, Bhopal, M.P.
- CPWD, Hoshanagabad, M.P.
- Telecom Department, M.P.
- State Electricity Board, M.P.
- Saguna Baugh Farm, Neral
- Tata Power Co. Mahseer Farm, Lonavla
- Govt. Fish Farm, Khopoli
- Arrey Fish Farm, Mumbai
- Shramajivi Janata Sahayyak Mandal, Mahad, Raigarh, Maharashtra

MoU

Headquaters, Mumbai

MoU signed between ICAR-CIFE,Mumbai and University of Mumbai on 15 December, 2021 for carrying out collaborative research and acedemics.

Kolkata Centre

MoU signed on 15 December, 2021 for technical support and partnership farming for adoption of Integrated Fish Farming model between ICAR-CIFE, Kolkata Centre, and Mr. Alok De and Mr. Utpal Dey, Village + P.O.- Shashpur, P.S.- Indas, District- Bankura, PIN: 722205, West Bengal. Since CIFE has vast expertise and novel technologies in the field of integrated fish farming technologies, the MoU has been signed to provide technical support to initiate trials for developing package of practices for integrated fish farming with poultry (broilers) in West Bengal and effective dissemination of the same.

09

Events and Meetings

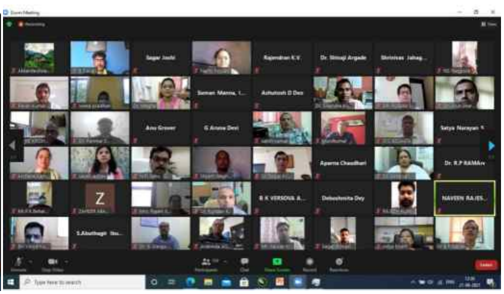
9.1 Events

72nd Republic Day of India

The 72nd Republic Day of India was celebrated by the ICAR-Central Institute of Fisheries Education, with earnest patriotic spirits, conforming to social distancing protocol at the Mumbai Headquarter and its five Centers at Kolkata, Kakinada, Rohtak, Powarkheda, and Motipur. The Director & Vice-Chancellor Dr. Gopal Krishna hoisted the national flag; which was followed by the rendition of the National Anthem. During his address, the Director and Vice-chancellor mentioned that the last year 2020 due to the covid-19 pandemic we have been exposed to new challenges and proudly proclaimed that CIFE faculty ably faced the challenge of completing student dissertations and evaluation online. He highlighted that the targets that he had envisioned are being achieved with the concerted efforts of staff and students, who have joined hands to take this national Institute to greater heights. Patriotic songs and recitation by staff members and the plantation program (reinforcing our pledge for a healthier green campus), were among the other solemn events to commemorate the day with a promise to excel in our future endeavors.

7th International Day of Yoga

ICAR-Central Institute of Fisheries Education, Mumbai, organized an online workshop on "Yoga for Wellbeing", for celebrating the 7th International Day of Yoga, on 21 June, 2021. Staffs and students of ICAR-CIFE participated in this workshop with full enthusiasm. Total 170 participants including Head of Departments, Officer incharge of centers, Scientists, Technical officers, Administrative staff and students of ICAR-CIFE participated in the program. The programme started with a welcome note by Dr. N. S. Nagpure, Nodal Officer International Yoga Day celebration. Joint Director, ICAR-CIFE, Dr. N. P. Sahu addressed the participants and spoke about genesis and the theme of celebration of International day of Yoga. The workshop was inaugurated by Honourable Director and Vice chancellor, ICAR-CIFE, Dr. Gopal Krishna, who emphasized on "understanding the concept of yoga for benefit of body, mind and soul". Invited Yoga instructor Mrs Sayali Jadhav, from Yoga Kendra Nashik, took a practice session on Sukshma Vyayam and Pranayam. Other invited faculty, Dr. Alpa A. Shah, from Brahmakumari, Versova, Mumbai, delivered a soulful lecture on Raj yoga. Workshop was ended with mediation session, which was guided by guest speaker and phycologist Mrs. Archana Kamat. Dr. Megha Kadam Bedekar and Dr .Pavan Kumar coordinated the program.



Plantation Drive on ICAR's 73rd Foundation Day

ICAR-Central Institute of Fisheries Education and its 5 Regional Centers planted 551 trees on their campuses in 6 different States on the occasion of ICAR's 93rd Foundation Day on 16 July, 2021. The following trees were planted - *Mangifera indica* – Mango (52), *Aegle marmelos* – Indian Bael (3), *Citrus maxima* – Pomelo (1),







Malpighia emarginata – Cherry (1), *Cinnamomum verum* – True cinnamon tree (1), *Garcinia indica* – Kokum tree (1), *Syzygium cumini* – Jamun (6), *Psidium guajava* – Guava (133), *Areca catechu* – Areca palm (1), Citrus limon – Lemon (29), *Murraya koenigii* – Kari Patta Plant (2), *Azadirachta indica* – Neem tree (3), *Millettia* pinnata – Karanja tree (4), Delonix regia (4), *Peltophorum pterocarpum* – yellow poinciana (4), Manilkara *zapota* – Different varieties of Chiku (25); Mahogany (200), Banana (60), *Phyllanthus emblica* – Amala (10), *Artocarpus heterophyllus* – Jackfruit (5), *Cocos nucifera* – Coconut (6).

Brainstorming session on National Education Policy 2020

The ICAR-Central institute of Fisheries Education, Mumbai organized a virtual Brainstorming session on "National Education Policy: Developing the Future Road Map" on 4 August, 2021 to discuss the strategies to structure ICAR Deemed University to multidisciplinary institutions as per the NEP-2020. Dr. R. C. Agarwal, Deputy Director General (Agricultural Education) and National Director (NAHEP), ICAR the Chief guest of the programme stressed the importance of holistic development of students to address the societal issues in a scientific manner and restructuring the universities as per the NEP-2020. He explained the different activities undertaken by ICAR to formulate the guidelines for implementing the NEP in the Agricultural sector. Agricultural education undertaken by SAUs and Deemed Universities of ICAR are already following many recommendations of NEP 2020. However, we have to wait for the detailed guidelines to come from the ministry of education with respect to minimum credit requirement, credit transfer, modalities of involving overseas faculties in the course curriculum, making the degree multidisciplinary etc. He said that the gross enrolment ratio should be increased at the rate of 10%. The guideline will be issued from ICAR for the modalities of implementing NEP in the DUs of ICAR. He also advised to relook into the budgetary requirement for the different infrastructural development based on the recommendation of NEP. Dr Agrawal clarified the different ambiguities related to the queries raised by the faculty member. In his initial remarks, Dr. Gopal Krishna, Director, ICAR-CIFE highlighted the importance of NEP-2020 in achieving the skilled manpower and in creating a holistic educational ecosystem. He informed that the course curriculum should be prepared keeping the multiple entry/exit options. Dr. N. P. Sahu, Joint Director and Dean, ICAR-CIFE accentuated the objective of NEP as a paradigm shift from 'what to think' to 'how to think'. He stressed

the importance of technology based education and introduced "Green Education" in the syllabus in achieving the objectives of the NEP-2020. All scientists and technical officers of the ICAR-CIFE participated in the Brainstorming session.

Celebration of the 75th Independence Day of India

The 75th Independence Day of India was celebrated by the ICAR-Central Institute of Fisheries Education, with all earnest fervor and patriotic spirits, conforming to social distancing protocol at the Mumbai Headquarter and its five Centers at Kolkata, Kakinada, Rohtak, Powarkheda, and Motipur. The Director & Vice-Chancellor Dr. Gopal Krishna hoisted the national flag and marked the beginning of the celebration; which was followed by the rendition of the National Anthem. During his address, the Director and Vice-chancellor appreciated all the staff and students for bringing laurels to the institute. He highlighted that the targets that he had envisioned are being achieved with the concerted efforts of staff and students, who have joined hands to take this national Institute to greater heights. He highlighted the events that are slotted for this year and emphasized the institute achievements in terms of human resource developments, research projects, New Education Policy, fish production, and urged everyone to contribute to society and work in a target-oriented manner. He also emphasized the role of alumni and networking in the process of setting a goal and accomplishing one's mission. He expressed his confidence that all the staff and students will work together to take our institute to new heights in the future. Patriotic songs and recitations were performed by students and staff to set the mood of patriotism on this important national day. Plantation by the dignitaries commemorated our pledge to keep the campus green and healthy.

Annual Day 2021

The 61st Annual Day of ICAR-CIFE, Mumbai was celebrated virtually on 6th June 2021. The programme was graced by Dr. J. K. Jena, Deputy Director General (Fisheries Science) as the Chief Guest, and Dr Kuldip Lal Director, NBFGR was the Guest of Honour. Dr. Gopal Krishna, Director/Vice-Chancellor, CIFE enlightened the audience about the journey of ICAR-CIFE, Mumbai, and its achievements in the year 2020-21. He highlighted the initiatives taken by the Deemed University to fulfill its academic activities throughout the Covid 19 crisis. Messages from former Directors of CIFE and various dignitaries were read out. Institute Awards honouring best performance in scientific, academic, administrative, technical, etc. activities were announced for the years 2019-2020 and 2020-2021. Director's Appreciation Awards were also announced on this occasion. Prizes were also distributed for various literary and cultural competitions of staff and students. The Chief Guest, Dr. J. K. Jena congratulated CIFE on the occasion and encouraged staff and students to achieve greater heights.

Dance Competition
I prize: Ms. Itishree Das
II prize: Ms. Shreyasi Kar
III prize: Ms. Shilpa Pradeep

Self-written poetry recitation
I prize: Ms. Suchismita Prusty
II prize: Mr. Shiv Kumar

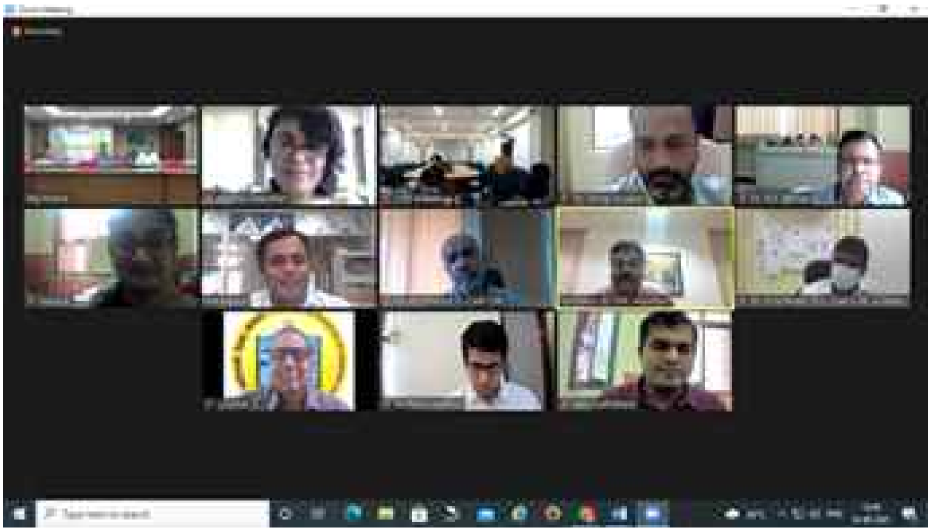
Slogans for promoting fisheries
I prize: Mr. Naveen Rajeshwar
II prize: Ms. Pragati Pradhaan and Mr. Shyam Kumar

Photography with caption contest
I prize: Mr. Jeevan T. M.
II prize: Ms. Sonam Angmo and Mr. Tao Kara
III prize: Mr. Naveen Rajeshwar

Staff Singing competition
I prize: Dr. Paramita. B. Sawant
II prize: Dr. Sikendra Kumar
III prize: Mr. Pradeep Angne

Staff self-written poetry recitation
I prize: Mr. Raj Moitra

हिन्दी पखवाड़ा



संस्थान में दिनांक 14 सितम्बर 2021 को हिन्दी पखवाड़ा - 2021 का उद्घाटन ऑनलाइन किया गया। उद्घाटन सत्र की अध्यक्षता संस्थान के संयुक्त निदेशक डा. एन. पी. साहू महोदय ने किया। इसी के साथ सभी अधिकारियों एवं कर्मचारियों से अपील किया कि संवैधानिक दायित्वों का निर्वहन करते हुए हिन्दी के प्रगामी प्रयोग को बढ़ावा दें तथा अपना अधिकाधिक कार्य हिन्दी में ही करें। संस्थान के संयुक्त निदेशक डा. एन. पी. साहू ने सर्वप्रथम राजभाषा विभाग, गृहमंत्रालय, भारत सरकार द्वारा जारी राजभाषा प्रतिज्ञा का वाचन करते हुए समस्त कर्मचारियों को राजभाषा के प्रति उत्तरदायित्व निभाते हेतु शपथ दिलाया। उद्घाटन सत्र के पश्चात संस्थान प्रधानमंत्री मत्स्य संपदा योजना (PMSSY), रोंगो से बचाव हेतु टीकों का विकास, मछली पालन का भारतीय अर्थव्यवस्था के लिए महत्व इस विषय में व्याख्यान प्रस्तुत किए। संस्थान में हिन्दी पखवाड़ा के अंतर्गत को सभी विभागों के बीच सोशल मिडिया का सदुपयोग एवं दुरुपयोग, राष्ट्रीय शिक्षा नीति के परिपेक्ष्य में मात्स्यिकी शिक्षा का स्वरुप, क्या ऑनलाइन शिक्षा से ऑफलाइन शिक्षा श्रेष्ठ है, मातृभाषा में शिक्षा की प्राथमिकता इस विषय में प्रतियोगिता का आयोजन किया गया। संस्थान परिवार के बच्चों के लिए चित्रकला प्रतियोगिता का आयोजन किया गया। ऑनलाइन भाषण प्रतियोगिता का आयोजन किया गया। इस प्रतियोगिता का विषय था, वैश्विक हिन्दी एवं मानवाधिकार संरक्षण - भारत के परिपेक्ष्य में, राष्ट्रभाषा हिन्दी का बहुआयमी स्वरुप एवं उपयोगिता, भारतीय संस्कृति में महिलाओं का समापन, उच्च शिक्षा में ऑनलाइन एवं ऑफलाइन माध्यमों की तुलनात्मक भूमिका, अंतर्राष्ट्रीय नैतिकता एवं आतंकवाद। संस्थान में प्रश्नोत्तरी प्रतियोगिता (Quiz Competition), महिला दिवस, गीत / कविता प्रतियोगिता का आयोजन किया गया। सायंस क्लब व्याख्यान के अंतर्गत एनबीएफजीआर, लखनउ के निदेशक डा. कुलदीप लाल ने राष्ट्रीय मत्स्य आनुवंशिकी ब्यूरो की अनुसंधान उपलब्धियां एवं जीन्स संरक्षण विषय पर व्याख्यान प्रस्तुत किया। जलवायु परिवर्तन से होनेवाले खतरे एवं इनके उपाय - मात्स्यिकी एवं जलीय जीवों, राष्ट्रीय एकता में हिन्दी भाषा का महत्व, कोविड - 19 के कारण किसानों के बेहतर जीवन निर्वाहन हेतु उपाय, राष्ट्रीय शिक्षा नीति की संभावनाएं - उच्च शिक्षा के संदर्भ में लेखन प्रतियोगिता का आयोजन किया गया। मुख्य अतिथि डा. अन्नपूर्णा चेरला मैडम ने हिन्दी की महत्ता, संविधान में अनुच्छेद 343 से 351 तक राजभाषा संबंधी प्रावधानों की व्याख्या, भाषा के माध्यम से मनुष्य का व्यक्तित्व विकास, साहित्य एवं विभिन्न भाषाओं में उपलब्ध साहित्यों को जन-जन तक पहुंचाने में अनुवाद की महत्ता, मानव और भाषा का सहसंबंध, मातृभाषा, क्षेत्रीय भाषा, संपर्क भाषा, राजभाषा एवं राष्ट्रभाषा का अस्तित्व, विकास एवं शिक्षा में अनिवार्यता, नई शिक्षा नीति में हिन्दी भाषा एवं मातृभाषा पर जोर आदि विषयों पर आपने विस्तार से प्रकाश डालते हुए सभा का संबोंधित किया तथा आपने विचार एवं सुझाव प्रस्तुत किए।

Nutri-Garden and Tree Plantation Drive

On this occasion of Nutri-Garden and Tree Plantation drive on 17 September, 2021, 27 species of fruit/ forest trees were planted/ distributed in CIFE Mumbai and its Centers located in 5 States – Maharashtra, Madhya Pradesh, Haryana, Andhra Pradesh, and West Bengal & Bihar. A total of 190 saplings were planted and 440 saplings were distributed. On this occasion, farmers and participating staff and students were informed about the nutritious qualities of millets and snacks made of millets were distributed. Names of trees planted: Mango (*Mangifera indica*), Citrus (*Citrus maxima*), Guava (*Psidium guajava*), Chicku, Jackfruit, Papaya, Amara, Poi, Pomegranate, Banana, Lemon, Neem, Jamun, Barhar, Kari Patta, Areca nut, Hibiscus, Pipal, Bheri, Sapota, (*Terminalia catappa*, Saraca asoca, *Pongamia pinnata*, *Syzygium cumini*, Cocus nucifera, *Azadirachta indica*). The tree plantation was also conducted by ICAR-CIFE, Kolkata Center at Canning, Sunderban, South 24 Parganas. At Canning 60 saplings were distributed to the farmers for plantation of their field. Inside CIFE campus a total of 8 trees have been planted (Areca nut -5, Citrus – 1, Hibiscus – 1, Pipal)

–1).

Celebration of Gandhi Jayanti

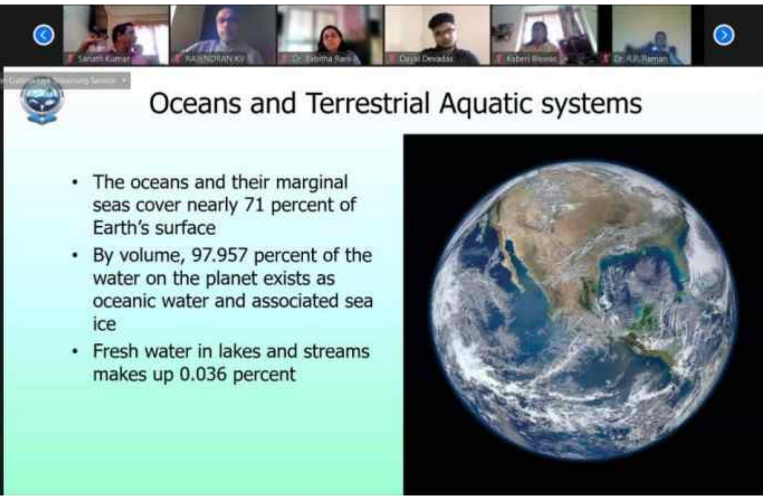
Gandhi Jayanti Week was celebrated on 2nd October, 2021 at ICAR-CIFE, Mumbai. Events were organised to commemorate the 152nd Birth Anniversary of Mahatma Gandhi. Cleanliness drives were conducted in both the campuses of CIFE including boys and girls hostels. Dried leaves and organic waste were collected to make compost and plastic waste materials were collected for recycling.

Vigilance Awareness Week

Following directives from central vigilance commission Government of India all the faculty and staff took integrity pledge to raise voice against corruption & dishonesty. As a part of vigilance awareness week during 26 October- 1 November, 2021 Rashtriya Ekta Diwas (National Unity Day) was celebrated on the birth anniversary of Sardar Vallabhbhai Patel on 31 October. The program was attended by all the staff of ICAR-CIFE, Mumbai and Centers .

World Fisheries Day

World Fisheries Day was celebrated on 21 November, 2021 by ICAR-CIFE, Mumbai with an aim to demonstrate solidarity with all fisher folk, fish farmers and concerned stakeholders throughout the world. The programme started with a welcome address by Dr. N.P. Sahu, Director (Acting) ICAR-CIFE, Mumbai. In his address he highlighted the importance of this day which is dedicated to highlight the critical importance of healthy ocean ecosystems and to ensure sustainable stocks of fisheries in the world. He highlighted issues of exploring the unexplored, climate change, livelihood, anthropogenic pollution, environment, equity and the focus of the Government fisheries sector. This was followed by an address by the Chief Guest, Dr. K Riji John, Vice Chancellor of Kerala University of Fisheries and Ocean Studies (KUFOS), Kochi, a renowned fisheries scientist known for his work in aquaculture, fish virology and sustainability. He presented his talk on The 'Three Es (Economic, Environment and Equity) for Sustainable Fisheries Development'. He highlighted the fisheries sector's role in protecting the ecosystem, providing livelihood, incomes, foreign exchange, health and nutritional security to many people across the world. Scientists, staff and students of ICAR-CIFE Mumbai benefitted from his talk. After this the participants put forward their views/queries/opinions and interactions followed. Students raised different issues related to artisanal fisheries, climate change, harmful subsidies etc. and these were discussed by scientists. Dr. Arpita Sharma, Principal Scientist, FEES Division coordinated the programme and presented the vote of thanks. She highlighted that the World Fisheries Day celebrations serve to focus on changing the way the world manages global fisheries to ensure sustainable stocks and healthy ecosystems. The programme was attended by 203 participants comprising Scientists, Technical Officers, Staff and Students of ICAR-CIFE, Mumbai and its centers.



Samvidhan Diwas

Samvidhan Diwas (Constitution day) was celebrated on 26 November, 2021 by ICAR-CIFE, Mumbai in hybrid mode. The programme started with a welcome address by Dr. N.P Sahu, Director (Acting) ICAR-CIFE, Mumbai. He mentioned that every word in the preamble has an in depth meaning and requested all to read the preamble along with him. Thereafter, all staff and students were requested to visit two portals developed by the Ministry of Parliamentary Affairs viz: Portal for reading preamble to the constitution in 23 languages (22 official languages and English): https://readpreamble.nic.in and Portal for Online Quiz on


Constitutional Democracy: https://constituionquiz.nic.in. Samvidhan Diwas was celebrated with enthusiasm by 156 participants (28 participants in offline mode following Covid-19 protocols and 155 participants in online mode) comprising Scientists, Technical officers, Administrative Staff and Students of ICAR-CIFE, Mumbai and its centers. In order to create awareness amongst youth about the Constitution "Quiz 30: Knowledge Check Workshop" on Preamble of Constitution of India " was organised in online mode in which students of ICARCIFE participated. Winners were Mr. Abhilash Wodeyar and Ms. Naila M. Bhat (First prize shared between 2 students), Mr. Prakesh Patekar (Second Prize) and Ms. Sahina Akter (Third Prize). The Programme was coordinated by Dr. Arpita Sharma and Dr. Neha Qureshi.

Interactive Workshop on Rights and Laws against Sexual Harassment

A virtual interactive workshop on "Rights and Laws against Sexual Harassment" was organised on 30th November, 2021 by ICAR-CIFE, Mumbai with the assistance of "PoSH (Prevention of Sexual Harassment) At Work", empanelled by Ministry of Women and Child Development, Govt. of India. Programme Director Dr. Gayatri Tripathi, gave a brief introduction of the workshop and also explained the purpose of the workshop aimed to educate & empower staff and students about their rights as well as duties under the Law against Sexual Harassment. Dr. N. P. Sahu, Director/Vice-Chancellor spoke on the role of such workshops for creating a healthy work environment among staff members. He also talked about the latest apps launched by the government for women's security. Dr. Megha Bedekar, Programme Coordinator and Chairperson, ICC, ICAR-CIFE, gave a brief introduction of both the esteemed speakers. Ms. Prerana Saraf, an advocate associated with PoSH at Work. The speakers spoke on the Sexual Harassment of Women at Workplace (Prevention, Prohibition and Redressal). Both the speaker addressed participants on the important legal aspects and topics such as understanding terms such as sexual harassment, role of IC, procedure for filing & redressal of a complaint etc. They also explained the consequences of malicious complaints, rights and duties of each employee, preventive measures under the law and explained the power of act which recognizes that sexual harassment results in the violation of a woman's fundamental right to equality under Articles 14, 15 and 21.


Agricultural Education Day celebration

Agricultural Education Day was celebrated 3 December, 2021 by ICAR-CIFE. Student Speech Contest on "Aligning Fisheries Education with the New Higher Education Policy 2020" . was organized on the occasion of Agricultural Education Day. Eight M.F.Sc. and Ph.D. students participated in the contest and the best three were awarded.

Swachhta Pakhwada

The institute flagged off the Swachhta Pakhwada with the swachhta pledge and display of banners at the HQ and Centers. The function was organized under the guidance of Dr. N. P. Sahu, Director, CIFE and overall coordination of Dr. Aparna Chaudhari, Nodal Officer, Swachhta Abhiyan, CIFE. The OICs of 5 Centers coordinated the activity at CIFE Centres. The programme included several activities over 15 days from 16-31 December, 2021. Cleanliness drives were conducted in all the divisions and sections in addition to laboratories, library, wetlab facility and aquaculture hatcheries, boys hostel at old and new campus, girls hostel at new campus, canteen and basement, staff quarters of CIFE. Sanitation Campaign at surrounding areas of the campus was conducted in the surrounding areas of the Institute. All the staff members from different divisions and sections actively participated in cleanliness drives. Necessary steps were taken to initiate weeding-out of old office files. Since 100% work is now on e-office, the use of paper and printing is reduced. Students cleaned their work stations, sitting areas and surroundings. The chemicals and equipment were arranged properly. Discarded plastic items were collected for recycling. A march to the Versova Landing Center and versova beach was conducted to create awareness among people by showing them banners and placards and cleaning up and segregation of the plastic waste collected. Awareness about cleanliness was created by delivering the lecture on "Ocean and water pollution and cleanliness initiatives" to Class VIII students of Versova Welfare School. The schoolchildren enjoyed the talk and interacted actively. They showed commitment towards cleanliness and protection of beaches from pollution and also promised to spread awareness. An e-poster making competition for the CIFE students and a drawing competition for CIFE staff children was organized. The topics for poster-making were Evergreen Revolution/Zero Emission, and Natural farming, while staff children were asked to depict Nature, Climate change, Swachh Bharat Mission, etc. Students and children participated enthusiastically. A waste plastic collection drive was organized at CIFE to create awareness about minimizing plastic use and promote recycling. CIFE conducts such drives monthly. Plastic waste weighing 142 kg was handed over to Sampurna Earth Foundation for recycling. On the final day of the Swachhta Pakhwada, a tree plantation drive was conducted. Flowering and fruit trees were planted by Dr. N. P. Sahu (Director, Acting) and other scientists and officials. Plantation was also done at CIFE Centres by the OICs and staff.





Kisan Diwas

Kias diwas was celebrated on 23 December, 2021 at ICAR- CIFE, Mumbai and centers by organizing an online workshop on "Water Management in Aquaculture ". All the scientists, staff, students and farmers from headquarter and centers participated in the event that was coordinated by Dr. Aparna Chaudhari (Nodal Officer, Swachhta Abhiyan) and the OICs of the Centres. In his opening remarks, Dr. N.P. Sahu (Director, Acting) apprised everyone about the significance of Kisan Diwas. He emphasized the issues of water conservation, reviving nutritional value of the soil and organic farming. Talks were delivered on this occasion. Dr. K. K. Krishnani spoke on "Wastewater Recycling", and Dr. Sunil K. Nayak delivered a talk on "Aquaponics and Recirculatory Aquaculture System: Water budgeting options in aquaculture".

9.2 Important Meetings

Meetings	Date
26^{th} Extension Council Meeting	18 February, 2021
Research Advisory Committee Meeting	3 March, 2021
Core committee meeting	19 April, 2021
Board of management meeting	23 April, 2021
Academic Council Meeting	5 May, 2021
Institute Research Council Meeting (Annual Meeting)	6-7 May, 2021
iInteraction of secretory , DARE & DG, ICAR with young scientists	8 December, 2021

हिन्दी प्रगति प्रतिवेदन

हिन्दी जलवाणी पाठ्यक्रम का संचालन
संस्थान के एम.एफ.एस.सी. के सत्र 2020-2022 के प्रथम वर्ष के छात्र-छात्राओं हेतु हिन्दी जलवाणी एक क्रेडिट कोर्स की कक्षाएं इस वर्ष महामारी कोविड -19 के कारण ऑनलाइन प्लेटफार्म से नियमित रुप से संचालित की गई ।

जलचरी अंक 24 एवं 25 का प्रकाशन
संस्थान की गृह पत्रिका जलचरी अंक - 24 एवं अंक 25 रजत जयंती विशेषांक के रुप में प्रकाशित किया गया । जिसे संस्थान की वेबसाइट पर अपलोड कर दिया गया ।

राजभाषा कार्यान्वयन समिति की बैठक का आयोजन
संस्थान की राजभाषा कार्यान्वयन समिति की 96 वीं, 97 वीं एवं 98 वीं बैठक का आयोजन क्रमश: दिनांक 14 मार्च, 2021, 11 अगस्त, 2021 एवं 30 अक्टूबर, 2021 को निदेशक महोदय डा. गोपाल कृष्णा की अध्यक्षता में संपन्न हुई । बैठक में लिए गए निर्णयों पर अनुवर्ती कार्रवाई की गई ।

हिन्दी कार्यशाला का आयोजन
संस्थान के मुख्यालय एवं समस्त उपकेन्द्रों के वैज्ञानिकों, तकनीकी एवं प्रशासनिक अधिकारियों/कर्मचारियों हेतु दिनांक 4 फरवरी, 2021, 6 सितंबर, 2021 एवं 28 दिसंबर, 2021 का क्रमश: यूनिकोड, संघ की राजभाषा व्यवहारिक एवं संवैधानिक पक्ष तथा राजभाषा हिन्दी एवं तकनीकी सुविधाओं विषय पर ऑनलाइन कार्यशाला का आयोजन किया गया ।

मोबाइल एप मत्स्य किरण का हिन्दी अनुवाद
संस्थान के हिन्दी अनुभाग द्वारा अंग्रेजी में तैयार किए गए "मत्स्य किरण" मोबाइल ऐप का हिन्दी अनुवाद उपलब्ध कराया गया ।
संस्थान के एम.एफ.एससी. एवं पीएच.डी. छात्रों के शोध-प्रबंधों के सारांश हिन्दी में अनुवाद कर उपलब्ध कराया गया ।

राजभाषा निरीक्षण
भारतीय कृषि अनुसंधान परिषद, नई दिल्ली के डा. सीमा चोपड़ा, निदेशक (हिन्दी) द्वारा दिनांक 18 अगस्त, 2021 को के.मा.शि.सं, मुख्यालय मुंबई में राजभाषा हिन्दी से जुड़े कार्यों का निरीक्षण किया गया । इस हेतु भा.कृ.अनु.प. द्वारा निरीक्षण प्रश्नावली भरकर उपलब्ध कराई गई ।

पारंगत पाठ्यक्रम प्रशिक्षण
हिन्दी शिक्षण योजना, क्षेत्रीय कार्यालय, मुंबई द्वारा संस्थान के अधिकारियों / कर्मचारियों हेतु जुलाई, 2021 से पारंगत प्रशिक्षण की ऑनलाइन कक्षाएं संचालित की गई जिसके अंतिम परीक्षा में समस्त प्रशिक्षणार्थी उत्तीर्ण हुए ।

नगर राजभाषा कार्यान्वयन समिति की बैठक
नगर राजभाषा कार्यान्वयन समिति, मुंबई उत्तर की नौवहन महानिदेशक एवं अवर सचिव, भारत सरकार की अध्यक्षता में दिनांक 25 अगस्त, 2021 को माइक्रोसॉफ्ट टीम मीडिया के माध्यम से ऑनलाइन आयोजित बैठक में संस्थान के डा.गोपाल कृष्णा, निदेशक महोदय, डा. के. वी. राजेन्द्रन, विभागाध्यक्ष, प्रभारी एवं हिन्दी अनुभाग के श्री प्रताप कुमार दास, मु. तक. अधिकारी, सुश्री रेवती धोंगडे, श्रीमती रेखा नायर, स.मु.तक.अधिकारी ने भाग लिया ।

नगर राजभाषा कार्यान्वयन समिति की कार्यशाला में प्रतिनिधित्व
नराकास, मुंबई द्वारा आयोजित नीटी संस्थान मुंबई में आयोजित संप्रेषण कुशलता (21 दिसंबर, 2021) में संस्थान के हिन्दी अनुभाग के समस्त अधिकारियों ने भाग लिया ।

हिन्दी पखवाड़ा का आयोजन
संस्थान में दिनांक 14 से 28 सितम्बर, 2021 तक आयोजित हिन्दी पखवाड़ा - 2021के अंतर्गत विभिन्न प्रतियोगिताओं एवं कार्यक्रमों का आयोजन किया गया । इसी के साथ समस्त विजयी प्रतिभागियों को पुरस्कार एवं प्रमाणपत्र वितरित किए गए ।

संगोष्ठी में प्रतिनिधित्व एवं लेख प्रस्तुति
भा.कृ.अनु.प.- भारतीय गन्ना अनुसंधान संस्थान, लखनऊ द्वारा आयोजित अंतरराष्ट्रीय संगोष्ठी में "आत्मनिर्भर भारत" लोकल के लिए वोकल' विषय पर संस्थान के श्री प्रताप कुमार दास, सहायक मुख्य तकनीकी अधिकारी, डा. एस. एन. ओझा, विभागध्यक्ष एवं डा. गोपाल कृष्णा, निदेशक ने उपरोक्त विषय पर लेख प्रस्तुत किया तथा दिनांक 16-17 मार्च, 2021 को

ऑनलाइन प्लेटफार्म पर आयोजित अन्तरराष्ट्रीय संगोष्ठी (हिन्दी) में संस्थान के श्री प्रताप कुमार दास, सुश्री रेवती धोंगडे, श्रीमती रेखा नायर, सहायक मुख्य तकनीकी अधिकारियों ने भाग लिया ।

प्रमुख अनुवाद कार्य

प्रमुख अनुवाद कार्यों में कार्प में जीवाणु रोग एवं झींगा में जीवाणु रोग बुक चाप्टर का हिन्दी अनुवाद कार्य किया गया ।

Annual Report

2021

ICAR-CIFE
Mumbai

Azadi Ka Amrit Mahotsav

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Ranking of Agricultural Universities 2020

This is to certify that

ICAR-Central Institute of Fisheries Education, Mumbai

is ranked Number **7** amongst Agricultural Universities

7th RANK

(R.C. Agrawal)
Dy Director General (Ag. Edn)

3 December 2021, New Delhi

(Trilochan Mohapatra)
Secretary, DARE & DG, ICAR


GREEN
&
CLEAN
CAMPUS
AWARDS
2020-21

ICAR

आज़ादी का
अमृत महोत्सव

NAHEP

राष्ट्रीय कृषि उच्चतर शिक्षा परियोजना
भारतीय कृषि अनुसंधान परिषद्
National Agricultural Higher Education Project
Indian Council of Agricultural Research

Certificate of Award

Presented to

Main Campus, ICAR-Central Institute for Fisheries Education, Mumbai for securing **3rd Position** carrying a cash award of **₹ 6.0 Lakhs** (Rupees Six Lakhs only) in the **'Green and Clean Campus Awards'** contest sponsored by the National Agricultural Higher Education Project.

स्वच्छ भारत
एक कदम स्वच्छता की ओर

Dated : 28th September, 2021

(R.C. Agrawal)
National Director-NAHEP
DDG-Education, ICAR

(Trilochan Mohapatra)
Secretary, DARE and
DG, ICAR

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