ANNUAL REPORT

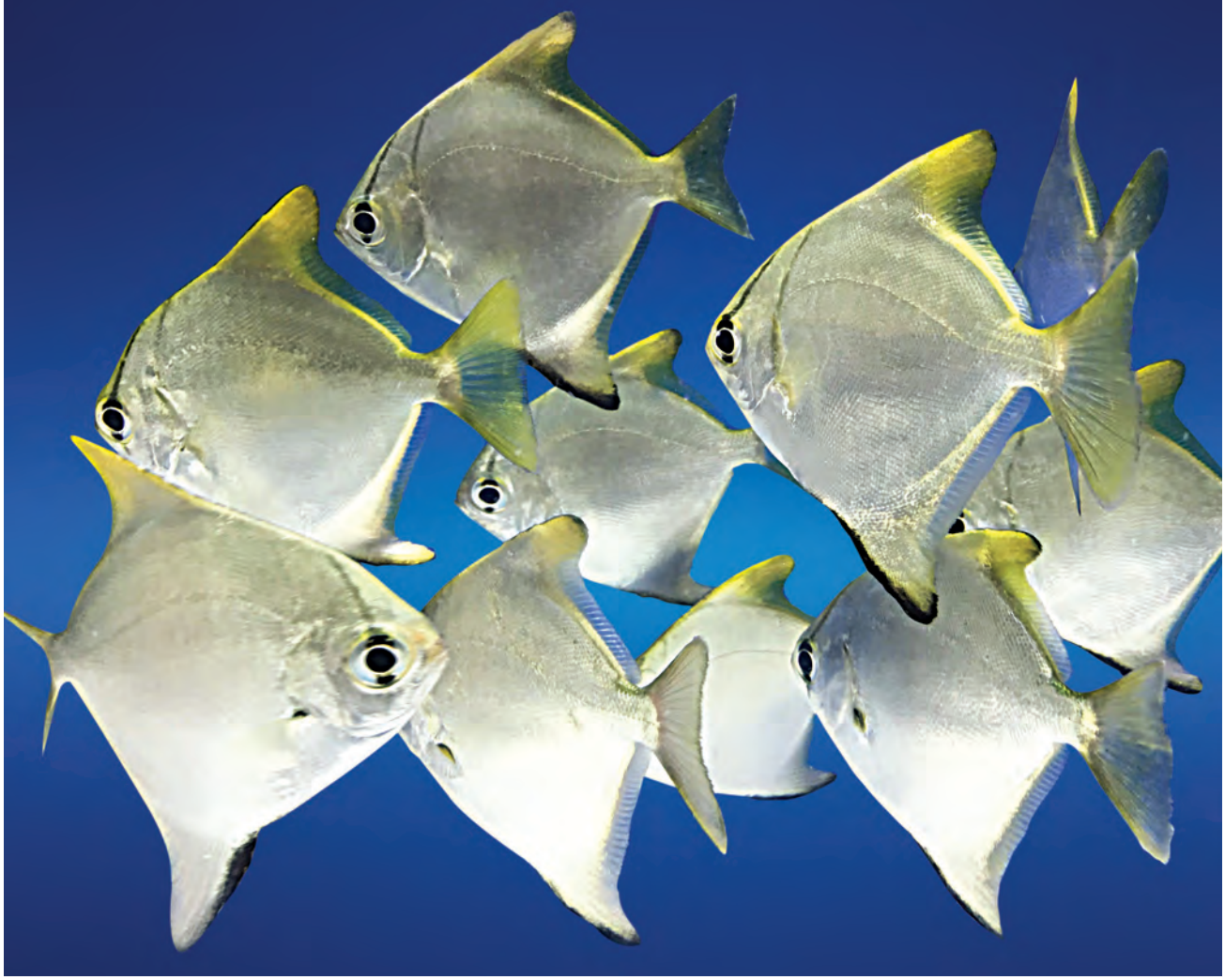
2018 - 2019

CIBA

ICAR-CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE

भा.कृ.अनु.प.–केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान

The Silver Moony, *Monodactylus argenteus* is a shiny silvery fish with yellowish edges to the fins which definitely finds a place in any brackish aquarium. This is a good size fish, deep bodied and laterally compressed with an attractive roundish diamond shape is a favorite aquarium fish.



Asian seabass (*Lates calcarifer*) is a high-value, carnivorous food sh in brackishwater suitable for farming. Seabass can be very well adopted to pelleted feed and farmed in ponds, open water cages and intensive recirculatory aquaculture systems. ICAR-CIBA perfected the technology for year-round breeding, seed production, feed and farming of seabass as pioneer in India.

Finfish farming in open brackishwater using custom made indigenous cages using cost effective epoxy coated galvanized iron frames in mangrove regions on Sindhudurg, Maharashtra. CIBA promotes this as a sustainable livelihood model for expanding finfish farming in open brackishwater in both east and west coast of India.

Muttukadu Experimental Station of CIBA
Kovalam Post, Muttukadu 603 112, Tamil Nadu
Telephone : +91 44 27472344, 27472061

Kakdwip Research Centre of CIBA
24 Parganas District (South)
Kakdwip 743 347, West Bengal
Telephone : +91 3210255072
Fax : +91 3210255072
E-mail : krckakdwip@yahoo.co.in

Navsari Gujarat Research Centre
1st Floor, Animal Husbandry Polytechnic,
Navsari Agricultural University Campus,
Eru Char Rasta, Dandi Road,
Navsari – 396 450, (Gujarat) INDIA.
Phone : +91 7977078509; 9421717537

वार्षिक प्रतिवेदन

ANNUAL REPORT

2018-19

भा.कृ.अनु.प.–केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान
(भारतीय कृशि अनुसंधान परिशद)
75, संथोम हाई रोड़, आर.ए.पुरम, चेन्नई–600 028

ICAR - Central Institute of Brackishwater Aquaculture
ISO 9001 : 2015
(Indian Council of Agricultural Research)
75 Santhome High Road, M.R.C. Nagar, R.A. Puram
Chennai - 600028, Tamil Nadu, India

PUBLISHED BY

Dr. K.K.Vijayan
Director

EDITORIAL COMMITTEE

Dr. C.P. Balasubramanian
Dr. T. Ravisankar
Dr. Debasis De
Dr. R. Saraswathy
Dr. K.P. Kumaraguru vasagam
Dr. Sujeet Kumar
Dr. K.K. Vijayan

EDITORIAL ASSITANCE

Shri S. Nagarajan
Smt. K. Jacquiline

ISSN 0976-5536

Citation : CIBA - 2019. Annual Report 2018-19. ICAR-Central Institute of Brackishwater Aquaculture, Chennai, Tamil Nadu, India, pp 282.

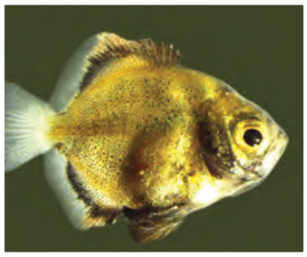
Printed at: **SAROJA PRESS**

Corporate Office :
"Saroja House" New No. 18, Arcot Road, (NSK Salai),
Kodambakkam, Chennai - 600 024.
T : +91 44 2484 4363 / 2246 / 1129 , M : +91 90031 16177
W : www.sarojaenterprises.com
E : chennai@sarojaenterprises.com / sarojapresschennai@gmail.com

Contents

4 PREFACE
6 EXECUTIVE SUMMARY (HINDI)
18 EXECUTIVE SUMMARY (ENGLISH)
30 INTRODUCTION
38 ON-GOING RESEARCH PROJECTS
47 RESEARCH HIGHLIGHTS

BRACKISHWATER PRODUCTION SYSTEM RESEARCH
REPRODUCTION, BREEDING & LARVAL REARING
NUTRITION & FEED TECHNOLOGY
AQUATIC ANIMAL HEALTH
AQUACULTURE ENVIRONMENT
GENETICS & BIOTECHNOLOGY
SOCIAL SCIENCE & DEVELOPMENT



204 HRD TRAINING & CAPACITY BUILDING
209 WORKSHOPS, SEMINARS AND MEETINGS
227 AWARDS & RECOGNITIONS
231 LINKAGES & COLLABORATIONS
232 CONSULTANCIES & TECHNOLOGY DEVELOPMENT
243 RESEARCH & ADMINISTRATIVE MEETINGS
248 SERVICES & ASSIGNMENTS
251 ARYA
253 MERA GAON MERA GAURAV
256 SWACHH BHARAT MISSION PROGRAMMES
259 DISTINGUISHED VISITORS
261 PERSONNEL
266 INFRASTRUCTURE DEVELOPMENT
267 LIBRARY & DOCUMENTATION
269 PUBLICATION, PARTICIPATION IN CONFERENCES & MEETINGS

PREFACE

We are promoting community based, sustainable brackishwater aquaculture in coastal states to improve the quality of rural life and diversifying the livelihood opportunities.

Fish is one of the most-traded food commodities worldwide with more than half of the global production coming from developing countries. World per capita fish supply peaked at 20/kg in 2014, mainly due to development in aquaculture. Fisheries and aquaculture are expected to contribute significantly to the food security and nutritional requirement, for the projected global population of 9.8 billion by 2050. Brackishwater aquaculture, particularly shrimp farming, is one of the most dynamic and fast growing food producing sectors, contributing substantially to the economy and sustainability of coastal communities worldwide. Indian brackishwater aquaculture production alone has touched 0.75 million tons, valued at 7 billion US $, in the year 2017-2018. Modern day aquaculture is rapidly evolving with the support of scientific innovations and technological support in the areas of genetics, breeding and stock improvement, nutrition and feed biotechnology, disease and health management, farm management and social aspects.

The year 2018-19 was remarkable for ICAR-CIBA with the conduct of a world conference on brackishwater aquaculture, BRAQCON 2019, a significant event in the context of brackishwater aquaculture, food security and societal development.It was a unique platform that brought a large number of Indian and overseas researchers, academicians, farmers, and other private sector stakeholders. BRAQCON has been conceived as a biannual world conference, representing the bracksihwater aquaculture sector on world platform, that provide an excellent opportunity to exchange latest scientific information and ideas, and more importantly it represents a new and exciting chapter in the scientific journey of CIBA

Brackishwater aquaculture plays a leading role role in the nutritional and financial security of the country. The major mandate of CIBA has been to innovate, catalyse and transform brackishwater aquaculture towards the goal of sustainability. In India, the growth engine and economic face is the shrimp farming sector, it has been almost synonymous to the aquaculture of Pacific white shrimp, *Penaeus vannamei*. After achieving a record growth in farmed shrimp production, currently the industry has been confronting sustainability challenges, due to multitudes of reason ranging from emergent disease to the the fluctuation in market rates. The institute has been addressing this issue holistically by developing diversified production systems and species, and formulating science based strategies for better biosecurity protocols. A cost effective biofloc based nursery system has been developed and demonstrated in Odisha and Andhra Pradesh. Within 28 days of rearing, animals reached almost 1 g with a survival of 94%. This intervention effectively reduced the total production cost

Diversification of species has been well acknowledged as an option for achieving sustainable development. As Indian brackishwater aquaculture heavily depends on a single exotic species, it is imperative to find a 'desi' option to complement and the single species development. Indian white shrimp, *Penaeus indicus*, has been identified as the national priority species for domestication and genetic improvement. Demonstration trials have been carried out in the different agro climatic zones, and it is confirmed that growth and production of this species are comparable to vannamei, in size ranges of 15-22 g, at lower and higher salinity regimes are similar. Further, we are a step closer to the domestication of *Penaeus indicus* by developing F0 generation, and successfully producing F1 generation of *P. indicus* under captivity. A procedure for in vitro fertilization of *P. indicus* has been successfully developed, and it provides an opportunity to remove the barriers of natural mating in breeding programs as well as in the hybridization programs particularly in closed thelycum species.

The recycling of waste in the fish market and landing centres into useful product is one

of the efficient management measures to improve ecosystem health and diversification of the livelihood of coastal fishers. Almost 25 to 50% of fish in the fish markets becomes waste; the institute has made an efficient method to transform these wastes into a useful commercial product, a plankton booster ('Plankton ^{Plus}'), in aquaculture ponds fertilizer for horticulture crops, and quality fish meal. Application of plankton plus in shrimp ponds, resulted in significant improvement in the average daily growth, specific growth rate, total biomass gain and survival even when 30% less feed was offered.

Deciphering draft genome sequence of organisms has major impact on multiple research fields, and it would provide knowledge on entire genetic architecture of their biology. Genetics and biotechnology group of CIBA was able to decipherabout 73% of the genome of Indian white shrimp, *Penaeus indicus*, using Pacbio sequel technology. By the end of this year we expect that we would have a complete genome sequence of this species only second shrimp genome, after vannamei. This understanding would catalyse research progress in several fields of biology, particularly selective breeding program of this priority species.

We are promoting community based brackishwater aquaculture in coastal states to improve the quality of rural life and diversifying the livelihood opportunities. In general, brackishwater aquaculture is considered to be high valued and cost intensive, and therefore, rural poor were excluded from the real benefits of this form of food production system that was theoretically offered. We, in collaboration with the Mangrove cell, Maharashtra have initiated three-tier seabass farming program such as nursery rearing, pre-grow out and grow out culture in mangrove coastal ecosystem as a community based farming. It provides novel employment opportunity to the coastal communities also produces the valuable and quality fish such as seabass through cage farming in backwaters.

Although most aquaculture production is devoted to food production, ornamental fish production for aquarium trade is an important and vibrant component of aquaculture world over. Whilst most aquarium trade focuses on freshwater species, there is a continued interest in developing new salt water species. During the last year our fish breeding group was successful in developing a captive rearing technology for an important brackishwater ornamental species, silver moony, *Monodactylus argenteus*. This is an important step for the transition of ornamental fish trade of this species from wild caught stocks to more sustainable breeding based mode.

One of the highlights of the year 2018-19 was that our nutrition scientific team won the prestigious ICAR team award, Nanaji Deshmukh ICAR Award. The team has successfully developed indigenous feed processing technologies and cost-effective feeds for all the life stages of potential candidate brackishwater shell fish and finfish species cultured in India. At CIBA, feed biotechnology research team could successfully downsize the commercial feed mill machinery and customize the requirements and processing conditions as per the demand of the clients, and successfully commercialising the technologies for the benefit of stakeholders.

As a research and development organization, the success is measured by the output of the scientists who implemented the research projects. In the the current year, CIBA scientists published forty five research articles in reputed national and international journals. CIBA's Technology management unit has seen a significant success during this year. In order to expand the adaptation of research, technologies and intellectual assets, the institute has made 21 partnership agreements with private farmers, industry and government.

It has been greatly rewarding to serve as the Director of this prestigious Institute, and closely work with motivated and resourceful players. Looking back at what CIBA has done during the last one year makes me immensely happy. Our contribution is tangible and visible, although we have a long way to go in the journey of sustainability. I look forward to having much greater achievements in multidisciplinary brackishwater aquaculture research. It will help us to evolve a sustainable aquaculture with economic benefits.

What I narrated in this brief preface is only a snapshot of CIBA's achievements of the current year. I invite you all to peruse the full report in print or online. The following pages are the testimony for our combined and dedicated passion to provide scientific solutions for challenges and problems in the brackishwater aquaculture.

We are incredibly grateful to all the stakeholders and farming community who supported us. I am immensely grateful to Dr Trilochan Mohapatra, the Director General of ICAR and Secretary DARE without his professional support all these research performance and achievements would not have been possible. I am deeply indebted to Dr J.K. Jena, Deputy Director General (Fisheries) for his keen support, enthusiasm and timely help. I sincerely thank Dr Pravin Puthra, Assistant Director General (Marine Fisheries) for his continued support and guidance. ■

K.K.Vijayan
Director

कार्यकारी सारांश

चालू वर्ष 2018-19 सीबा के लिए एक महत्वपूर्ण एवं फलदायक वर्ष रहा है। संस्थान, सतत खारा जलजीव पालन के विकास हेतु अनुसंधान एवं विकास कार्यों में संलिप्त है। संस्थानिक और बाहरी संगठनों द्वारा वित्तपोषित 29 अनुसंधान परियोजनाओं और अनेक आउटरीच गतिविधियों से सीबा ने खारा जलजीव पालन के विज्ञान में उल्लेखनीय योगदान दिया है। अनुसंधान और विकास संगठन होने के नाते इसकी सफलता और प्रभावकारिता को वैज्ञानिकों/अनुसंधानकर्ताओं के आउटपुट से तौला जाता है। चालू वर्ष में सीबा के वैज्ञानिकों ने विभिन्न प्रख्यात राष्ट्रीय और अंतर्राष्ट्रीय जर्नलों में सहकर्मी की समीक्षा वाले 39 अनुसंधान लेख प्रकाशित किए हैं। चालू वर्ष के दौरान स्टेकहोल्डरों से 31 वाणिज्यिक करारनामों पर हस्ताक्षर किए गए हैं। संस्थान ने अनुसंधान की गुणवत्ता को बनाए रखा और संस्थान को प्राप्त आईसीएआर का प्रतिष्ठित टीम एवार्ड, सीबा के मत्स्य पोषण प्रभाग को उत्कृष्ट अंतर्विषयक टीम के लिए नानाजी देशमुख आईसीएआर एवार्ड इसका प्रमाण है। सीबा के प्रधान वैज्ञानिक डॉ. एम. कुमारन को स्वामी सहजानंद सरस्वती उत्कृष्ट विस्तार वैज्ञानिक पुरस्कार प्राप्त हुआ। संस्थान की पिछले वर्ष की कुछ अनुसंधान एवं विकास की उपलब्धियों को नीचे दर्शाया गया है।

तालाब में संवर्धित इंडियन व्हाइट श्रिम्प स्टॉक का विकास

भारत में झींगा पालन, जो लगभग पूरी तरह विदेशी प्रजाति *पीनियस वन्नामेय* पर आधारित है, अब यह उभरते रोगों, घटती उत्तरजीविता दर, उत्पादन लागत में बढोत्तरी तथा हाल ही में मूल्यों में गिरावट के कारण चौराहे पर खड़ा प्रतीत होता है। इन स्थितियों में झींगा पालन की सततता बनाए रखने हेतु स्थानीय प्रजाति का विकास एक व्यवहारिक विकल्प है। भारतीय सफेद झींगा, *पी. इंडिकस* को पालतू बनाने एवं आनुवांशिक सुधार के लिए उपयुक्त प्रत्याशी किस्म के रूप में पहचान की गई। बंद/तालाब में संवर्धित *पी. इंडिकस* की प्रजनन संपदा के विकास हेतु प्रयोगात्मक परीक्षण किए गए, जो किसी भी चयन कार्यक्रम के लिए एक प्राथमिक आवश्यकता है। हैचरी में संवर्धित *पी. इंडिकस* के पोस्ट लार्वा को मिट्टी के तालाबों में ब्रूड स्टॉक (25-35 ग्रा.) तक पालन किया गया है, इन एफ0 पीढी का बंद स्थितियों के अंतर्गत सफलतापूर्वक प्रजनन कराया गया और एफ1 पीढी की संततियों को आगे पालन किया जा रहा है।

भारतीय सफेद झींगा (*पीनियस इंडिकस*) तथा मिल्कफिश (*चनोस चनोस*) का पॉलीकल्चर

जलजीव पालन संसाधनों में पोषण तत्वों को नष्ट होने से बचाने के लिए तथा कम लागत से झींगा पालन के लिए झींगों का पॉलीकल्चर एक व्यहार्य विकल्प प्रमाणित हुई है। *पी. इंडिकस* (संग्रहण घनत्व : 25 पीएल/वर्गमीटर) और *सी. चनोस* (0.25 नग/वर्गमीटर और 0.5 नग/वर्गमीटर) के पॉलीकल्चर में उत्पादन संबंधी निष्पादन के मूल्यांकन हेतु एक 75 दिनों का प्रयोग किया गया। *पी. इंडिकस* के साथ मिल्कफिश (0.5 नग/वर्गमीटर) संग्रहीत तालाब में उच्चतम उत्तरजीविता (79.33±1.88%) तथा उत्पादन (1451.28±22.15 कि.ग्रा./हे.) दर्ज किया गया, तथापि 0.25 नग/वर्गमीटर संग्रहण घनत्व से संग्रहीत मिल्कफिश के तलाब में उल्लेखनीय रूप से उच्चतर औसत शारीरिक भार प्राप्त हुआ।

पीनियस वन्नामेय के लिए बायो-फ्लॉक आधारित संवर्धन प्रौद्योगिकी

पर्यावरण अनुकूल जलजीव पालन की दिशा में बायो-फ्लॉक प्रौद्योगिकी एक उभरता विकल्प है। जल विनिमय कम होना, घटता आहार उपयोग तथा उन्नत जैवसुरक्षा इस प्रौद्योगिकी की विशेषता है। *पीनियस वन्नामेय* पीएल को 28 दिनों तक 3500 पीएल/वर्गमीटर संग्रहण घनत्व की दर से संस्थान

द्वारा विकसित 350 मेट्रिक टन क्षमता वाले नर्सरी टैंक में संवर्धन किया गया। नर्सरी में पालित जीवों का शारीरिक भार 0.92±0.15 ग्रा. तथा उत्तरजीविता दर 94.20±2.86% दर्ज की गई।

आरएएस इन्वीरॉनमेंट में वृद्धि निष्पादन, जलीय गुणवत्ता और प्रतिरक्षा प्रतिक्रियाओं पर एक्वा-मिमिक्री का मूल्यांकन

कार्बन स्रोत को उपलब्ध कराते हुए एवं पूरक आहार के रूप में रोटीफर देते हुए एक आरएएस आधारित नर्सरी संवर्धन कार्य किया गया। प्रत्येक उपचार में 15 दिनों के अंतराल पर उत्तरजीविता एवं वृद्धि की लनगरानी की गई। उपचारों में सी : सामान्य, टी1 : केवल बायो-फ्लॉक, टी2 : बायो-फ्लॉक एवं रोटीफर, टी3 केवल रोटीफर सम्मिलित है। प्रयोग के अंत में बायो-फ्लॉक के साथ रोटीफर की स्थिति बेहतर वृद्धि (3.89±0.25) और उत्तरजीविता (91%) दर्शायी है जो सामान्य जीवों (3.24±0.29, 85%) से उल्लेखनीय रूप से भिन्न है।

विभिन्न लवणीय स्तरों में संवर्धित भारतीय सफेद तरूण झींगों का वृद्धि निष्पादन और परासारिता (आस्मोलारिटी)

विभिन्न लवणीय स्तरों में संवर्धित *पी. इंडिकस* के तरूण झींगो (0.4-0.5 ग्रा.) का वृद्धि निष्पादन, जलीय गुणवत्ता, परासारिता तथा सीरम मिनरल प्रोफाइल के अध्ययन हेतु एक 50 दिवसीय प्रयोग किया गया। परासारित अध्ययन से स्पष्ट हुआ है कि परिवेशी जलीय लवणता के साथ सीरम परासारिता अनुपातिक रूप से बदल जाता है।

आजीविका के रूप में ज्वारनदमुखी परितंत्र में *पीनियस इंडिकस* का नर्सरी संवर्धन

कलपक्कम (तमिलनाडु) के निकट उयलीकुप्पम गांव के स्वयं सेवी समूह के लिए भारतीय सफेद झींगा पीनियस इंडिकस के एक नर्सरी संवर्धन मॉडल का निरूपण किया गया। *पीनियस इंडिकस* (400 नग) के 1.5 ग्रा. भार वाले तरूण झींगों को 4 हापाओं (2 मी. X 1 मी. आमाप) में 60 दिनों तक संवर्धन किया गया। *पी. इंडिकस* झींगों का औसत भार 8.50 ग्रा. और 90% उत्तरजीविता प्राप्त हुई।

कीचड़ केकड़ों के पालन के लिए निमज्जित पिंजरा प्रणाली (सबमर्सीबल केज सिस्टम) का विकास

कीचड़ केकेड़े बेन्थिक जीव होते हैं, अत: पेलाजिक/तैरने वाले पिंजरें सापेक्षिक रूप से उच्चतर सतह और उपसतह के तापमान के कारण इन जीवों की कार्यिकी पर प्रतिकूल डालते हैं। उपसतह/तैरने वाले पिंजरों की पहलुओं के समाधान हेतु निमज्जित पिंजरों का विकास किया गया है। निमज्जित प्रणाली में शारीरिक भार का औसत लाभ >100 ग्रा. है जब कि तैरने वाली पिंजरा प्रणाली में यह कम (<15 ग्रा.) है, जिससे यह सूचित होता है कि परम्परागत तैरने वाली पिंजरा प्रणाली से निमज्जित प्रणाली बेहतर है। निष्कर्ष के रूप में कहा जा सकता है कि केकड़ों के विकास के लिए परम्परागत पद्धति की तुलना में निमज्जित सह तैरने वाले पिंजरों में केकड़ा पालन प्रणाली से उच्चतर वृद्धि प्राप्त होती है।

महाराष्ट्र के मैंग्रोव क्षेत्र में खुले जल में पिंजरा जलजीव पालन

मैंग्रोव सेल, महाराष्ट्र के सहयोग से सीबा ने स्वयं सेवी समूहों की प्रतिभागिता द्वारा सिन्धूदुर्ग में मैंग्रोव तटीय जल और आसपास के क्षेत्र में तीन चरणीय सीबास फार्मिंग प्रारम्भ किया। स्वयं सेवी समूहों की प्रतिभागिता से 6 नर्सरियां, एक प्रि-ग्रो-आउट तथा 33 ग्रो-आउट केज कल्चर तैयार किया गया। स्वयं सेवी समूहों ने सीबास नर्सरी तथा प्रि-ग्रो-आउट संवर्धन कार्य से कुल 3.16 लाख रूपयों का राजस्व अर्जित किया। ग्रो आउट पालन से आशा है कि 400-500 ग्रा. तक पालन किया जा सकता है और इसका आकलित राजस्व उत्पत्ति 10-12 लाख होगी।

सीबास और ग्रीन मसल्स का एकीकृत बहु-पोषी जलजीव पालन (आईएमटीए)

भारत के पश्चिमी तट में प्रत्याशी पखमीन एवं कवचमीन मछलियों के पारिवारिक उत्पादन मॉडल के विकास एवं प्रवर्धन हेतु मलवन, सिन्धूदुर्ग के गाद क्रीक में आईएमटीए प्रारम्भ किया गया। वर्तमान समय में सीबास मछलियां, संग्रहण आमाप 60 ग्रा. से बढ़कर 400 ग्रा. की हो गई हैं और इनकी उत्तरजीविता दर 79.30-90.03% है। सीबास की 400-500 ग्रा. की मछलियों की उपज मध्य जून, 2019 में प्राप्त होने की संभावना है और उत्पन्न कुल राजस्व का आकलन 2-2.5 लाख रूपए हैं।

रंगीन 'सिल्वरफिश' के रूप में तरूण मिल्कफिश

दुधिया सफेद भडकीला, चमकता शरीर, चपलता, अर्ध-पारदर्शी V आकार का पुच्छ पख, त्वरित गति से तैरने की पद्धति, व्यापक लवणता के प्रति सहिष्णुता, टैंक शैवाल का भक्षक और रोग प्रतिरोधी

गुण तरूण मिल्कफिश मछलियों को संभावित रंगीन/अलंकारिक मछली बनाता है जिसे सिल्वरफिश कहा जाता है। अन्य रंगीन मछलियों के साथ सुसंगत के कारण इन मछलियां की एक जोड़ी मछलियों की कीमत 50-100 रूपए है।

पश्चिम बंगाल में डेक्कन हिल्सा के रूप में मिल्कफिश का उत्पादन

मिल्कफिश की मांग और स्थानीय बंगालियों की पसन्द पर विचार करते हुए सीबा ने पश्चिम बंगाल में मिल्कफिश को 'डेक्कन हिल्सा' के रूप लोकप्रिय बनाने का प्रयास किया। चार भिन्न पालन परितंत्रों में उत्पादन कर, 1.3 टन मिल्कफिश उपज प्राप्त किया गया जिसे बंगालियों ने डेक्कन हिल्सा के रूप में स्वीकार किया।

भारतीय झींगा पालन में फार्म निवेशों के उपयोग की पद्धति

वर्ष 2017 के दौरान झींगा उत्पादन वाले राज्यों आन्ध्र प्रदेश, तमिलनाडु, गुजरात और महाराष्ट्र में निवेशों के उपयोग की पद्धति जानने हेतु एक सर्वेक्षण किया गया। अध्ययन से ज्ञात हुआ है कि मृदा और जल की गुणवत्ता में सुधार हेतु बड़े पैमाने पर पर्यावरण संशोधकों का उपयोग किया जा रहा है और इसके बाद का स्थान प्रोबायोटिक्स (जल, मृदा और आंत प्रोबायोटिक्स) और निस्संक्रमकों का है। अध्ययन के दौरान सूक्ष्मजीव विरोधी उत्पादों के उपयोग संबंधी सूचनाएं नहीं मिली हैं।

तालाबों में हिल्सा मछलियों का ग्रो-आउट पालन

पश्चिम बंगाल में हिल्सा मछलियों के विपणन की अच्छी सम्भावनाएं हैं और खाने योग्य आमाप की मछलियों की भारी मांग है। दो माह आयु वाली अंगुलिकाओं पेल्लेटेड आहार के उपयोग से को दो भिन्न प्रणालियों जैसे मिट्टी के तालाब और आरएएस में आगे का संवर्धन किया गया। ग्यारह माह बाद मछलियों का आमाप 80 ग्रा. हो गया है और मिट्टी के तालाबों में निष्पादन बेहतर रहा है।

लवणता के प्रति धारीदार रेबिट फिश *सिगानस जावस* की व्यापक सहिष्णुता

तेज विकास दर, शाकाहारी आहार प्रवृत्ति तथा आर्थिक महत्व के कारण स्ट्रीक्ड स्पाइन फुट रेबिट फिश *सिगानस जावस* को महत्वपूर्ण खाद्य मछली माना जाता है। इन मछलियों की लवण सहिष्णुता जानने हेतु 30 दिनों का एक प्रयोग किया गया। इस प्रयोग से पहली बार *सिगानस जावस* की व्यापक लवण सहिष्णुता का प्रलेखन किया गया, जो खारा जलजीव पालन के लिए एक संभावित शाकभोजी खाद्य मछली है।

नर *पीनियस इंडिकस* झींगों की प्रजनन गुणवत्ता

पेनोयड झींगों का शुक्राणु कोश और शुक्राणओं की गुणवत्ता अक्सर बीज उत्पादन की सफलता का विशेषकर बंद स्थितियों में, निर्धारण करता है। यह सूचना मिली है कि सामान्यत: बंद स्थितियों के अंतर्गत रिप्रोडक्टिव ट्रैक्ट का विकास तथा शुक्राणु कोश की उत्पत्ति बाधित होती है। जनन संबंधी विकास की प्रक्रिया के मूल सिद्धांतों के मूल्यांकन हेतु नर झींगों का मूल्यांकन टैंकों और तालाबों में किया गया और इनकी तुलना वन्य रूप से प्राप्त झींगों से की गई। वन्य रूप से प्राप्त झींगों की तुलना में टैंकों और तालाबों में संवर्धित झींगों में शुक्राणुओं की संख्या काफी कम पायी गयी।

पीनियस इंडिकस की शुक्राणु कोश गुणवत्ता पर अल्पकालिक शीत भंडारण का प्रभाव

नर युग्मकों (गैमीट) के भंडारण से कृत्रिम निषेचन हेतु प्रजनकों के रखरखाव की समस्या हल हो सकती है। गुग्मकों, शुक्राणु कोश की गुणवत्ता पर शीत भंडारण के प्रभाव को मूल्यांकित करने हेतु इन्हें 4^0 से. के तापमान पर संग्रहीत किया गया और भिन्न भिन्न अंतरालों पर इनका मूल्यांकन किया गया। पांचवे दिन के नमूने की तुलना में प्रथम दिन के नमूने में सामान्य शुक्राणु काफी अधिक पाए गए। पांच दिनों के परिरक्षण में भंडारित शुक्राणु कोश में एक्रोसोम प्रतिक्रियाएं देखी गईं। पांच दिनों के बाद शुक्राणु कोशिकाएं विघटित होने लगी हैं और जीविष्णुता (वयाबिल्टी) भी नही देखी गई। इस अध्ययन से शुक्राणु कोश के परिरक्षण पद्धति में शीत भंडारण की प्रयोजनीयता प्रमाणित होती है।

भारतीय सफेद झींगा *पीनियस इंडिकस* का कृत्रिम परिवेशीय निषेचन और संकरण क्षमता

पेनोयड झींगों के कृत्रिम परिवेशीय निषेचन पद्धति का सफलतापूर्वक विकास किया गया। पी. इंडिकस का अंत: विशिष्ट निषेचन में सफलता प्राप्त की गई जिसमें निषेचन दर 4.8% और 29% नौप्ली को पोस्ट लार्वा में विकसित किया गया।

पीनियस इंडिकस के बंदी प्रजनकों की शारीरिक विशेषताओं पर विभिन्न आहारीय व्यवस्थाओं का प्रभाव

बंद स्थितियों के अंतर्गत *पी. इंडिकस* को परिपक्वन आहार (प्रतिदिन शारीरिक भार का 5%, 10% तथा 25%) तथा बंद स्थितियों में पालन से होने वाले शारीरिक बदलाव जैसे वृद्धि, मोल्टिंग रिदम तथा परिपक्वन हार्मोन स्तर पर प्रभाव के मूल्यांकन हेतु यह अध्ययन किया गया। झींगों को शारीरिक भार के15% आहार दिए जाने वाली समूह में मोल्टिंग आवृत्ति अधिक पायी गयी। आगे 45 दिनों के बंद स्थितियों में पालन से इस समूह में न्यूनतम GIH mRNA पाया गया।

सीबास बीज उत्पादन की नई ऊंचाईयां

सीबा, बंद प्रजनन और सीबास बीज उत्पादन में अग्रणी है, हाल ही में बंद स्थितियों में प्राकृतिक अंडजनन प्रोटोकॉल को मानक बनाया है। पिछले वर्ष जनित 5.53 मिलियन अंडों में से 2.66 मिलियन अंडों का स्वाभाविक अंडजनन तथा 2.87 मिलियन अंडों का प्रेरित अंडजनन हुआ। वर्ष 2018-19 में एक सर्वकालिक उच्च, 0.59 मिलियन पोनों को बेचा गया जिससे 1.72 मिलियन का राजस्व प्राप्त हुआ। इसके अतिरिक्त, 1.20 लाख बीजों को कृत्रिम आहार के पूरी तरह अलग करके महाराष्ट भेजा गया।

मिल्कफिश (*चनोस चनोस*) के दो भिन्न भौगोलिक सम्पदाओं के प्रजनन का निष्पादन

पूर्वी तट से पृथक किए गए मिल्कफिश के दो भौगोलिक सम्पदाओं की जनन क्षमताओं की तुलना में, चेन्नई की सम्पदा का निष्पादन बेहतर पाया गया जिसमें अंडजनन का विस्तारित अवधि देखी गयी। दोनों की सम्पदाओं में एक से अधिक अंडजनन हुआ और बंद स्थितियों में मिल्कफिश का वर्षभर प्रजनन का अवसर देखा गया।

प्रक्षेत्र में पालित पैतृक सम्पदा के उपयोग से ग्रे-मुल्लेट के बंद प्रजनन में अच्छी प्रगति

वर्ष 2017 में मुल्लेट का अंडजनन हुआ और पहली बार अंडों का निषेचन हुआ, परन्तु लार्वा केवल 8 दिनों तक जीवित रहें हैं, तीव्र प्रयासों बृहत स्तर पर 0.75 मिलियन लार्वा का उत्पादन किया गया। लार्वा 28 दिनों तक जीवित रहें हैं। आगे लार्वा संवर्धन के अनुकूलन कार्य प्रगति पर है।

तालाब की स्थितियों में संवर्धित *लिजा पार्सिया* का परिपक्वन

लिजा पार्सिया की प्रजनन परिपक्वता के लिए 300 मछलियों पर एक प्रयोग किया गया, जिसमें अनुकूलतम जल की गुणवत्ता और आहार से बंद स्थितियों में परिपक्वता का प्रमाण मिलें हैं। प्रजनन परिपक्वता के लिए 300 नंबर लिजा परसिया (गोल्ड्सपोट मलेट) के साथ किए गए एक अध्ययन ने इष्टतम पानी की स्थिति और फ़ीड के साथ कैप्टिव परिपक्वता की आसानी का सबूत दिया। अंडाणु जिनका व्यास 100 μm से भी कम है, वे प्रकृति से नॉन-विटेल्लोजेनिक होते हैं और बंद स्थितियों में अधिकतम जीएसआई और अंडाणुओं का व्यास क्रमश: 606.55±17.02 और 18.31±2.0 प्राप्त किए हैं। इस अध्ययन से प्रमाणित होता है कि *लिजा पार्सिया* के प्रजनकों को आसानी से तालाब की स्थितियों में विकसित किया जा सकता है।

मैंग्रोव स्नेप्पर का बंद स्थितियों में परिपक्वता की अच्छी प्रगति

मैंग्रोव स्नेप्पर के बंद प्रजनन प्रौद्योगिकी को लक्ष्य बनाकर, 90 वयस्क मछलियों का ब्रूडस्टॉक होल्डिंग सिस्टम में रखरखाव किया जा रहा है। जून से अक्टूबर, 2018 तथा फरवरी से मार्च, 2019 के दौरान स्रावी नर मछलियों को देखा गया, जिससे सूचित होता है कि 8-21% नर मछलियां परिपक्वता प्राप्त कर रहीं हैं। तथापि, मादा परिपक्वन प्राप्त नहीं हुआ है और अंडकों के विकास के संकेत मिलें हैं।

आरएएस आधारित होमस्टेड फिश ब्रीडिंग मॉडल में स्पॉटेड स्काट की प्रेरित परिपक्वता और अंडजनन

स्पॉटेड स्काट के प्रजनन को सरल बनाने हेतु 3000 ली. क्षमता, सेन्द्रल ड्रैनेज सिस्टम तथा 12.9 घनमीटर/प्रतिदिन प्रवाह दर वाला एक आरएएस तैयार कर उसमें प्रयोग किया गया। वयस्क स्काट मछलियों हार्मोनों के भिन्न खुराकों तथा संयोजनों से प्रेरित किया गया। मादा मछलियों LHRHa 25 μg/कि.ग्रा./माह से सफलतापूर्वक प्रेरित हुई जब कि नर मछलियों में LHRHa + 25 + 25 μg/कि.ग्रा./माह की दर से 17-αMT के मिश्रित खुराक से शुक्राणु घनत्व में वृद्धि में सहायता मिली है। आरएएस आधारित होमस्टेड मॉडलों में इन अनुकूलित खुराकों से अंडजनन और लार्वा उत्पादन में सहायता मिलेगी।

सिल्वर मूनी *मोनोडेक्टीलस अर्जेन्टियस* का बंद प्रजनन

हार्मोनल प्रेरण से संभावित खाराजलीय रंगीन मछली का बंद प्रजनन और बीज उत्पादन प्राप्त किया गया। निषेचन 18 घंटों में हुई और अंडों का व्यास 860±14.11 μm तथा निषेचन दर 90% रही है। नव विकसित लार्वा की लम्बाई 1.60-1.67 मि.मी. पायी गयी। वन्य रूप से प्राप्त मछलियों से हटकर बंद प्रजनन से निर्यात के लिए व्यापक उत्पादन का मार्ग प्रशस्त करेगा।

भारतीय झींगा पालन के लिए डब्ल्यूएसएसवी, ईएचपी और आईएमएनवी के बड़े खतरे

वर्ष 2015-19 के दौरान झींगा प्रक्षेत्रों में रोगों की सक्रिय निगरानी में पाया गया है कि झींगा उत्पादन करने वाले दो प्रमुख राज्यों तमिलनाडु और प्रदेश में व्हाइट स्पॉट सिंड्रोम वायरस (डब्ल्सूएसएसवी) तथा एन्टेरोसाइटोजून हेपाटोपेनेय (ईएचपी) प्रमुख रोगजनक हैं। डब्ल्सूएसएसवी का फैलाव 11-40% और ईएचपी का फैलाव 21-43% है। वर्ष 2018-19 के दौरान संक्रामक माइवनक्रोसिस वायरस (आईएमएनवी) एक और चुनौती के रूप में उभरी है, जिसका फैलाव 15% है।

पॉलीकीट कृमियों के माध्यम से झींगों में *एन्टेरोसाइटोजून हेपाटोपेनेय* संक्रमण

सीबा के अध्ययनों से स्पष्ट हुआ है कि डब्ल्सूएसएसवी और ईएचपी जैसे रोगजनकों को झींगों तक पहुंचाने में वॉलीकीट कृमियां वाहक की भूमिका निभाते हैं। ईएचपी क्षैतिज रूप से फलती है, संक्रमित झींगों से पॉलीकीट में और पॉलीकीट से झींगों में। तथापि पॉलीकीट के विभिन्न विकासात्मक अवस्थाओं में ऊर्ध्वाधर संचरण के प्रमाण नहीं मिले हैं।

परवेशी तापमान पर समुद्री जल में ईएचपी के बीजाणु एक वर्ष तक संक्रामक रहते हैं

समुद्री जल में परवेशी तापमान पर ईएचपी के बीजाणुओं की संक्रमणता एक वर्ष से अधिक समय तक रहती है। इस प्रकार की भंडारण स्थितियों में सक्रियता डेढ वर्ष बाद छूटी है। तथापि 40 से., -200 से., तथा -800 से में भंडारित बीजाणु में, एक माह के बाद बजाणुओं की व्यवहार्यता पूर्ण रूप से नष्ट और संक्रमणता नाटकीय रूप से कम हो गयी है।

ईएचपी बीजाणुओं के उद्भेदन (जर्मीनेशन) को प्रयोगात्मक तौर पर प्रेरित किया जा सका है।

पोटाशियम हाइड्राक्साइड तथा फ्लोक्साइन जैसे डाइस के उपयोग से ईएचपी बीजाणुओं के उद्भेदन को प्रेरित किया गया। उद्भेदन की सम्पूर्ण क्रिया दो क्षण से भी कम समय में पूर्ण हो जाती है। उद्भेदित बीजाणु कोशिका को भेद कर और अपनी झिल्ली को चुभोकर आस-पास के संभावित मेजबान कोशिका को संक्रमित करती है।

झींगों में डब्ल्यूएसएसवी का ऊर्ध्वाधर संचरण

प्रयोगात्मक रूप से संक्रमित *पीनियस इंडिकस* में, डब्ल्यूएसएसवी संक्रमित गर्भाशय कोशिकाओं में वीपी28 प्रोब के प्रति प्रतिक्रियात्मक इंट्रान्यूक्लीयर बॉडीस देखा गया है जिससे स्पष्ट होता है कि डब्ल्यूएसएसवी के निम्न स्तर का संक्रमण से भी ऊर्ध्वाधर संचरण की सम्भावना होती है।

अन्ध्र प्रदेश में कीचड़ केकड़ों *स्काइला सेर्राटा* की खेती में व्यापक मार्त्यता

वर्ष 2018 में आन्ध्र प्रदेश राज्य में कृष्णा जिले के नागयालंका में कीचड़ केकड़ों की खेती में बड़े पैमाने पर मृत्यु दर देखी गई। मृत केकड़ों व्हाइट स्पॉट सिड्रोम वायरस के प्रति समारात्मक पाए गए। उनमें मेटाजोन क्रस्टासियन पारासाइट, स्टाल्क्ड बार्नेकल, ओक्टोलास्मिस एसपीपी का भी भारी संक्रमण पाया गया। स्वस्थ तालाबों की तुलना में संक्रमित केकडों के हेमोलिम्प में कुल प्लेट काउंट और कुल वाइब्रियो काउंट में वृद्धि देखी गई।

सीबास में तिलापिया लेक वायरस (TiLV) का संचरण

तिलापिया के साथ सीबास की खेती वाले प्रक्षेत्रों में रोग निगरानी के दौरान, सीबास में TiLV से प्रभावित हेमोरहेजिक एनसेफालिटिस से जुड़ी क्रोनिक मार्त्यता देखी गई। संक्रमित तिलापिया से सीबास में अंतर प्रजातीय संचरण के परीक्षण हेतु चुनौतीपूर्ण प्रयोग में देखा गया कि TiLV से सीबास में उच्च समुच्चय मृत्यु दर के साथ सफल संचरण हुआ है।

खाराजलीय पखमीन में परजीवीय संक्रमण

वर्ष 2016-19 के दौरान खाराजलीय प्रत्याशी मत्स्य प्रजातियों तथा केकड़ों के परजीवीय रोगों के प्रोफाइलिंग से ज्ञात होता है कि 6 प्रमुख परजीव

जैसे *अर्गुलस, कैलीगस, लेरनानथ्रोपस, जेलानीकॉडेल्ला, अनिसाकिस* और *आक्टोलासमिस* मौजूद हैं। तथापि मलेट और मिल्कफिश में कोई परजीवीय संक्रमण दर्ज नहीं हुई है।

जोआ सिंड्रोम का मैक्रोबियल प्रोफाइलिंग

जोआ-2 सिंड्रोम की एटियालॉजी जानने के लिए मेटाजेनोमिक अध्ययन किया गया। समग्र रूप से स्वास्थ्य के लिए विशिष्ट 46 वंश, अस्वस्थता के लिए विशिष्ट 328 वंश तथा दोनों के लिए समान 371 वंशों को देखा गया। जोआ-2 से प्रभावित नमूनों में कुछ वंशों जैसे डेवोसिया, अवर्गीकृत रोडोबैक्टेरासी, नॉनलबेंस, मुरीकौडा, अवर्गीकृत फ्लावोबैक्टीरियलेस तथा सूडोआल्टेरोमोनास की प्रचुरता पाई गई।

सीबामाक्स का मैक्रोबियल प्रोफाइलिंग

16s rDNA आधारित मेटाजेनोमिक मैक्रोबियल प्रोफाइलिंग से स्पष्ट हुआ है कि नाइट्रोजन उपापचय में अनेक अनोखे जीवाणु सम्मिलित हैं। अमोनिया आक्सीकरण में *नाइट्रोसोमोनास* और *नाइट्रोबैक्टर* के अतिरिक्त काल्डीलिनिएसी कुल संबंधित जीवाणु समूह की भी आधिक्यता है। एओबी तथा एनओबी समृद्धता में पहचान की गई सूक्ष्मजीवों का बड़ा भाग *प्रोटियोबैक्टेरिया* समुदाय से संबंधित है।

वाइब्रियो हार्वेयी क्लेड में कोरम सेंसिंग सिस्टम का गुणचित्रण

विषैलेपन के समझने के लिए, वाइब्रियो हार्वेयी क्लेड के 60 जेनामों के कोरम सेंसिंग सिस्टम का गुणचित्रण किया गया। *वी. हार्वेयी* क्लेड के सभी पृथककरणों में आटोइनड्यूसर 2 सिंथेसाइजिंग *luxS* जीन मौजूद हैं। तथापि, *वी. हार्वेयी, वी. कैम्पबेल्ली, वी. जासीसिडा* और *वी. ओवेनसी* में आटोइनड्यूसर 1 सिंथेसाइजिंग जीन *luxM* मौजूद है परन्तु वी. *नेट्रीजेन्स* और *वी. रोटिफेरियानस* में गैर-मौजूद है।

व्यवहार्य और मृत ईएचपी बीजाणुओं में विभेद करने हेतु त्वरित पहचान करने की तकनीक

ईएचपी बीजाणुओं की व्यवहार्यता के मूल्यांकन के लिए एक अभिरंजन (स्टैनिंग) तकनीक का विकास किया गया। कैलकोफ्लूअर व्हाइट से अभिरंजित व्यवहार्य बीजाणु वायलेट फिल्टर (395-415 nm) में फिरोजा-नीले रंग में प्रतीत होता है। साइटाक्स ग्रीन से अभिरंजित मृत बीजाणु ब्लू एक्साइटेशन फिल्टर (470-490 nm) में पीले-हरे अंडाकार शरीर वाले तथा वायलेट फिल्टर (395-415) में सफेद-पीला प्रतीत होते हैं।

मछली में इरिडोवायरस संक्रमण की पहचान हेतु SYBR Green आधारित रियल टाइम पीसीआर परख तकनीक का विकास।

मछली में इरिडोवायरस संक्रमण की पहचान हेतु SYBR Green आधारित रियल टाइम पीसीआर परख तकनीक का विकास किया गया जिसकी पहचान करने की सीमा 10 वायरल अणु हैं। इरिडोवायरस पहचान करने हेतु एक मेम्बरेन कोफैक्टर प्रोटीन जीन आधारित पीसीआर का मानकीकरण किया गया।

वन्य *पीनियस इंडिकस* अंडजनकों में डब्ल्यूएसएसवी का मातृ संचरण (मेटर्नल ट्रासमिशन)

युग्मकों के माध्यम से प्रत्यक्ष रूप से डब्ल्यूएसएसवी का ऊर्ध्वाधर संचरण को प्रमाणित करना अभी बाकी है। इस कल्पना के परीक्षण के लिए, डब्ल्यूएसएसवी से संक्रमित मादा मछलियों के प्रजनन ऊतकों का क्यूआरटी पीसीआर के माध्यम से डब्ल्यूएसएसवी रोग की पहचान की गई और पाया गया कि प्रजनन ऊतकों में डब्ल्यूएसएसवी के 50 से 60 प्रतियां ही हैं, और संक्रमित मादाओं के 36% प्रजनन ऊतकों में ही डब्ल्यूएसएसवी की मौजूदगी देखी गयी। तथापि स्वस्थान पर संकरण अध्ययनों में डब्ल्यूएसएसवी के सकारात्मक संकेत नहीं मिले हैं।

अंतड़ियों के मैक्रोब्स का पृथक्करण तथा गुणचित्रण

बायोफ्लॉक प्रणाली लाभप्रद पाया गया और आंतिडयों क्षेत्र में लाभदायक बैक्टीरियो की उपनिवेशीकरण में सहायक होती है। कुल 94 नस्लों (स्ट्रेइन) की जांच की गई और पाया गया कि 36 नस्ल एमिलेज एंजाइम उत्पन्न करते हैं, 20 नस्ल प्रोटियेज, 27 नस्ल लिपेज, 6 नस्ल सेल्लुलेज और 8 नस्ल जइलानेज उत्पन्न करते हैं। कुल 21 वियोजको (आइसोलेट्स) को आगे की पहचान हेतु चयन किया गया और बायोफ्लॉक ट्रीटमेंट्स से *कोबेटिया, एक्सीगुओबैक्टेरियम, बेसिलस, मेरिनिलेक्टीबेसिलस, स्टाफाइल्लोकोकस* तथा *नोवोस्पिंगोबियम* के विभिन्न प्रजातियों की पहचान की गई। *बेसिलस* और *एक्सीगुओबैक्टेरियम* के

सामान्य नस्लों में ही देखा गया। इन सभी नस्लों में से, जीनस *एक्सीगुओबैक्टेरियम* की पहचान सभी ट्रीटमेंट्स और कंट्रोल में की गई।

जल विश्लेषण किट का वाणिज्यिकरण

विभिन्न स्रोतों और भिन्न भिन्न लवणीयता स्तर के तालाब जल में घुलित आक्सीजन, अमोनिया (0.1 से 2 पीपीएम), नाइट्राइट (0.05 से 1 पीपीएम), कैल्शियम एवं मैग्निशियम खनिज, कुल कठोरता, कार्बोनेट, बाइकार्बोनेट तथा कुल क्षारीयता के मापन हेतु एक मल्टी-पारामीटर पोर्टेबल वाटर एनालाइसिस किट का विकास किया गया और इसका वाणिज्यिकरण न्यू बायो साईंस कम्पनी, मैसूर के साथ किया गया।

जलजीव पालन वेब टूल

जल निकायों की वहन क्षमता के आकलन के लिए एक ऑनलाइन एक्वाकल्चर प्लानिंग वेब टूल 'कैरीकैपद्ध' विकसित किया गया और आंध्र प्रदेश राज्य सरकार द्वारा जलजीव पालन विकास के अनुकूलन और संसाधन उपयोगकर्ताओं के बीच टकराव से बचने के लिए एक्वा ज़ोनेशन कार्य के लिए इसका उपयोग किया जा रहा है।

मृदा जल स्वास्थ्य कार्ड और स्थान विशिष्ट बीएमपी

तमिलनाडु के चिदंबरम और नागपट्टिनम जिलों के जलजीव पालकों को लगभग 55 मृदा और जल स्वास्थ्य कार्ड वितरित किए गए। भौगोलिक भिन्नता को समझने के लिए एसडब्ल्यूएचसी डाटाबेस का विश्लेषण किया गया, जो स्थान विशिष्ट बीएमपी को तैयार करने में मदद करता है।

विभिन्न पालन पद्धतियों के अंतर्गत पोषक तत्व गतिशीलता

शून्य जल विनिमय के साथ 25 पीपीटी लवणता के अंतर्गत सिम्युलेटेड (कृत्रिम) मिट्टी और पक्के तालाब में *पी. वन्नामेय* पालन पर किए गए अध्ययन से पता चला है कि रेखित तालाबों (लाइन्ड पांड्स) में पानी की गुणवत्ता, विशेषकर अपचयोपचय क्षमता तुलनात्मक रूप से बेहतर है और मेटाबोलाइट्स रेखित तालाबों में कम थे। यद्यपि, मिट्टी के तालाबों में विकास दर 21% अधिक थी।

जलवायु में आकस्मिक परिवर्तन के अंतर्गत *पी. वन्नामेय* का अनुकूलन

लवणता में आकस्मिक रूप से लवणता 25 से 5 पीपीटी तक पर घटने की स्थितियों में *पी. वन्नामेय* की अनुकूलन क्षमता पर किए गए अध्ययन से पता चला है कि हालांकि जल ऑस्मोलैलिटी में व्यापक भिन्नता है, 5 घंटे में सीरम ऑस्मोलैलिटी 510-687 mOsmol/कि.ग्रा. की कम सीमा में है तथा 24 घंटे में यह सीमा कम तथा स्थिर (639-665 mOsmol/किग्रा) की गई। यह दर्शाता है कि *पी. वन्नामेय* अपनी ओस्मोरेगुलेटरी क्षमता के कारण लवणता में परिवर्तन के प्रति जल्द अनुकूलन करने में सक्षम है।

पी. वन्नामेय पालन में वृद्धि और नाइट्रोजन चयापचय संकेंद्रण पर मिट्टी पॉलिमर अवशोषण का प्रभाव

पी. वन्नामेय पालन में साप्ताहिक अंतराल पर 2.5 ग्रा./100 लीटर की दर से मिट्टी के पॉलीमर यौगिकों के अनुप्रयोग ने पहले सप्ताह के दौरान टीएएन (TAN) को 88.3 और 78.9 प्रतिशत कम कर दिया और यह अंतिम सप्ताह में निम्न (60 और 90 नग/वर्ग मीटर) और उच्च (90 सं/वर्ग मीटर) संग्रहण घनत्व में क्रमशः 45.1 और 43.2 प्रतिशत घट गया।

जल गुणवत्ता पर ऑक्सीजन रिलीज करने वाले यौगिक का प्रभाव

विकसित 3, 4 और 5 कि.ग्रा./हेक्टेयर की दर से ऑक्सीजन रिलीज करने वाले उत्पाद के अनुप्रयोग से घुलित ऑक्सीजन स्तर को क्रमशः 7.5, 9.2 और 12.1 पीपीएम तक बढ़ गया और अनुप्रयोग के 2 घंटे बाद कुल अमोनिया नाइट्रोजन स्तर को 0.25 पीपीएम से 0.025 तक कम कर दिया। घुलित ऑक्सीजन स्तर और अन्य जलीय गुणवत्ता प्राचलों के आधार पर, अनुकूलतम खुराक 3 कि.ग्रा./हेक्टेयर पाया गया।

पंजाब और हरियाणा में अंतर्स्थलीय लवणीय जलजीव पालन के लिए उपयुक्त स्थलों का आकलन

पंजाब और हरियाणा के चयनित जिलों से अंतर्स्थलीय लवणीय जल की लवणता, पीएच, कठोरता और क्षारीयता क्रमशः 2-20 पीपीटी, 7.2 से 8.3, 540-6570 पीपीएम और 126-601

पीपीएम तक पायी गयी। स्रोत जल कैल्शियम से भरपूर हैं, लेकिन मैग्नीशियम और पोटेशियम की कमी दूर करने हेतु पूरक खनिजों का उपयोग बाध्यकारी है। राजस्थान की अंतर्स्थलीय लवणीय मृदाओं में जल घुलनशीलता और विनिमेय योग्य पोटाशियम में भिन्नता 15 से 223 कि.ग्रा./हेक्टेयर और 27 से 814 कि.ग्रा./हेक्टेयर के बीच है।

जल की विभिन्न लवणताओं में कुल अमोनिया नाइट्रोजन का माइकोटिक जैवोपचार

भिन्न भिन्न लवणताओं 1, 15, 30 और 45 पीपीटी में *प्लुरोटस प्रजातियों* के उपयोग से कुल अमोनिया नाइट्रोजन (1 और 2 मि.ग्रा./ली.) के माइकोटिक जैवोपचार के लिए एक *कृत्रिम परिवेशीय* अध्ययन किया गया। 72 घंटे के भीतर कुल अमोनिया नाइट्रोजन में 1, 15 और 30 पीपीटी में 80% से अधिक और 45 पीपीटी में 80% से कम की कमी आयी।

झींगा जलजीव पालन में अन्य पोषक तत्वों के संबंध में कार्बन की गतिशीलता

विभिन्न लवणीयताओं में तालाब के तलछटों में नाइट्रोजन और फास्फोरस जैसे अन्य पोषक तत्वों के साथ कार्बन की सांद्रणता में भिन्नता का अध्ययन किया गया। लवणता के साथ जैविक कार्बन और उपलब्ध नाइट्रोजन की मात्रा में कमी पाई गई, जबकि उपलब्ध फॉस्फोरस मात्रा में विपरीत प्रवृत्ति देखी गई। लवणता के साथ जल में घुलनशील कार्बन में वृद्धि देखी गई, जो 1.4 मि.ग्रा./कि.ग्रा. से 2.5 मि.ग्रा./कि.ग्रा. के बीच है : डब्ल्यूएससी 45> डब्ल्यूएससी 25> डब्ल्यूएससी 11> डब्ल्यूएससी 6.

झींगों में डब्ल्यूएसएसवी के प्रकोप पर पालन तापमान की भूमिका

रोग चुनौती के 6 दिनों के भीतर 30°से और 32°से के परवेशी तापमान में झींगों की 100% मृत्यु दर पायी गई और पीसीआर परीक्षण में मृत/रुग्ण झींगों में प्रथम चरण की सकारात्मकता देखी गई। झींगों को 34°से और 35°से तापमान में पालने से क्रमशः 0% और 7% मृत्यु दर देखी गई और दोनों ही तापमानों में दूसरे चरण की सकारात्मकता पायी गई। इस अध्ययन से डब्ल्यूएसएसवी संक्रमकता और सामूहिक मृत्यु दर पर तापमान की भूमिका की पुष्टि होती है।

जलजीव पालन तालाबों में जीएचजी उत्सर्जन

पी. वन्नामेय पालन तालाबों में उपज प्राप्ति के प्रथम और दूसरे माह के दौरान जीएचजी का अधिक उत्सर्जन देखा गया विशेषकर कार्बनडाइऑक्साइड। तालाब को सुखाने तथा चूना डालने की प्रथा ने ग्लोबल वार्मिंग की संभावनाओं को बढ़ाया है। पालन के दौरान, आहार में 40% किण्वित सोयाबीन और बेसिलस स्ट्रेंस 10^6 सीएफयू/मि.ली. की खुराक के समावेशन तथा सूक्ष्मजीवीय हस्तक्षेप से कार्बनडाइऑक्साइड और मिथेन की तुलना में नाइट्रोजन उत्सर्जन कम हुआ है।

झींगा के लिए वृद्धि नियामक के रूप में भूरे समुद्री शैवाल एक्सट्रैक्ट का अनुप्रयोग

तरूण झींगों के लिए वृद्धि नियामक के रूप में भूरे समुद्री शैवाल (*एस्कोफाइलम नोडोसम*) एक्सट्रैक्ट का उपयोग किया गया। सूक्ष्म शैवाल मिश्रण से तैयार आहार देने पर तीन गुना तरलीकरण में भी 20% अधिक वृद्धि दर्ज की गई। हालांकि, समुद्री शैवाल एक्सट्रैक्ट की उच्च सांद्रणता से वृद्धि तथा उत्तरजीविता पर नकारात्मक प्रभाव पड़ा।

लैक्टिक एसिड बैक्टीरिया के पूरक आहार से *पी. वन्नामेय* की वृद्धि और उत्तरजीविता में सुधार

लैक्टिक एसिड बैक्टीरिया (एलएबी) के दो वियोजकों (आइसोलेट्स) नामत: *लैक्टोकोकस लैक्टिस* उपप्रजाति *लैक्टिस* एसडीकेआरसी-5 और *लैक्टोबैसिलस* वियोजक (एसडीकेआरसी-6) के पूरक आहार के साथ *पी. वन्नामेय* पर एक आहारीय परीक्षण किया गया। आहारीय परीक्षण के 63 दिनों के बाद, एलबीए पूरक आहार दिए गए समूह में सामान्य की तुलना में 14% उच्चतर वृद्धि और 10% अधिक उत्तरजीविता दर्ज की गई।
एशियाई सीबास में क्रस्टेशियन परजीवी संक्रमण के विरूद्ध इमामेक्टिन बेंजोएट की प्रभावकारिता
एशियाई सीबास में *कैलिगस मिनिमस* संक्रमण के विरुद्ध इमामेक्टिन बेंजोएट (ईबी) के साथ एक उपचारात्मक परीक्षण किया गया और उपचार के पांचवें दिन के बाद उत्तरजीविता में 92% सुधार और परजीवीय भार में कमी पाई गई। उपचार के 7वें दिन के बाद कोई परजीवी प्राप्त नहीं किया जा सका जिससे यह सुझाव मिलता है कि पखमीन मछलियों में परजीवीय संक्रमण के नियंत्रण हेतु इमामेक्टिन बेंजोएट दिया जा सकता है।

विभिन्न लवणताओं के तहत ऑक्सीटेट्रासाइक्लिन (ओटीसी) क्षरण पर पीएच का प्रभाव

समुद्री जल में ओटीसी क्षरण पर पीएच और लवणता के प्रभाव पर एक अध्ययन किया गया। लवणता के किसी भी स्तर पर, उच्च पीएच की तुलना में निम्न पीएच स्तर पर ओटीसी का क्षरण तेज गति से होता है।

झींगा मांसपेशियों के ऊतकों से क्लोरमफेनिकॉल की निकासी

पीनियस वन्नामेय में क्लोरमफेनिकॉल की निकासी के अध्ययन हेतु वाणिज्यिक रूप से उपलब्ध आहार पर 500 मि.ग्रा./कि.ग्रा. आहार की दर से क्लोरैम्फेनिकॉल लेपित करके 7 दिनों तक आहार दिया गया। क्लोरमफेनिकॉल खिलाना बंद करने के बाद दो दिन के भीतर ही मांसपेशियों के ऊतकों में सांद्रता तेजी से कम (0.64±0.08 ppm) हो गई तथा 20 दिनों में अवशेष पूर्ण रूप से समाप्त हो गए।

जलीय रोगों के लिए नैदानिक, रोगनिरोधी और चिकित्सकीय प्रौद्योगिकी का विमोचन

सीबा के जलीय जीव स्वास्थ्य प्रभाग ने नैदानिकी (उन्नत डब्लूएसएसवी रियल टाइम पीसीआर किट और ईएचपी रियल टाइम पीसीआर किट), रोगनिरोधी (सिबामॉक्स - वाटर प्रोबायोटिक) और चिकित्सकीय (लुमिपेज - वाइब्रोस के नियंत्रण के लिए) संबंधी कई तकनीक जारी किया है। उन्नत डब्लूएसएसवी रियल टाइम पीसीआर किट और ईएचपी रियल टाइम पीसीआर किट का कोस्ट्रा बायोसोल्यूशन प्रा. लि., चेन्नई से और सीबामॉक्स का टाटा रैलिस (इंडिया) लिमिटेड, मुम्बई के साथ वाणिज्यीकरण किया गया। इसके अतिरिक्त, लुमिफेज प्रौद्योगिकी में सुधार के लिए आईआईटी-एम और टाटा रैलिस इंडिया लिमिटेड के साथ एक समझौता ज्ञापन पर हस्ताक्षर किया गया।

खारा जलीय जीवों के रोगों के लिए राष्ट्रीय रेफरल प्रयोगशाला

सीबा का जलीय जीव स्वास्थ्य और पर्यावरण प्रभाग, खारा जलीय जीवों के रोगों के लिए एक राष्ट्रीय रेफरल प्रयोगशाला के रूप में कार्य कर रहा है। जलीय संगरोधन और प्रमाणन सेवाओं (एक्यूसीएस) के एक भाग के रूप में वर्ष 2018-19 के दौरान ओआईई सूचीबद्ध झींगा और मछली रोगजनकों के लिए कुल 63 नमूनों का परीक्षण किया गया जिनमें आयातित *आर्टीमिया* सिस्ट, फ्रोजन टिशू तथा आहार नमूने सम्मिलित हैं। ओआईई सूचीबद्ध रोगजनकों के संदर्भ में सभी नमूनों में नकारात्मकता पायी गयी।

मछली के अपशिष्ट को प्लवक बूस्टर में परिवर्तित करने की एक अनूठी विधि, प्लैंकटन$^{प्लस}$

स्वच्छता समस्याओं को कम करने की दृष्टि से सीबा ने 47-49% प्रोटीन तथा 20-30% लिपिड वाले प्लैंकटन$^{प्लस}$ मत्स्य उत्पाद की तैयारी के माध्यम से मछली बाजार के अपरद्द की सफाई हेतु प्रयास किया जिसे जलकृषि तालाबों में प्लवकों की वृद्धि करने या आहार सूत्रण में घटक के रूप में उपयोग करने तथा कृषि/बागवानी में खाद के रूप में उपयोग किया जा सकता है।

प्लवकों के स्तर और झींगा/मछली के वृद्धि निष्पादन पर प्लैंकटन$^{प्लस}$ के अनुप्रयोग का प्रभाव

प्लैंकटन$^{प्लस}$ पूरक आहार को 20 पीपीएम की दर के भागों में बांटकर देने पर *पी. वन्नामेय* की उल्लेखनीय रूप से (पी <0.01) दैनिक औसत भार में वृद्धि, विशिष्ट वृद्धि दर, कुल बायोमास प्राप्ति और उत्तरजीविता में वृद्धि हुई जबकि 30% कम आहार दिया गया। यद्यपि, प्लैंकटन$^{प्लस}$ पूरक की इसी खुराक से *चनोस चनोस* के वृद्धि निष्पादन और उत्तरजीविता को प्रभावित किए बिना 50% आहार की बचत की जा सकती है। प्लैंकटन$^{प्लस}$ पूरक से बेसिलिरियोफाइसे, प्रसिनोफाइसे और डिनोफाइसे आदि लाभदायक सूक्ष्म शैवालों के घनत्व को बढ़ाने में सहायता मिली है।

जीवंत आहार का समृद्धिकरण

प्लैंकटन$^{प्लस}$ पूरक पोषण से आर्टीमिया बायोमास उत्पादन में सुधार हो सकता है और आर्टेमिया पालन में शैवाल का उपयोग 50% तक कम किया जा सकता है। पख मीन और कवच मीन मछलियों के लार्वा पालन में उपयोग हेतु आर्टेमिया के लिए पीयूएफए से समृद्ध थ्रॉस्टोचाइट्रिड्स, यूनीसेल्यूलर मोनोसेंट्रिक कवक जैसे प्रोटिस्ट का उपयोग किया जा सकता है।

जलजीव आहार में उपयोग के लिए नए आहार घटकों और आहार योगजों का मूल्यांकन

झींगा और मछली के आहार में घुन से संक्रमित शकरकंद, खमीर किण्वित मूंगफली खली, *लीउकेना ल्यूकोसेफला* पत्ती आहार को में 5 से 10% तक समावेश किया जा सकता है। समुद्री शैवाल, *ग्रेसिलारिया टेनुइस्टिपिटाटा* को झींगा आहार में एक प्राकृतिक योजक के रूप में उपयोग करने की क्षमता पाई गई। अध्ययन से पता चला है कि वृद्धि और प्रतिरक्षा बढ़ाने के लिए स्पिरुलिना से निकाले गए सी-फाइकोसाइनिन को झींगा आहार सूत्रण में 750 से 1000 पीपीएम तक समावेश किया जा सकता है। अध्ययन में यह भी ज्ञात होता है कि बेहतर विकास और उत्तरजीविता प्राप्त करने के लिए *पीनियस वन्नामेय* के तरूण झींगों के आहार में 0.4% क्रिल ऑयल का समावेश किया जा सकता है।

सीबा द्वारा विकसित आहार और नवीन उत्पादों का निरूपण

तालाब में सामान्य की तुलना में प्लैंकटन$^{प्लस}$ पूरक पोषण से *पी. वन्नामेय* की उत्तरजीविता में उल्लेखनीय वृद्धि (12.31%) और 1.71 टन/हे. उपज वृद्धि हुई। प्लैंकटन$^{प्लस}$ पूरक पोषण दिए गए तालाबों में संवर्धित घनत्व और पादप प्लवक (बेसिलारियोफिसे, प्रोसिनोफिसे और डाइनोफिसे आदि) और जंतु प्लवक की विविधता *पीनियस वन्नामेय* में बढ़े हुए वृद्धि निष्पादन का कारण हो सकता है। खुले जल के पिंजरों में केकड़ा (*स्काइला सेराटा*) पालन निरूपण से पता चला कि तलहटी पिंजरों में गुटिका आहार से कुल बायोमास की प्राप्ति अधिक (7.27 कि.ग्रा.) थी। कम लागत वाली मछली की तुलना में सूत्रबद्ध आहार दिए गए बॉक्स में पालित केकड़ों (*स्काइला सेराटा*) में इसी प्रकार की अंडाशय भार प्राप्ति तथा गोनाडोमेस्टिक इंडेक्स प्राप्त हुआ।

कैप्टिव *पीनियस इंडिकस* ब्रूडस्टॉक की कार्यिकीय विशेषताओं पर विभिन्न आहार पद्धतियों का प्रभाव

यह अध्ययन परिपक्वता आहार के विभिन्न स्तरों (शारीरिक भार का 5%, 15% और 25% प्रति दिन) तथा बंद स्थितियों में पालन से कैप्टिव *पीनियस इंडिकस* ब्रूडस्टॉक में कार्यिकीय बदलाव जैसे वृद्धि, मोल्टिंग रिथम, परिपक्वता हार्मोन स्तर पर पड़ने वाले प्रभाव के मूल्यांकन के लिए किया गया था। शारीरिक भार के 15% की दर से आहार दिए गए समूह में मोल्टिंग आवृत्ति अधिक पाई गई। इसके अलावा, बंद स्थितियों पालन के 45 दिनों के बाद, इस समूह में न्यूनतम GIH mRNA स्तर पाया गया।

पोषक तत्वों की आवश्यकताओं का अनुकूलन और आहार विकास

मिल्कफिश लार्वा के आहार विकास के लिए टॉरिन और विटामिन ई (α-टॉकोफेरल एसीटेट) की आवश्यकता को अनुकूलित किया गया और यह क्रमशः आहार का 1% और 196-218 पीपीएम पाये गये। सीबास के लार्वा पालन के लिए उपलब्ध वाणिज्यिक फीड की तुलना में एशियन सीबास के लिए विकसित लार्वा आहार (सीबास लार्वी$^{प्लस}$) से उच्च वृद्धि निष्पादन दर्ज किया गया।

हिल्सा के ब्रूडस्टॉक आहार के विकास के लिए परिपक्वता के विभिन्न चरणों के दौरान हिल्सा के फैटी एसिड के जमाव पर अध्ययन किया गया। अध्ययन में यह पाया गया कि भले ही मांसपेशी में कम से कम जमा हुआ फैटी एसिड एराकिडोनिक एसिड (सी 20:4) है परंतु यह अंडाशय में सबसे अधिक (96%) है, जबकि पामिटोलेनिक एसिड (सी 16: 1) सबसे अधिक जमा हुआ फैटी एसिड है लेकिन अंडाशय में इसकी मौजूदगी सबसे कम (22.7%) है।

आहार प्रबंधन विकल्प

मिल्कफिश, *चनोस चनोस* लार्वा की वृद्धि और उत्तरजीविता पर विलंबित प्रारंभिक आहार के प्रभाव से ज्ञात होता है कि बेहतर विकास और उत्तरजीविता प्राप्त करने के लिए मिल्कफिश के लार्वा को आहार देने की प्रक्रिया निषेचन के 24 घंटे के बाद शुरू की जानी चाहिए। एक्वा मिमिक्री सिस्टम में झींगा पालन पर किए गए अध्ययन से पता चला है कि सिस्टम में उपलब्ध प्राकृतिक आहार सांद्रता केवल कम संग्रहण घनत्वों में अच्छे वृद्धि निष्पादन में मदद कर सकती है। जैविक कार्बन स्रोत के रूप में ग्राउंड राइस ब्रान के उपयोग से बनाए गए बायोफ्लाक का ही सेवन करने वाले झींगों (4.19 ग्रा.) की अपेक्षा बायोफ्लॉक और आहार का सेवन करने वाले झींगों में अधिकतम अंतिम भार (19.58 ग्रा.) तथा उत्तरजीविता (> 90%) देखी गई।

डब्ल्यूआरएनएवी संक्रमण के दौरान miRNAs की अभिव्यक्ति प्रोफाइलिंग

हाल के वर्षों में विषाणु पुनरावर्ति तथा मेजबान कोशिकीय तंत्र की सम्बद्धता में विषाणु तथा होस्ट (मेजबान) माइक्रो आरएनए (miRNA) के महत्व का

पता चला है तथा संक्रमण के दौरान मेजबान और रोगजनक से miRNAs के सहसंबंध को समझने के लिए प्रयास तेज किए गए हैं।

डब्ल्यूएसएसवी संक्रमण की स्थिति में झींगा (*पीनियस वन्नामेयी*) की प्रतिरक्षात्मक प्रतिक्रियाओं में सम्मिलित miRNAs की पहचान करने के लिए छोटे आरएनए अनुक्रमण किये गये। प्रक्षेत्र की दो विपरीत परिस्थितियों अर्थात प्रकोप और नियंत्रित प्रायोगिक स्थितियों के अंतर्गत डब्ल्यूएसएसवी से संक्रमित झींगा के miRNAs की अभिव्यक्ति प्रोफाइल की तुलना की गई और इसके परिणामस्वरूप 23365 ज्ञात miRNAs और 481 नवीन miRNAs की पहचान की गई। इसलिए, हमारा अध्ययन दो अलग-अलग स्थितियों में डब्ल्यूएसएसवी संक्रमण के दौरान झींगा के miRNA अभिव्यक्ति का तुलनात्मक विश्लेषण प्रदान करता है।

लांग-रीड्स वाले *पीनियस इंडिकस* का कांटिग-लेवल एसेम्बली

पेसिफिक बायोसाइंसेस सीक्वल प्लेटफॉर्म पर PacBio सीक्वेंस डाटा का सृजन किया गया। सीक्वेंसिंग के लिए 20 केबी सीक्वेंसिंग लाइब्रेरी का इस्तेमाल किया गया था, जहां ब्लूपीपिन साइज सेलेक्शन के आधार पर 17 केबी साइज से अधिक इंसर्ट्स रखे गए थे। सीक्वेंस डाटा के 176,539,267,324 आधार की लंबाई के लगभग 20,857,430 रीड्स, जो जीनोम के 71X कवरेज के बराबर हैं, का उपयोग फाल्कन, कैनु और डब्ल्यूटीडीबीजी 2 असेम्बलर्स के साथ कांटेग-लेवल जीनोम के निर्माण के लिए किया गया था। आप्टिकल मैप तथा HiC डाटा का सृजन, स्कैफफोल्डिंग और क्रोमोजोम लिंकिंग कार्य प्रगति पर है।

dbVAST: झींगा ट्रांसक्रिप्टों के साथ जुड़ी विविधताओं का डाटाबेस

पालन पद्धति के उत्पादन में वृद्धि के लिए संभावित जीनोमिक संसाधनों की खोज और उनके उपयोग को बढ़ावा देने के लिए, झींगा ट्रांसक्रिप्टों से जुड़ी विविधताओं का एक डाटाबेस बनाया गया। तीन झींगा प्रजातियों *पीनियस वन्नामेय, पीनियस इंडिकस* और *पीनियस एजटेकस* के कोडिंग अनुक्रमों में सिंगल न्यूक्लियोटाइड बहुरूपता (एसएनपी) का प्रलेखन किया गया और ब्राउज़ करने के लिए उपयोगकर्ता के अनुकूल ऑन-लाइन टूल प्रस्तुत किया गया।

एमआरएफ : मिसिंग रीजन फाइंडर

किसी भी अन्य रोगज़नक़ के साथ समानता प्रदर्शित न करने वाले व्हाइट स्पॉट सिंड्रोम वायरस (डब्ल्यूएसएसवी) जीनोम की विशिष्टता है कि इसके एन्नोटेशन सीमित है। डब्ल्यूएसएसवी जीनोम पर सम्पूर्ण ज्ञान प्राप्त करने के लिए मिसिंग रीजन फाइंडर नाम से एक वेब टूल विकसित किया गया। क्वेरी में डिलीट किए गए जीनोम रीजन को ढूंढने के लिए एमआरएफ, क्वेरी जीनोम की तुलना संदर्भ जीनोम से करता है तथा संदर्भ जीनोमों की व्याख्या के अनुसार डिलीट किए गए इन रीजंस की सीडीएस को सारणीबद्ध करता है। इससे एकल संदर्भ की व्याख्या नामकरण में तुलनात्मक जीनोम विश्लेषण के निष्कर्ष आसानी से समझ में आ जाएंगे। डब्ल्यूएसएसवी जीनोमों से संबंधित नामकरण वर्गीकरण के मुद्दे में इस प्रकार का टूल क्षमतावान है क्योंकि इसमें उपयोगकर्ता एकल संदर्भ जीनोम की तुलना कई जिनोम से कर सकते हैं।

उपसमूह, डेंड्रोब्रानचियाटा में झींगा के फाइलोजीनोमिक्स

जीनस *पीनियस सेंसु लेटो* में टैक्सोनोमिक संशोधन पर शोधकर्ताओं के बीच मतभेद और भ्रम मौजूद है। संपूर्ण माइटोकॉन्ड्रियल डीएनए जीनोम अनुक्रमों पर किए गए अध्यन में अधिकतम संभाव्यता और बेसियन फाइलोजेनेटिक निष्कर्ष से *पीनियस सेंसु लेटो* में मोनोफाइली सूचित हुआ। इसके अतिरिक्त, औसत अमीनो एसिड पहचान (एएआई) के अनुमान में भी *पीनियस सेंसु लेटो* के मोनोफाइली की सूचना मिली है।

मछली में लिंग विभेद

एंटी-मुलेरियन हार्मोन (*एएमएच*) की अभिव्यक्ति से *ग्रे मुलेट, मुगिल सेफालस* और *रेड स्नैपर लुटजानुस अरजेंटिमैकुलैटस* में एक नर विशिष्ट अभिव्यक्ति का संकेत मिला कि मछली में सेक्स विभेद मार्कर के रूप में *एएमएच* के उपयोग की संभावना है।

पर्लस्पॉट, ऑरेंज क्रोमाइड और ग्रे मुलेट के समष्टि आनुवंशिक स्टॉक

वाणिज्यिक रूप से महत्वपूर्ण खारा जल पखमीन में माइटोकॉन्ड्रियल एटीफेज 6/8 के उपयोग से विश्लेषण के आधार पर समष्टि विविधता की जांच की गई। परीक्षित *इट्रोप्लस सुराटेंसेस* के लगभग सभी स्टॉकों में उल्लेखनीय आनुवंशिक विविधता

देखी गई परंतु दूरी से अलगाव गैर-उल्लेखनीय था। *इट्रोप्लस मैकुलाटस* के वेंबानाड और पुलिकेट सम्पदाओं के बीच महत्वपूर्ण आनुवंशिक विचलन देखा गया। *मुगिल सेफालस* में, परिणामों ने भारतीय तट में दो अलग-अलग आनुवंशिक सम्पदाओं अर्थात एक ओडिशा और केरल के बीच और दूसरा (गोवा और गुजरात) के बीच मौजूद होने का संकेत दिया है।

पर्लस्पॉट फुल-सिब फैमिली का वृद्धि निष्पादन

दर्ज किए गए दो पर्लस्पॉट (*इट्रोप्लस सुरार्टेसेस*) फुल-सिब कुलों के वृद्धि निष्पादन में दोनों कुलों की मछलियों में शरीर की कुल लंबाई की तुलना में शारीरिक भार में विविधता के उच्च गुणांक (सीवी) हैं।

भारतीय तटीय क्षेत्र में माइक्रोसेटेलाइट मार्करों के उपयोग से भारतीय सफेद झींगों के संपूर्ण समष्टि की आनुवंशिक संरचना

भारतीय तटीय क्षेत्र में *पी. इंडिकस* में 7 लोसी माइक्रोसैटेलाइट डाटा की तुलना से ज्ञात हुआ है कि चेन्नई और क्विलोन की सम्पदा में अन्य सम्पदाओं से काफी भिन्नता है। यह जानकारी संरक्षण और स्टॉक विशिष्ट चयनित प्रजनन कार्यक्रमों में सहायक होगी।

भारतीय प्राकृतिक जल में जावानीस राइसफ़िश, *ओरीज़ियास जवानिकस* (ब्लीकर, 1854) (बेलोनिफ़ॉर्मस: एड्रियनिचथइडे) की पहली सूचना

भारतीय प्रायद्वीप के प्राकृतिक जल में *ओ. जवानिकस* के पहली बार फैलाव से भारत में *ओरिज़ियास* प्रजातियों की संख्या पांच होने की पुष्टि हुई है। पृष्ठीय और पुच्छीय पख के उदरीय भाग के किनारों पर पीले उप-सीमांत बैंड की मौजूदगी, इसे अन्य भारतीय प्रजातियों अलग पहचान देती है। भारत और इंडोनेशिया में मौजूद समष्टि के बीच न्यूक्लियोटाइड आनुवंशिक दूरी अविवेच्य (इनडिस्टिंकगिशेबल) पाई गई।

इट्रोप्लस सुरार्टेसिस की वृद्धि में सुधार के लिए CRISPR-Cas9 मध्यस्तता वाले जिनोम इंजीनियरिंग

लक्षित जिनोम एडिटिंग के लिए एक सशक्त टूल CRISPR-Cas9 के उपयोग से इट्रोप्लस सुरार्टेसिस में मयोस्टेटिन जीन को भंग करने हेतु प्रयोग किए गए। निषेचित अंडों में CRISPR/Cas9 प्रोटीन का मैक्रो इनजेक्शन लगाया गया और भ्रूण विकास को प्रलेखित किया गया।

EXECUTIVE SUMMARY

The current year, 2018-19 was an important and productive year for CIBA. The institute has been pursuing research and development for the development of sustainable brackishwater aquaculture. With twenty-nine in-house and external funded research grants, and with several out-reach activities, CIBA has contributed remarkably towards the development of science of brackishwater aquaculture. As a research and development organization, the success and effectiveness of the organization have been measured by the outputs of scientists/researchers. The current year, the scientists from CIBA has published 39 peer –reviewed research articles in the various reputed national and international journals. Further, thirty-one commercial agreement has been signed with the stakeholders during the current year. The institute maintained the quality of the research and it is evidenced by winning the most prestigious ICAR team award, Nanaji Deshmukh ICAR Award for outstanding interdisciplinary team by the Fish nutrition division of CIBA. Further, Dr M. Kumaran, Principal Scientist of CIBA obtained Swami Sahajanand Saraswati Outstanding Extension Scientist Award. Some of the highlights of research and development accomplished by the institute during the last year are presented below.

Development of pond reared Indian white shrimp stock

Shrimp farming in India, which is almost exclusively based on exotic *Penaeus vannamei*, is at a cross road due to the emerging disease, reduced survival, increase in the cost of production and recent falls in the prices. At this context, development of a native species is a viable option to ensure sustainability of shrimp farming. Indian white shrimp, *P. indicus*, has been identified as suitable candidate species for domestication and genetic improvement. Experimental trials have been carried out to develop captive/pond reared broodstock of *P. indicus*, which is the primary requirement of any selection program. Hatchery reared post larvae of P. indicus were grown to broodstock size (25-35 g) in earthen pond, These F0 generation were successfully bred under captivity, and F1 generation offspring were are being further reared.

Polyculture of Indian white shrimp (*Penaeus indicus*) and milkfish (*Chanos chanos*)

Polyculture of shrimp has been proved to be viable alternative to reduce the nutrient waste from the aquaculture facilities and to optimize the economy shrimp farming. In order to evaluate the production performance of polyculture of *P. indicus* (stocking density: 25 PL/m^2) and *C. chanos* (0.25 no/m^2 and 0.5 no/m^2), a 75 day culture experiment was carried out. Highest survival (79.33± 1.88 %) and production (1451.28± 22.15 kg/ha) of shrimp was recorded in the pond which *P. indicus* reared with milkfish at a stocking density of 0.5 ind. /m^2, although significantly higher average body weight obtained at the pond stocked with milkfish at a stocking density of 0.25 m^2.

Bio-floc based nursery rearing technology for *Penaeus vannamei*

Bio-floc technology has been an emerging alternative towards the environmental friendly aquaculture. This technology is characterized by reduced water exchange, reduced feed use and improved biosecurity. *Penaeus vannamei* PL were reared at a stocking

density3500 PL/m^2 in 350 mt capacity nursery tank designed by the institute for a period of 28 days. Nursery reared animals were grown up to 0.92 ± 0.15 g with a survival of 94.20± 2.86 %)

Evaluation of Aqua-mimicry technology on growth performances, water quality and immune responses in RAS environment

A RAS based nursery rearing was carried out with addition of carbon source and rotifer as feed supplement. The survival and growth was monitored every 15 days in each treatment. The treatments included as C: control, T1: only Biofloc, T2: Biofloc and rotifer, T3: only Rotifer. At the end of Experiment the rotifer with biofloc condition showed better growth (3.89±0.25) and survival (91%) which is significantly different from control animals (3.24±0.29, 85%).

Growth performance and osmolarity of Indian white shrimp juveniles reared at different salinity

A 50-day experiment was carried out to study the growth performance, water quality, osmolarity and serum mineral profiles of *P. indicus* juveniles (0.4-0.5g) reared at different salinity. Osmolarity study reveals serum osmolarity changes proportionately with ambient water salinity

Nursery rearing of *Penaeus indicus* in the estuarine ecosystem as a livelihood activity:

A nursery rearing model for Indian white shrimp, *Penaeus indicus*, has been demonstrated for self-help groups at Uyallikuppam village (Palar backwaters) near Kalpakkam (Tamil Nadu). *Penaeus indicus* (n=400) of 1.5g size were separately stocked in 4 hapas (2 m x 1m size) and reared for sixty days. On an average of 8.50 g size of *P. indicus* were obtained with 90% survival

Development of submersible cage system for mud crab grow out production:

Mud crabs are benthic organisms, and therefore, pelagic/floating cages adversely affect the physiology of these animals owing to the relatively higher surface and sub surface temperature. In order to circumvent the issues of subsurface/floating cages, easy-to-manage submersible cages have been developed, and evaluated the culture performance with reference to the floating cages. Average weight gain was >100 g in submersible system whereas it is significantly less in floating system (<15 g) indicating that submersible system outperforms traditional floating system. It could be concluded that implementation of submersible cum floating crab culture system provide higher growth compared to conventional one for crab fattening.

Open water cage aquaculture in mangrove regions of Maharashtra

In collaboration with Mangrove cell, Maharashtra CIBA initiated three-tier seabass farming involving in and around of mangrove coastal waters in Sindhudurg, Maharashtra with participation of self-help groups. (SHGs). Around six nurseries, a pre-grow-out and 33 grow-out cage cultures with the participation of SHGs have been formed. The SHGs have generated a total revenue of Rs. 3.16 lakhs through seabass nursery and pre grow out rearing work. From the grow out farming it is expected to grow 400-500g with an estimated total revenue generation of 10-12 lakhs.

Integrated Multi-trophic Aquaculture (IMTA) of Seabass and Green Mussels

To develop and propagate family farming models of candidate finfish and shellfish species in the west coast of India, initiated IMTA cage culture in Gad creek of Malvan, Sindhudurg. At present seabass have grown to size 400 g from the stocking size of 60 g with survival ranging from 79.30-90.03%. Harvest of 400-500g seabass is expected in mid-June 2019 with estimated total revenue generation of 2-2.5 lakhs.

Juvenile milkfish as ornamental "Silverfish"

Milky white glittering, shining body, agility, semi-transparent V-shaped caudal fin, swifte movement pattern, wide salinity tolerance, voracious gracing on tank algae and disease resistance qualifies milkfish juveniles as a potential ornamental fish called "Silverfish". Being a highly compatible fish with other ornamental tankmates, were sold @Rs. 50/- /10 pair.

Milkfish farming in West Bengal as Decan Hilsa

Considering demand and preference of milkfish by local Bengalis, CIBA took efforts to popularize milkfish

as 'Decan Hilsa' in West Bengal. By farming in four different culture systems, 1.3 ton of milkfish was harvested and well accepted by the Bengalis by the name Decan Hilsa.

Farm inputs usage pattern in Indian shrimp culture

A survey was conducted during 2017 to understand the input usage pattern in the shrimp producing states, Andhra Pradesh, Tamil Nadu, Gujarat and Maharashtra. The study showed use of environmental modifiers being used highest quantity to improve soil and water quality, followed by probiotics (water, soil and gut probiotics) and disinfectants. No record of use of anti-microbial product was observed during the study.

Growout farming of Hilsa in ponds

Hilsa has good market potential in West Bengal, and there is a huge demand for table size hilsa. Two months old fingerlings were further reared in two different system viz. earthen pond and RAS using pelleted feed. After 11 months fishes reached around 80 g size, and the performance was better in ponds.

Wide salinity tolerance of streaked rabbit fish, *Siganus javus*

Streaked spine foot Rabbit fish, *Siganus javus* considered as important food fishes because of their fast growth rates, herbivorous food habits, and economic value. An experiment was carried out for 30 days to know their salinity tolerance levels. This experiment for the first time documented the wide salinity tolerance of *Siganus javus*, a potential herbivorous food fish for brackishwater farming

Male reproductive quality of *Penaeus indicus*

Spermatophore and sperm quality of penaeid shrimp often determine the success of seed production, particularly under captive condition. It is reported that reproductive tract development and spermatophores generation are generally compromised under captive condition. In order to evaluate the underlying principle of the process of reproductive development male shrimp reared in tanks and ponds were evaluated, and compared with wild caught shrimp. Sperm count was found to be significantly lower at the pond reared and tank reared animals compared to the wild caught shrimps.

Effect of short term chilled storage on the spermatophores quality of *Penaeus indicus*

Storage of male gametes would eliminate the need to keep breeders for artificial fertilization. In order to evaluate the effect of chilled storage on quality of male gamets, spermatophores were refrigerated at 4 °C and sperm quality was evaluated at different intervals. Number of normal sperms was significantly higher in the first day of sampling than the fifth day of sampling. Acrosome reaction was also observed in the stored spermatophores at five days of preservation. Beyond five days, the sperm cells were disintegrating and viability was also not observed. This study proves the applicability of chilled storage as a preservation method for spermatophores

In-vitro fertilization and hybridization potential of Indian white shrimp, *Penaeus indicus*

Procedure for *in vitro*-fertilization of penaeid shrimp was successfully developed. Successful intra specific fertilization of *P. indicus* was achieved with a hatching rate of 4.8%, and 29% of nauplii developed into post larvae.

Effect of various feeding regimes on the physiological characteristics of captive *Penaeus indicus* broodstock

This study was carried out to evaluate the effect of different levels of maturation diet (5%, 15% and 25% of body weight per day) and captive rearing on physiological changes such as growth, molting rhythms and maturation hormone levels of captive *P. indicus* broodstock. Molting frequency was found to be higher at treatment group fed at 15% of body weight. Further, after 45 days of captive rearing, this treatment group had the minimum GIH mRNA level.

Seabass seed production accomplished newer heights

CIBA being a pioneer in captive breeding and seed production of seabass, recently standardised the protocols for natural spawning in captive condition. Out of 5.53 million eggs spawned in the last year, 2.66

million eggs spawned spontaneously and 2.87 million from induced spawning. An all-time high of 0.59 million fry seeds were sold in the year 2018-19 and a revenue of Rs. 1.72 million was realized. Additionally, 1.20 lakhs seeds were completely weaned for artificial feed and sent to Maharashtra.

Breeding performance of two different geographical stocks of milkfish (*Chanos chanos*)

While comparing the reproductive performance of milkfish from different geographically isolated stocks of east coast, Chennai stocks showed better performance with extended period of spawning. Both the stocks showed multiple spawning, and exposed the scope for year-round breeding of milkfish in captivity.

A good progress in captive breeding of grey mullet using farm reared parental stocks

In 2017 mullet spawned and eggs got fertilized for the first time, but the larvae survived only for eight days. In 2018, due to intensive efforts lead to resulted in mass larval production 0.75 million. The larvae survived up to 28 days. Further optimizations on larval rearing is in progress.

Maturation of *Liza parsia* reared in pond conditions

A study attempted with 300 number of *Liza parsia* (Goldspot mullet) for the reproductive maturation evidenced the ease of captive maturation with optimum water conditions and feed. Oocytes having less than 100 µm in diameter are non-vitellogenic in nature and, attained the maximum GSI and oocytes diameter of 606.55±17.02 and 18.31±2.0, respectively in captive condition. This observation evident that broodstocks of Liza parsia could be easily developed in pond conditions.

A good progress in captive maturation of mangrove snapper

Targeting the technology on captive breeding of mangrove snapper, a total of 90 adult fishes are being maintained in broodstock holding systems. Oozing males were observed in during June to October 2018 and February to March 2019, indicating 8-21% male stocks were attained maturity. However, female maturation has not been achieved and indications are there for oocyte development.

Induced maturation and spawning of spotted scat in RAS based homestead fish breeding model

For simplification breeding in spotted scat, a RAS of 3000 L capacity and 12.9 m3/day flow rate with central drainage was fabricated and experimented. Adult scats were induced with varying level of and combinations of hormones. Female fishes were induced successfully with LHRHa 25 µg/kg/month, whereas combined dose of LHRHa + 17-αMT @ 25 + 25 µg/kg/ month was helpful to increase sperm density in males. These optimized doses would be useful for attaining spawning and larval production under RAS based homestead models.

Captive breeding of Silver moony, *Monodactylus argenteus*

Captive breeding and seed production of this potential brackishwater ornamental fish was achieved using hormonal induction. The diameter of the egg was 860 ± 14.11 µm, hatched out in 18 h, and the hatching percentage was 90%. Newly hatched larvae were 1.60-1.67 mm. This will pave way for mass production and transition in use of wild caught to captive bred fish for export.

WSSV, EHP and IMNV are major threats to Indian shrimp farming

Active disease surveillance of shrimp farms during 2015-19 suggests that white spot syndrome virus (WSSV) and *Enterocytozoon hepatopenaei* (EHP) are the predominant pathogens affecting two major shrimp farming states AP and TN. The prevalence of WSSV ranged between 11-40% and EHP between 21-43%. The infectious myonecrosis virus (IMNV) has emerged as another major challenge with prevalence rate of 15% during 2018-19.

Polychaete worms can transmit *Enterocytozoon hepatopeanei* to shrimp

CIBA studies revealed that the polychaete worms (*Marphysa* spp.) serve as carrier for shrimp pathogens such as WSSV and EHP. The EHP is horizontally transmitted from infected shrimp to polychaetes

and *vice versa*. However, no evidence of vertical transmission was recorded in different developmental stages of polychaetes.

EHP spores remain infectious for more than a year in seawater at room temperature

The EHP spores were found to retain infectivity for a period of over 1 year in seawater at room temperature. The activity at such storage condition was lost only after 1 ½ years. However, spores stored at 4°C, -20°C and -80°C showed dramatic decrease with complete loss of spore viability and infectivity after one month.

Germination of EHP spores could be experimentally induced

Germination of EHP spores was induced by using dyes such as potassium hydroxide and phloxine. The entire event of germination takes place in fewer than two seconds. The germinating spores infect the nearby potential host cell by striking the cell and piercing its membrane.

Mass mortality of farmed mud crab, *Scylla serrata* in Andhra Pradesh

Mass mortality of mud crab *Scylla serrata* culture was observed in Nagayalanka, Krishna district, Andhra Pradesh in 2018. Diseased crab samples were positive for white spot syndrome virus (WSSV). They were also heavily infested with metazoan crustacean parasite, stalked barnacle, *Octolasmis* spp. The haemolymph of infected crab showed increased total plate count and total Vibrio count compared to that of healthy ponds.

Tilapia lake virus (TiLV) can be transmitted to seabass

During disease Surveillance of sea bass farms co-cultured with tilapia, seabass experienced chronic mortalities associated with haemorrhagic encephalitis were found to be affected with TiLV. Challenge experiment conducted to test the inter species transmission of TiLV from infected tilapia to seabass showed successful transmission of TiLV to seabass with high cumulative mortalities.

Prevalence of parasitic infections in brackishwater finfishes

Profiling of parasitic diseases during 2016-19 in brackishwater candidate fish species and crab suggested the presence of six major parasites such as *Argulus, Caligus, Lernanthropus, Zeylanicobdella, Anisakis* and *Octolasmis*. However, no parasitic infections were recorded in in mullets and milkfish.

Microbial profiling of Zoea syndrome

Metagenomic study was conducted to figure out the etiology of the zoea-2 syndrome. Overall a total of 46 genera were seen specific to healthy, 328 specific to diseased and 371 genera common in both. Some of the genera were more abundant in zoea-2 syndrome affted samples are Devosia, Unclassified Rhodobacteraceae, Nonlabens, Muricauda, Unclassified Flavobacteriales, and Pseudoalteromonas.

Microbial profiling of CIBAMOX

The 16s rDNA based metagenomic microbial profiling revealed several novel bacteria involved in nitrogen metabolism. Bacterial group belonging to Caldilineaceae family were also dominant in ammonia oxidation besides *Nitrosomonas* and *Nitrobacter.* A large percentage of microbes identified in the AOB and NOB enrichments belonged to the phylum *Proteobacteria*.

Characterization of quorum sensing system in *Vibrio harveyi* clade

To understand the virulence, quorum sensing system was characterised in sixty genomes of *Vibrio harveyi* clade. The autoinducer 2 synthesizing *luxS* gene was present in all the isolates of *V. harveyi* clade. However, autoinducer 1 synthesizing gene *luxM* was present in *V. harveyi, V. campbellii, V. jasicida* and *V. ovensiii* but absent in *V. natriegens* and *V. rotiferianus*.

Rapid detection technique to differentiate viable and dead EHP spore

A staining technique to assess the viability of EHP spores was developed. The viable spores stained by Calcofluor White appeared as turquoise-blue through

the violet filter (395-415 nm). The dead spores stained by Sytox Green appeared as yellow-green oval bodies through the blue excitation filter (470-490 nm) and white-yellow through violet filter (395-415 nm).

Development of real time PCR assay for detection of iridovirus infection in fish

SYBR Green based real time PCR assay was developed for detection of Iridovirus with detection limit of 10 viral particles. A membrane cofactor protein gene based PCR was also standardised for detection of iridovirus.

Maternal transmission of WSSV in wild *Penaeus indicus* spawners:

Vertical transmission of WSSV, directly through gametes, has yet to be proved. In order to test this hypothesis, reproductive tissues of WSSV infected females were diagnosed for WSSV through qRT PCR, and found that reproductive tissues had only 50 to 60 copies of WSSV, and only 36% of reproductive tissues of infected females showed the presence of WSSV. However, in situ hybridization studies did not reveal positive signal for WSSV.

Isolation and characterization of gut microbes:

The Biofloc system is found to be advantageous and allows colonizing beneficial bacterial population in the gut region. Out of 94 strains screened, 36 strains were found to produce amylase enzyme, 20 strains protease, 27 strains lipase and 6 strains cellulase and 8 strains xylanase. Totally 21 isolates selected for further identification and different species of *Cobetia, Exiguobacterium, Bacillus, Marinilactibacillus, Staphyllococcus* and *Novosphingobium* genera from biofloc treatments were identified. In control strains of Bacillus and Exiguobacterium only observed. Among all, the genus Exiguobacterium identified in all treatments and control.

Application of brown seaweed extract as growth promotor for shrimp

Brown seaweed (*Ascophyllum nodosum*) extract was used as growth promoter for shrimp juvenile. The shrimp fed with the micro algal preparation registered 20% higher growth at three-fold dilution. However, higher concentration of seaweed extract had negative effect on growth and survival.

Feed supplemented with lactic acid bacteria improve growth and survival of *P. vannamei*

A feeding trial was conducted on *P. vannamei* with feed supplemented with two isolates of lactic acid bacteria (LAB) viz., *Lactococcus lactis* subsp. *lactis* SDKRC-5 and Lactobacillus isolate (SDKRC-6). After 63 days of feeding trial, the LAB supplemented group recorded 14% higher growth and 10% enhanced survival over the control.

Emamectin benzoate effective against crustacean parasitic infestation in Asian Seabass

A therapeutic trial with emamectin benzoate (EB) against *Caligus minimus* infestation in Asian seabass provided 92% improvement in survival and reduction in parasitic load after fifth day of treatment. No parasite could be recovered after 7th day of treatment, suggesting that EB could be employed in controlling parasitic infestations in finfish.

Influence of pH on oxytetracycline (OTC) degradation under varying salinities

A study on influence of pH and salinity on OTC degradation in seawater was carried out. The degradation of OTC was faster at lower pH compared to higher pH irrespective of the salinity.

Withdrawal of chloramphenicol in shrimp muscle tissue

Withdrawal period of chloramphenicol in *Penaeus vannamei* was studied by feeding commercially available feed coated with chloramphenicol at 500 mg kg-1 feed for 7 days. Post cessation of chloramphenicol feeding, the concentration in the muscle tissues dropped drastically within two days (0.64±0.08 ppm) with complete elimination of residue by 20 days.

Release of diagnostic, preventive and therapeutic technology for aquatic diseases Aquatic Animal Health division of CIBA released several technologies related to diagnostics (Improved WSSV real time PCR kit and EHP real time PCR kit), preventive (CIBAMOX – water probiotic) and therapeutic (Lumiphage – for control of Vibrios). The Improved WSSV real time PCR kit and EHP real time PCR kit was commercialized to Coastra Biosolutions Pvt. Ltd., Chennai and CIBAMOX to Tata

Rallis (India) Ltd, Mumbai. For further, improvement of Lumiphage technology, an MOU was signed in association with IIT-M and TATA Rallies India Ltd.

National Referral Laboratory for Brackishwater Aquatic Animal Diseases

Aquatic Animal Health and Environment Division of CIBA is serving as National Referral Laboratory for brackishwater aquatic animal diseases. As part of Aquatic Quarantine and Certification Services (AQCS), a total of 63 samples including imported *Artemia* cyst, frozen tissue and feed samples were tested during 2018-19 for OIE listed shrimp and fish pathogens. All the samples were tested negative for OIE listed pathogens.

Commercialization of water analysis kit

A multi-parameter portable water analysis kit for dissolved oxygen, ammonia (0.1 to 2 ppm), nitrite (0.05 to 1 ppm), calcium & magnesium minerals, total hardness, carbonate, bicarbonate and total alkalinity in different source and pond waters of varying salinity has been developed and commercialised to New Bio Science Company, Mysore.

Aquaculture planning web tool

CarryCap – An online aquaculture planning web tool for the estimation of carrying capacity of water bodies was developed and being used for the aqua zonation work by AP State Govt. for optimization of aquaculture development and to avoid conflicts among resource users.

Soil water health cards and Location Specific BMPs

About 55 Soil water and health cards were distributed to aqua farmers of Chidambaram and Nagapattinam Districts, TN. The SWHCs database has been analysed to capture the geographical variation which helps in framing Location Specific BMPs.

Nutrient dynamics under different culture practices

Study on *P. vannamei* culture under simulated earthen and lined tanks under 25 ppt salinity with zero water exchange showed that water quality is comparatively better in lined ponds especially redox potential and metabolites were low in the lined ponds. However, the growth rate was 21% high in earthen ponds.

Adaptation of *P. vannamei* under a sudden change in climate

Study on the adaptability of *P. vannamei* under the sudden decrease of salinity from 25 to 5 ppt revealed that although the water osmolality varied drastically, serum osmolality varied within a short range of 510-687 mOsmol/kg at 5 hrs and still the range reduced and stabilized (639-665 mOsmol/kg) at 24 hrs. It shows that *P. vannamei* is able to adapt quickly to changes in salinity due to its osmoregulatory capacity

Effect of clay polymer adsorbent on growth and nitrogen metabolite concentration in *P. vannamei* culture

Application of clay polymer composite @ 2.5g/ 100 litre at weekly interval to *P. vannamei* culture reduced the TAN by 88.3 and 78.9 percent during the first week and it reduced to 45.1 and 43.2 percent in the last week at lower (60 and 90 no/m^2) and higher stocking density (90 no/m^2), respectively.

Effect of oxygen releasing compound on water quality

Application of developed oxygen releasing product at 3, 4 and 5 kg/ha enhanced the dissolved oxygen level to 7.5, 9.2 and 12.1 ppm, respectively and reduced the total ammonia nitrogen to 0.025 from 0.125 ppm after 2 hrs of application. Based on the DO levels and other water quality products, the optimum dose was found to be 3 kg/ha.

Assessment of suitable sites for inland saline aquaculture in Punjab and Haryana

The salinity, pH, hardness and alkalinity of inland saline waters from selected districts of Punjab and Haryana ranged from 2-20 ppt, 7.2 to 8.3, 540-6570 ppm and 126-601 ppm respectively. The source waters are rich in calcium but deficient in magnesium and potassium warranted for mineral supplementation. The water-soluble and exchangeable potassium of inland saline soils of Rajasthan varied between 15 to 223 kg/ha and 27 to 814 kg/ha.

Mycotic bioremediation of total ammonia nitrogen in varying water salinity

In vitro studies were conducted on mycotic bioremediation of total ammonia nitrogen (1 and 2 mg l-1) using the *Pleurotus species* in different salinities of

1, 15, 30 and 45 ppt. Total ammonia nitrogen showed a reduction of more than 80% in 1, 15 and 30 ppt and less than 80% in 45 ppt within 72 hrs.

Carbon dynamics in relation to other nutrients in shrimp aquaculture

The variation in carbon concentration along with other nutrients like nitrogen and phosphorus in pond sediments under varying in salinities were studied. The organic carbon and available nitrogen content were found to decrease with salinity, whereas available phosphorus content was observed to follow the reverse trend. The water-soluble carbon was found to increase with salinity, varying from 1.4 mg/kg to 2.5 mg/kg: WSC 45> WSC 25> WSC11> WSC 6

Role of rearing temperature on WSSV outbreak in shrimp

Shrimp in room temperature of 30° C and 32°C experienced 100% mortality within 6 days post challenge and the dead/moribund shrimps tested 1st step positive by PCR. The shrimps reared at 34 and 35°C experienced 0% and 7% mortality respectively and both were 2nd step positive. The study confirms the role of temperature on WSSV infectivity and mass mortality.

GHG emission in aquaculture ponds

P. vannamei culture pond soils during the fallow period after the first and second months of harvest exhibited more GHGs emission, particularly CO_2. Drying practice followed by liming contributed more to global warming potential. During the culture, the inclusion of 40% Fermented soybean meal and Bacillus strains at the dose of 10^6 CFU/ml as dietary and microbial interventions mitigated the emission of N_2O compared to CO_2 and CH_4.

A novel method of converting fish waste to plankton booster, Plankton*Plus*

An effort was put by CIBA for cleaning the fish market to diminish sanitary problems due to fish waste through its transformation into products, branded as Plankton*Plus* having protein content of 47-49% and lipid of 20-22%, which can be used for boosting plankton in aquaculture pond or as ingredients for feed formulation and also as manure for agriculture/horticulture.

Effect of Plankton*Plus* application on plankton status and growth performance of shrimp/fish

Plankton*Plus* supplementation @20 ppm with split application significantly (P<0.01) increased the average daily gain, specific growth rate, total biomass gain and survival of *P. vannamei* even when 30 % less feed was offered. Whereas, Plankton*Plus* supplementation at the same dose can save 50 % of feed without affecting growth performance and survival of *Chanos chanos*. Plankton*Plus* supplementation helped to increase the density of beneficial microalgae like Bacillariophyceae, Prasinophyceae, and Dinophyceae, etc. and zooplankton.

Live feed enrichment

Plankton *Plus* supplementation can improve artemia biomass production and reduce the usage of algae by 50 % for artemia culture. Thraustochytrids, unicellular monocentric fungi-like protists, rich in PUFA can be used for enriching artemia being used for larval rearing of finfish and shellfish.

Evaluation of newer feed ingredients and feed additives for use in aquafeeds

Weevil infested sweet potato, yeast fermented groundnut cake, *Leucaena leucocephala* leaf meal can be incorporated 5 to 10% in shrimp and fish diet. Seaweed, *Gracilaria* tenuistipitata was found to have the potential to be used as a natural binder in shrimp diet. The study revealed that C-Phycocyanin extracted from spirulina can be incorporated @750 to 1000 ppm in the shrimp feed formulations for boosting growth and immunity. Study also revealed that 0.4 % of krill oil might be incorporated in the diet of *Penaeus vannamei* juveniles for getting better growth and survival.

Demonstration of feed and novel products developed by CIBA

There was a significant increase (12.31%) in survival, and enhancement of *P. vannamei* yield to the tune of 1.71 t/ha in pond supplemented with Plankton *Plus* compared to control. Enhanced growth performance of *Penaeus* vannamei might be due to the augmented density and diversity of phytoplankton (Bacillariophyceae, Prasinophyceae, and Dinophyceae,

etc.) and zooplankton in the Plankton^{Plus} supplemented ponds. Demonstration of crab (*Scylla serrata*) culture in open water cages revealed that total biomass harvested was higher (7.27 kg) in bottom cages fed pellet feed. Crab (*Scylla olivacea*) culture in box with formulated feed showed similar ovary weight gain and gonadosomatic index when compared with low- cost fish.

Effect of various feeding regimes on the physiological characteristics of captive *Penaeus indicus* broodstock:

This study was carried out to evaluate the effect of different levels of maturation diet (5%, 15% and 25% of body weight per day) and captive rearing on physiological changes such as growth, molting rhythms and maturation hormone levels of captive *P. indicus* broodstock. Molting frequency was found to be higher at treatment group fed at 15% of body weight. Further, after 45 days of captive rearing, this treatment group had the minimum GIH mRNA level.

Optimization of nutrient requirements and feed development

For the development of milkfish larval feed, the requirement of taurine and Vit E (α-tocopheryl acetate) were optimized and were found to be 1 % and 196–218 ppm of feed, respectively. Larval feed developed for Asian seabass (Seebass Larvi ^{plus}) showed higher growth performance while compared with commercial feed available for larval rearing of seabass.

For the development of broodstock diet of hilsa, mobilization of fatty acids in hilsa during different stages of maturity has been studied. It was found that even though arachidonic acid (C20:4) is the least mobilized fatty acid from the muscle, it is the highest retained (96%) in the ovary whereas the palmitoleic acid (C16:1) is the highest mobilized fatty acid, but its retention in the ovary is the lowest (22.7%).

Feed management options

Effect of delayed initial feeding on growth and survival of milkfish, *Chanos chanos* larvae has revealed that the feeding of milkfish larvae must be initiated at 24 h post-hatching for getting better growth and survival. Study on shrimp culture in Aqua mimicry system revealed that natural feeds concentration available in the system could help only to realize a good growth performance in lower stocking densities. The shrimp which had access to biofloc & feed had a maximum final weight (19.58g) and survival (>90%) compared to the shrimp (4.19g) which had access to the only biofloc generated by using ground rice bran as organic carbon source.

miRNAs expression profiling during WSSV infection

In recent years, the importance of viral and host microRNAs (miRNA) in mediating viral replication and control of host cellular machinery, has been realized and increasing efforts have been taken in order to understand the interactions of miRNAs from host and pathogen during infection. small RNA sequencing was performed to identify the miRNAs involved in shrimp (*Penaeus vannamei*) immune responses under WSSV infection condition. The expression profiles of miRNAs of shrimp infected with WSSV under two contrasting conditions of field outbreak and controlled experimental conditions were compared and as a result, 23365 known miRNAs and 481 novel miRNAs were identified. Our study, therefore, provides the comparative analysis of miRNA expression from shrimp during WSSV infection in two different conditions.

Contig-level assembly of *Penaeus indicus* genome with long-reads

PacBio sequence data was generated on pacific biosciences sequel platform. The 20 Kb sequencing libraries were used for sequencing where inserts over 17 Kb size were retained based on BluePippin size selection. About 20,857,430 reads of 176,539,267,324 bases length of sequence data which is equivalent to 71X coverage of genome was used for building contig-level genome with assemblers Falcon, Canu and WTDBG2. Generation of optical map and HiC data, scaffolding and chromosome linking are in progress.

dbVAST: database of variations associated with shrimp transcripts

In order to promote the search and use of potential genomic resources that could augment culture production, a database of variations associated with

shrimp transcripts was created. The single nucleotide polymorphisms (SNPs) in coding sequences of three shrimp species, *Penaeus vannamei, Penaeus indicus* and *Penaeus aztecus* were documented and presented for browsing as a user-friendly on-line tool.

MRF: Missing Region Finder

The uniqueness of white spot syndrome virus (WSSV) genome, not exhibiting similarity to any other pathogen, has severely limited its annotation. A web tool named Missing Region Finder (MRF) was developed to gain insights in to WSSV genome. MRF compares the query genome against a reference genome to find deleted genome regions in query and tabulate the CDS in these deleted regions as per the annotations of reference genome. Thus, findings of comparative genome analysis in the annotation nomenclature of a single reference would be easily comprehensible. Such a tool has potential to sort the nomenclature issue concerning WSSV genomes, as users can compare several genomes against a single reference genome.

Phylogenomics of shrimp in suborder, Dendrobranchiata

Controversy and confusion exists among researchers on the taxonomic revision in Genus *Penaeus sensu* lato. The maximum likelihood and Bayesian phylogenetic inferences conducted on complete mitochondrial DNA genome sequences indicated monophyly of *Penaeus sensu* lato. Further, the average amino acid identity (AAI) estimates also suggested monophyly of Penaeus sensu lato.

Sex discrimination in fish

The expression of anti-mullerian hormone (*amh*) indicated a male specific expression in grey mullet, *Mugil cephalus* and red snapper, *Lutjanus argentimaculatus* suggesting the possibility of using *amh* as sex discrimination marker in fish.

Population genetic stocks of pearlspot, orange chromide and grey mullet

The population diversity in commercially important brackishwater finfish were examined based on the analysis using mitochondrial ATPase 6/8. Significant genetic difference was observed among all the stocks of *Etroplus suratensis* examined, but isolation by distance was non-significant. Significant genetic divergence was observed between the Vembanad and Pulicat stocks of *Etroplus maculatus*. In *Mugil cephalus,* the results indicated the presence of two distinct genetic stocks along the Indian coast, one between Odisha and Kerala and the other between (Goa and Gujarat).

Growth performance of Pearlspot full-sib families

Growth performance of two pearlspot (*Etroplus suratensis*) full-sib families recorded indicated higher coefficient of variation (CV) for body weight than the total body length in both the families.

Population genetic structure of Indian white shrimp across Indian coast using microsatellite markers

Comparison of 7 loci microsatellite data in *P. indicus* along Indian coast revealed that the Chennai and Quilon stocks differed significantly from other stocks. This information would be helpful in conservation and stock specific selective breeding programmes.

First record of the Javanese ricefish, *Oryzias javanicus* (Bleeker, 1854) (Beloniformes: Adrianichthyidae) in the natural waters of India

The distribution of *O. javanicus* in the natural waters of the Indian peninsula was confirmed for the first time bringing the number of *Oryzias* species recorded from India to five. The presence of yellowish sub-marginal bands on the dorsal and ventral sides of the caudal fin makes it easily distinguishable from other Indian species. The nucleotide genetic distance between the populations occurring in India and Indonesia was found to be indistinguishable.

CRISPR-Cas9 mediated genome engineering for growth improvement of *Etroplus suratensis*

Experiments were conducted to disrupt the myostatin gene in *Etroplus suratensis* using CRISPR/Cas9, a powerful tool for targeted genome editing. Fertilized eggs were microinjected with CRISPR/Cas9 protein and the embryonic development was documented.

Vanami Shrimpapp

Vanami Shrimpapp - the first interactive mobile app for shrimp aquaculture in India. As on March 2019, more than 15500 downloads across the world with 4.5/5.0 review rating. It is extensively used by the shrimp farmers and fishery extension workers in India and elsewhere. Farmers can post their queries and receive counseling within 48 hours. The Bengali version of shrimp app called "Chingri app" was developed under the International collaborative DBT project.

Publication of AquaStat India 2018

Publication of AquaStat India 2018, a comprehensive database of aquaculture and the same will be regularly updated. Further, the online version of the same will also be created. The Database includes aquaculture resources, production, trade and consumption database for World, India & various states of India.

Techno-economic viability of three-tier cage farming of Asian Seabass

Techno-economic viability of three-tier cage farming of Asian Seabass fish in open brackishwater bodies indicated that the technology is technically feasible and economically viable for fishers groups. Through this technology, each member of the group obtained a monthly income of Rs.8000, Rs.4900 and Rs.8500 per cycle of production respectively in nursery rearing, pre-grow out and the grow out farming.

ICAR-CIBA's technologies for livelihood of coastal fishers

ICAR-CIBA's technology for Planton^{plus} , and Horti^{plus}, ornamental fish production activities, nursery rearing of potential brackishwater candidates fishes given a confidence to the brackishwater fishers especially the women. It generates additional income, job-sharing, employment which could be taken up throughout the year as a livelihood activity for resource poor farmers/ fishers.

ABOUT ICAR-CIBA

Central Institute of Brackishwater Aquaculture (CIBA) is one among the 101 institutes under the nation's apex body, Indian Council of Agricultural Research (ICAR), New Delhi. The institute was established on 1st April 1987, and serves as the nodal agency for research and development of brackishwater aquaculture in the country. ICAR- CIBA with a vision of environmentally sustainable, economically viable and socially acceptable brackishwater aquaculture, it is involved in research and development related to fish seeds, cost effective feeds, environmental monitoring, farm and hatchery management, disease diagnosis, disease monitoring and social research etc. The institute is headquartered at Chennai with an experimental field station at Muttukadu, a backwater zone of the Bay of Bengal located about 30 km south of Chennai on ECR highway. The Institute has two research centres, one at Kakdwip (CIBA-KRC), famous for the delta region called the Sundarban, in West Bengal and another at Navsari (CIBA-NGRC), Gujarat.

INTRODUCTION

As the global demand for seafood is increasing every year against the plateauing wild fishery catches, aquaculture is looked up to with a lot of hope and responsibilities. Aquaculture is the fastest growing food-producing sector across the world currently produces 47 percent of food fish for the world, and it supplies over 60 percent of food fish to the Asian population. India is the second largest producer of farmed fish and offers a vast potential for aquaculture development and doubling the farmer's income. Though aquaculture is possible in all types of water resources (freshwater, brackishwater and seawater), the pressure on freshwater resources due to multi-user demands and climate change-related impacts constraint its expansion in the freshwater sector, hence the future aquaculture development is expected to occur mostly in salty brackishwater.

Out of a total 3.9 million ha of the brackishwater area estimated, 1.2 million hectares of coastal saline lands have been identified to be potentially suitable for brackish water farming. Also, about 9 million hectares of salt-affected inland soils in the hot semi-arid and arid ecoregion of northern plains and central highlands in the states of Haryana, Rajasthan, Punjab, Uttar Pradesh, Maharashtra and Gujarat are found suitable. Estimates show that only 11% of the potential coastal area available is utilized for farming. Hence this resource assessment was done long back, CIBA targeted to re-estimate the potential brackishwater resources with the advent of advanced satellite mapping and GIS tools. This mapping will help in planning for future expansion and management of brackishwater farming.

It is inspiring to witness the spectacular growth of this industry in India, spearheaded by shrimp farming with an export of about 7 billion US$ plus in 2017-18, which was only a nascent industry during the early 1990s. The aquaculture sector is also confronting severe challenges, such as the

impact of climate change and variability, disease outbreaks, environmental degradation, increasing input costs, anthropogenic activities, and related social and economic changes, increasing intra-regional trade and public health concern over food safety. Therefore, addressing these issues through research and development, and policy formulation is of utmost necessity.

At ICAR-CIBA, we support cutting-edge science and research to develop customized technologies suitable for different agro-climatic conditions to grow sustainable aquaculture in India and reap its social, economic, and environmental benefits. The institute has been advocating diversification of brackishwater aquaculture with alternative shellfish and finfish species and optimally utilising suitable brackishwater bodies with appropriate rearing systems through stakeholders' participation. We foster responsible aquaculture that provides safe, sustainable seafood; creates employment and business opportunities in coastal communities; and complements CIBA's comprehensive strategy for maintaining healthy and productive biological resource, ecosystems, and vibrant coastal communities.

Established in the year 1987, ICAR-CIBA headquartered at Chennai has its experimental station at Muttukkadu (MES), Tamil Nadu and research centres at Kakdwip (KRC), West Bengal in east coast and Navsari, Gujarat (NGRC) in the west coast. Established on 7th June 2018, research center in Navsari Gujarat (NGRC) is a CIBA's first aquaculture research center on the west coast of India. The main objective of the center is catering to the needs of aquaculture development along the west coast of India.

This annual report is a comprehensive combined report on ICAR-CIBA's research progress and administrative activities throughout the year 2018-19. Expectantly this report will provide adequate information about events, performance, and contribution to the brackishwater farming sector. ■

VISION

CIBA envisages its role as one of the world's foremost scientific research institute in brackishwater aquaculture through the pursuit of excellence in research and innovation that contribute modernization and development of sustainable brackishwater aquaculture in the country.

MISSION

Our mission is to realize this vision through basic and applied research, and providing technological backstopping suitable for Indian conditions for the development of sustainable brackishwater aquaculture. This would provide much-needed food, nutritional security, employment, economic well-being and societal development.

MANDATES

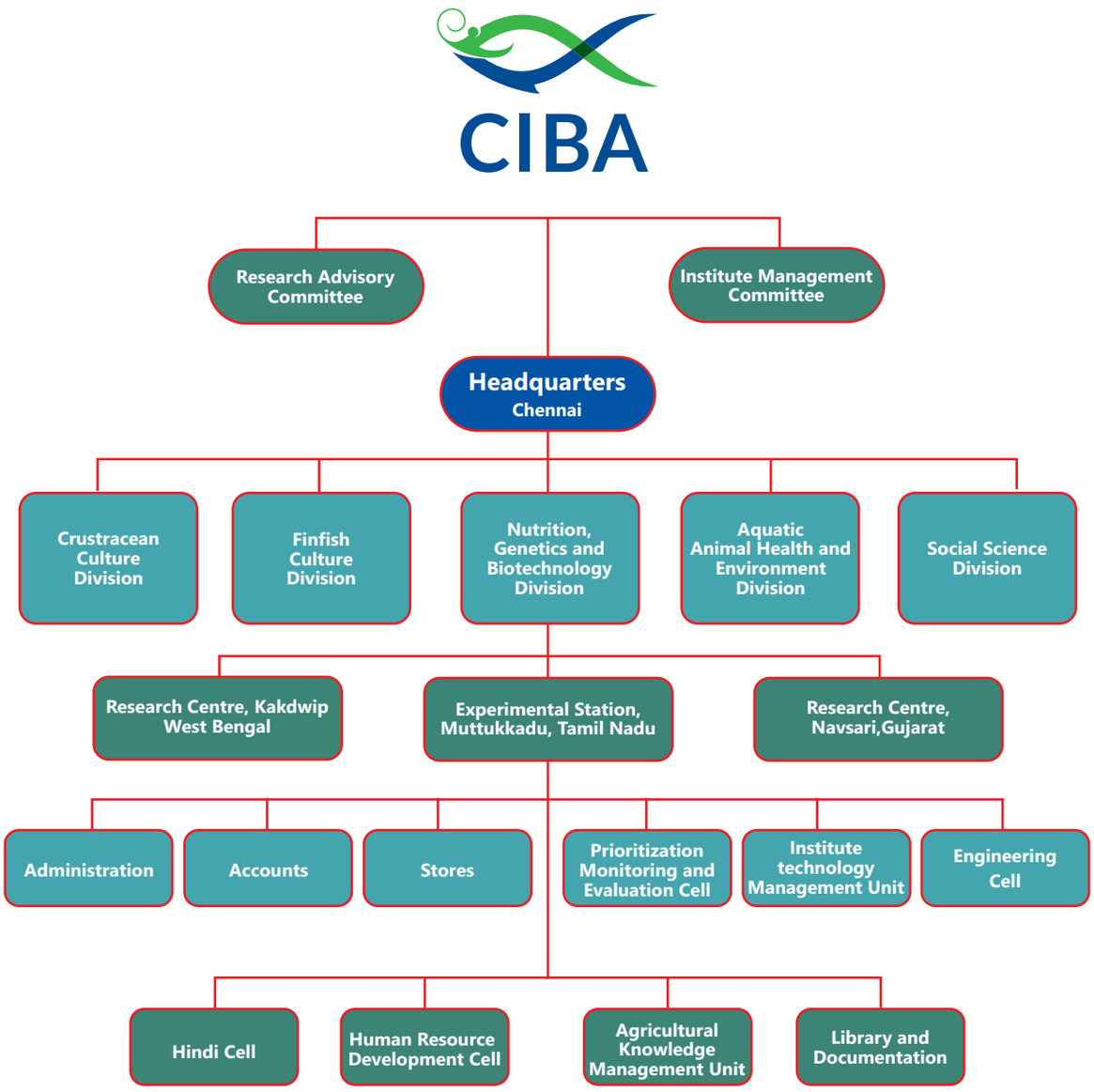
Basic, strategic and applied research for techno-economically viable and sustainable culture systems for finfish and shellfish in brackishwater.

Species and systems diversification in Brackishwater aquaculture.

Act as a repository of information on brackishwater fishery resources with a systematic database.

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

ORGANIZATON CHART



UNIFIED BUDGET OF CIBA FOR THE YEAR 2018-19

Rs. in lakhs

S.No.	Sub-Head	BE 2018-19	RE 2018-19	Actual expenditure during 2018-19
	Grants for creation of CAPITAL ASSETS (Capital)			
1	Works - Office building	220.00	139.00	139.00
2	Equipments	68.00	72.86	72.85
3	Information Technology	15.00	15.00	15.00
4	Library Books and Journals	10.00	10.00	10.00
5	Furniture & Fixtures	7.00	6.99	6.99
	Sub-total (A)	**320.00**	**243.85**	**243.84**
	Grants in Aid - SALARIES (Revenue)			
1	Establishment Expenses - Salaries	1797.00	2390.00	2389.96
	Sub-total (B)	1797.00	2390.00	2389.96
	Grants in Aid - GENERAL (Revenue)			
1	Pension & Other Retirement Benefits	1550.00	2071.00	2070.99
2	Traveling Allowances	30.00	35.00	35.00
3	Research & Operational Expenses	216.00	216.00	216.00
4	Administrative Expenses	1061.00	770.73	770.73
5	Miscellaneous Expenses (HRD & Others)	18.00	19.00	19.00
	Sub-total (C)	**2875.00**	**3111.73**	**3111.72**
	TSP			
1	Capital	36.00	17.00	17.00
2	Revenue	26.00	32.00	32.00
	Sub-total (D)	**62.00**	**49.00**	**49.00**
	SCSP			
1	Capital	0.00	26.15	26.11
2	Revenue	0.00	94.27	94.27
	Sub-total (E)	**0.00**	**120.42**	**120.38**
	GRAND TOTAL (A+B+C+D+E)	**5054.00**	**5915.00**	**5914.90**

STAFF POSITION

(as on 31.03.2019)

Category	Sanctioned	Filled	Vacant
Director	1	1	0
Head of Divisions/Principal Scientist	5	1	4
Senior scientists	10	6	4
Scientists	52	59	(+) 7
Technical Officers / Technical Assistants	25	22	3
Administrative Officer	1	0	1
Finance & Accounts Officer	1	1	0
Deputy Director (OL)	1	0	1
Assistant & Administrative Officer	3	3	0
Junior Accounts Officer	1	1	0
Private Secretary	1	1	0
Personal Assistants	2	2	0
Stenographers Gr. III	1	1	0
Assistants	7	6	1
Upper Division Clerks (UDC)	3	3	0
Lower Division Clerks (LDC)	5	2	3
Skilled Support Staff	55	25	30
Total	**174**	**134**	**47**

ON-GOING RESEARCH PROJECTS

CRUSTACEAN CULTURE DIVISION		
INSTITUTE FUNDED PROJECTS		
	Project Title	**Project Team**
1	Breeding biology, reproductive challenges and larviculture of candidate crustacean species of brackishwater aquaculture	**PI:Dr. C.P. Balasubramanian** **Co-PIs:** Dr. M. Jayanthi, Dr. A. Panigrahi, Dr. S. Kannappan, Dr. P. Nila Rekha, Dr. P. Shyne Anand, Ms. L. Christina, Dr. T.N. Vinay, Dr. N.S. Sudheer, Shri Jose Antony, Shri R. Aravind, Shri I.F. Biju, Dr. K.C. Neethu
2	Technological backstopping and promotion of sustainable aquaculture in west coast with particular reference to the state Gujarat	**PI:Dr. C.P. Balasubramanian** **Coordinator:** Shri Pankaj Amrut Patil **Co-PIs:** Dr. M. Kailasam, Shri Jose Antony, Shri Tanveer Hussain, Dr.P.K. Patil,Dr. P. Mahalakshmi, Dr. R. Saraswathy, Dr. K. Ambasankar
3	Novel approaches for technology refinement and upscaling of diversified systems and species of shrimp for sustainable development	**PI: Dr. A. Panigrahi** **Co-PIs:** Dr. M. Jayanthi, Dr. C.P. Balasubramanian, Dr. P. Nila Rekha, Dr. S. Kannappan, Dr. P. Shyne Anand, Ms. L. Christina, Shri R. Aravind, Shri Jose Antony, Dr. N.S. Sudheer, Shri I.F. Biju, Dr. T.N. Vinay, Dr. S. Sivagnanam, Shri S. Rajamanickam, Dr. K. Ambasankar, Dr. R. Geetha, Dr. T.K. Ghoshal, Dr. M. Kumaran, Dr. Sanjoy Das, Dr. Suvana Sukumaran, Shri Pankaj Amrut Patil

EXTERNALLY FUNDED PROJECTS			
	Project Title	**Funding**	**Project team**
4	Upgradation of breeding *P. indicus* through stock evaluation and culture demonstrations	**NFDB**	**PI: Dr. A. Panigrahi** **Co-PIs:** Dr. G. Gopikrishna, Dr. S. Kannappan, Dr. P. Mahalakshmi, Dr. K.P. Kumaraguru vasagam, Dr. K. Vinaya Kumar, Dr. P. Shyne Anand, Ms. L. Christina
5	Seaweeds for bioremediation in recirculatory aquaculture system	**DST**	**PI: Dr. P. Nila Rekha** **Co-PIs:** Dr. K. Ambasankar, Dr. A. Panigrahi, Dr. K.P. Kumaraguru vasagam
6	Evaluation and refinement of indigenous automatic feeder for shrimp farming	**NFDB**	**PI: Dr. P. Nila Rekha** **Co-PIs:** Dr. K. Ambasankar
7	Healthy shrimp and 'GIFT' tilapia production through bio-floc based farming system: Development of technology and standard operating procedure	**DBT**	**PI: Dr. A. Panigrahi** **PI: Dr. S. Felix, VC, TNJFU** **Co-PIs:** Dr. M. Shashi Shekhar, Dr. P. Nila Rekha, Dr. K.P. Kumaraguru Vasagam Dr. Antony Cheryl, TNJFU Dr. A. Gopalakannan, TNJFU
8	Optimization of aerators use to reduce production cost of shrimps under different brackishwater farming conditions	**NFDB**	**PI: Dr. M. Jayanthi** **Co-PIs:** Dr. T. Ravisankar, Dr. M. Muralidhar, Dr. R. Saraswathy, Dr. Aritra Bera
9	Mapping of coastal resources and identifying suitable areas for expanding Integrated Multi-Trophic Aquaculture (IMTA) in Maharashtra	**IMTA Maharashtra**	**PI: Dr. M. Jayanthi** **Co-PIs:** Dr. C.P. Balasubramanian Dr. M. Muralidhar, Dr.C.V. Sairam, Dr. K.P. Kumaraguru Vasagam, Dr. P. Kumararaja, Shri Pankaj Amrut Patil

	Project Title	Funding	Project team
10	Identifying suitable brackishwater lands for increasing aquaculture area in the coastal states of India with reference to environmental conditions and regulation using multi criteria decision support system	**ICAR**	**PI : Dr. M. Jayanthi** **Co-PI :** Dr. M. Muralidhar Shri J. Ashok Kumar Dr. R. Saraswathy
11	Coastal watershed based surface and subsurface salinity mapping and modelling of Thiruvallur and Kanchipuram districts, Tamilnadu for sustainable aquaculture	**NABARD**	**PI : Dr. Nila Rekha** **Co-PI:** Dr. C.P. Balasubramanian
	FINFISH CULTURE DIVISION		
INSTITUTE FUNDED PROJECTS			
12	Application of improved techniques for captive maturation, assessment of reproductive biology, system development of induced breeding larval rearing and seed production of brackishwater candidate finfish species		**PI: Dr. M. Kailasam** **Co-PIs:** Dr. M. Makesh, Dr. Satyanarayan Sethi, Dr. Krishna Sukumaran, Dr. G. Biswas, Dr. Prem Kumar, Dr. Aritra Bera, Smt. Babita Mandal, Smt. M.U. Rekha, Shri Pankaj Amrut Patil, Shri Tanveer Hussain, Shri T. Sivaramakrishnan, Shri Dani Thomas, Dr. K.C.. Neethu, Shri R. Subburaj
13	Development and evaluation novel culture technologies for candidate brackishwater finfishes for sustainable aquaculture.		**PI: Dr. M. Makesh** **Co-PIs:** Dr. M. Kailasam, Dr. Satyanarayan Sethi, Dr. Krishna Sukumaran, Dr. G. Biswas, Dr. Prem Kumar, Dr. Aritra Bera, Smt. Babita Mandal, Smt. M.U. Rekha, Shri Tanveer Hussain, Shri Dani Thomas, Shri Pankaj Amrut Patil , Shri T. Sivaramakrishnan, Shri R. Subburaj

	Project Title	Funding	Project team
EXTERNALLY FUNDED PROJECTS			
14	Development of brackishwater aquariculture through optimisation of captive breeding protocols of potential and emerging ornamental fish species, technology transfer and livelihood generation.	**ICAR**	**PI : Dr. M. Kailasam** **Co-PI :** Dr. Satyanarayan Sethi Dr. Krishna Sukumaran Dr. G. Biswas Ms. Babita Mandal Shri Dani Thomas, Shri Tanveer Hussain Dr. Raymond Jani Angel, Shri T. Sivaramakrishnan, Dr. K.C. Neethu
AQUATIC ANIMAL HEALTH AND ENVIRONMENTAL DIVISION			
INSTITUTE FUNDED PROJECTS			
15	Prevention and management strategies for viral, microbial and parasitic diseases of candidate species in brackishwater ecosystem		**PI: Dr. S. V. Alavandi** **Co-PIs:** Dr. K.K. Vijayan, Dr. K.P. Jithendran, Dr. M. Poornima, Dr. P.K. Patil, Dr. S. K. Otta, Dr. Sanjoy Das, Dr. P. Ezhil Praveena, Dr. R. Ananda Raja, Dr. Sujeet Kumar, Dr. T. Bhuvaneswari, Dr. Vidya Rajendran, Shri T. Sathish Kumar, Smt. Mary Lini, Shri Joseph Sahaya Rajan **Associates from other division** Dr. M. Makesh, Dr. N. Lalitha, Dr. Prem Kumar, Ms. Leesa Priyadarsini, Dr. Satheesha Avunje
16	Abiotic stress management for enhanced productivity and environmentally sustainable shrimp farming		**PI: Dr. M. Muralidhar** **Co-PIs:** Dr. R. Saraswathy, Dr. N. Lalitha, Dr. P. Kumararaja, Dr. Satheesha Avunje, Dr. Suvana Sukumaran , Dr. A. Nagavel
EXTERNALLY FUNDED PROJECTS			
17	National surveillance programme for aquatic animal diseases	**NFDB**	**PI: Dr. S. V. Alavandi** **Co-PIs:** Dr. K.K. Vijayan, Dr. K.P. Jithendran, Dr. M. Poornima, Dr. Sanjoy Das, Dr. Sujeet Kumar, Dr. P. Ezhil Praveena, Dr. T. Bhuvaneswari, Dr. R. Ananda Raja, Shri T. Sathish Kumar, Dr. Vidya Rajendran, Dr. Joseph Sahaya Rajan

	Project Title	Funding	Project team
18	All India network on fish health	**ICAR**	**National Coordinator: Dr. K.K. Vijayan** **PI: Dr. P.K. Patil** **Co-PIs:** Dr. S.V. Alavandi, Dr. S.K. Otta, Dr. R. Ananda Raja, Dr. T. Bhuvaneswari, Dr. Satheesha Avunje, Dr. M. Makesh, Dr. R. Saraswathy, Dr. N. Lalitha, Dr. P. Kumararaja, Dr. C.V. Sairam, Dr. T. Ravisankar, Dr. R. Geetha
19	Consortium research platform on vaccines and diagnostics	**ICAR**	**Project Coordinator:** Dr. M. Makesh
	a. Development of RNAi – mediated prophylaxis and therapy of white spot syndrome virus (WSSV)		**PI: Dr. S.K. Otta** **Co-PIs:** Dr. S.V. Alavandi, Dr. M. Makesh
	b. Development of vaccine for betanoda virus infecting seabass, *Lates calcarifer*		**PI: Dr. M. Makesh** **Co-PIs:** Dr. M. Poornima, Dr. K.P. Jithendran, Dr. P.K. Patil, Dr. Sujeet Kumar
	c. Biocontrol of vibrios in shrimp hatcheries using bacteriophages		**PI: Dr. S.V. Alavandi** **Co-PIs:** Dr. Satheesha Avunje, Dr. Vidya Rajendran Dr. Sujeet Kumar, Dr. Joseph Sahaya Rajan
	d. Development of probiotics and immunostimulants for shrimp		**PI: Dr. P.K. Patil** **Co-PIs:** Dr. S.V. Alavandi, Dr. Satheesha Avunje, Dr. T. Bhuvaneswari, Dr. R. Ananda Raja
	e. Development of improved diagnostics to existing and emerging pathogens of shrimp and fish		**PI: Dr. M. Makesh** **Co-PIs:** Dr. S.V. Alavandi, Dr. Ezhil Praveena, Dr. M. Poornima, Dr. S.K. Otta, Shri T. Sathish Kumar, Dr. Vidya Rajendran Dr. Joseph Sahaya Rajan

	Project Title	Funding	Project team
20	Network project on antimicrobial resistance	**ICAR**	**PI: Dr. S.K. Otta** **Co-PIs:** Dr. Satheesha Avunje, Dr. Vidya Rajendran
21	National Innovations in Climate Resilient Agriculture (NICRA)- Impact of climate change on aquaculture and mitigation options for minimizing green house gases from aquaculture sector	**ICAR**	**PI: Dr. M. Muralidhar** **Co-PIs:** Dr. M. Jayanthi , Dr. J. Syama Dayal, Dr. A. Panigrahi, Dr. M. Kumaran, Dr. R. Saraswathy, Dr. S.K. Otta, Shri J. Ashok Kumar, Dr. N. Lalitha, Dr. P. Kumararaja, Dr. Aritra Bera, Dr. Satheesha Avunje, Dr. Suvana Sukumaran, Dr. A. Nagavel
NUTRITION, GENETICS & BIOTECHNOLOGY DIVISION			
INSTITUTE FUNDED PROJECTS			
22	Application of advanced molecular and bioinformatic tools for improvement of brackishwater fish and shell fish		**PI: Dr. G. Gopikrishna** **Co-PIs:** Dr.K.K. Vijayan Dr. M. Shashi Shekhar, Dr. Sherly Tomy, Dr. K. Vinaya Kumar, Dr. B. Sivamani, Dr. J. Raymond Jani Angel , Ms. Misha Soman Smt. M.U. Rekha
23	Novel approaches for development and improvement of sustainable shrimp and fish feeds		**PI: Dr. K. Ambasankar** **Co-PIs:** Dr. J. Syama Dayal, Dr. T.K. Ghoshal, Dr. Debasis De, Dr. K.P. Kumaraguru vasagam, Shri K.P. Sandeep, Ms. Leesa Priyadarsani Shri T. Sivaramakrishnan
EXTERNALLY FUNDED PROJECTS			
24	Outreach activity on fish feeds and nutrient profiling of brackishwater fish and shrimp	**ICAR**	**PI: Dr. K. Ambasankar** **Co-PIs:** Dr. J. Syama Dayal, Dr. T.K. Ghoshal, Dr. Debasis De, Dr. K.P. Kumaraguru Vasagam, Ms. Leesa Priyadarsini Shri T. Sivaramakrishnan

	Project Title	Funding	Project team
25	Outreach activity on fish genetic stocks (Lead Centre: NBFGR, Lucknow)	**ICAR**	**PI: Dr. G. Gopikrishna** **Co-PIs:** Dr. M. Shashi Shekhar, Dr. B. Sivamani, Dr. C.P. Balasubramanian, Dr. Sherly Tomy, Dr. J. Raymond Jani Angel , Dr. T.N. Vinay, Ms. Misha Soman
26	Whole genome sequencing of Indian white shrimp *Penaeus indicus*	**ICAR**	**PI: Dr. M. Shashi Shekhar** **Co-PIs:** Dr. G. Gopikrishna, Dr. C. P. Balasubramanian, Shri J. Ashok Kumar, Dr. K. Vinaya Kumar, Dr. S.K. Otta
27	Poverty alleviation through prevention and future control of the two major socio economically important diseases in Asian aquaculture	**DBT**	**PI: Dr. M. Shashi Shekhar** **Co-PIs:** Dr. K.K. Vijayan, Dr. G. Gopikrishna, Dr. K. Vinaya Kumar, Mr. T. Sathish Kumar
28	Investigations on pathogenic microorganisms of shrimp aquaculture using metagenomic and other bioinformatics approaches	**ICAR**	**PI: Shri J. Ashok Kumar** **Co-PIs:** Dr. S.V. Alavandi , Dr. K. Vinaya Kumar Dr. Satheesha Avunje, Dr. Joseph Sahaya Rajan
SOCIAL SCIENCES DIVISION			
INSTITUTE FUNDED PROJECTS			
29	Research on socio-economics, frontline extension and information technology for sustainable brackishwater aquaculture sector	**ICAR**	**PI: Dr. C.V. Sairam** **Co-PIs:** Dr. T. Ravisankar, Dr. B. Shanthi Dr. D. Deboral Vimala, Dr. M. Kumaran Dr. P. Mahalakshmi, Shri J. Ashok Kumar Dr. R. Geetha, Dr. K.C. Neethu
EXTERNALLY FUNDED PROJECTS			
30	Brackishwater cage culture with multi-trophic candidate species diverse rearing systems for alternate livelihood and societal development in Maharashtra	**Mangrove cell Maharashtra**	**PI: Dr. C.V. Sairam** **Co-PIs:** Dr. M. Kailasam, Dr. C.P. Balasubramanian Dr. Pankaj Patil, Shri Tanveer Hussain Shri T. Sivaramakrishnan, Shri K.P. Sandeep

	Project Title	Funding	Project team
31	Knowledge and Economic Empowerment of women, tribal and their families in coastal villages of Tamil Nadu through adoption of brackishwater aquaculture and allied technologies integrated with societal development programmes	**CPCL**	**PI : Dr. B. Shanthi** **Co-PI :** Dr.C.V.Sairam Shri T. Sivaramakrishnan
32	Sustainable livelihood models for resource poor fish farmers/fisher folks in Nagapattinam district of Tamilnadu for doubling their income	**CPCL**	**PI : Dr. Deboral Vimala** **Co-PI :** Dr. M.Kumaran Dr. K.P. Kumaraguru Vasagam Dr.P.Nila Rekha, Dr.P.Mahalakshmi Ms. Babita Mandal
33	Development and Validation of Smart Aquaculture Model (SAM): Application of ICT and Data analytics for sustainable shrimp aquaculture	**NASF**	**PI : Dr. M. Kumaran** **Co-PI :** Dr. M. Muralidhar, Dr. D. Deboral Vimala Dr. K. Ambasankar, Dr. P. Mahalakshmi Shri J. Ashok Kumar Dr.T. Sathish Kumar, Shri Jose Antony Shri S. Nagarajan
34	Cage culture in brackishwaters of Puducherry and karaikal regions of Puducherry Union Territory A - feasibility study	**FIMSUL**	**PI: Dr. M. Kumaran** **Co-PIs:** Dr.M. Jayanthi Dr. D. Deboral Vimala Dr. C.V. Sairam Dr. M. Muralidhar Dr. K.P. Kumaraguru vasagam Smt. Babita Mandal Shri R. Subburaj

KAKDWIP RESEARCH CENTRE			
INSTITUTE FUNDED PROJECTS			
Project Title		**Funding**	**Project team**
35	Development and dissemination of economically viable and sustainable brackishwater aquaculture technologies for livelihood improvement of small and marginal farmers of Indian Sundarban		**PI: Dr. T. K. Ghoshal** **Co-PIs:** Dr. Sanjoy Das, Dr. G. Biswas, Dr. Prem Kumar, Ms. L. Christina, Smt. Leesa Priyadarsani
EXTERNALLY FUNDED PROJECTS			
36	Elucidation of molecular mechanism of dopamine action on final oocyte maturation of Goldspot mullet (Lisa parzia, Hamilton, 1822)	**DBT**	**PI: Dr. Prem Kumar** **Co-PIs:** Dr. G. Biswas, Dr.T.K. Ghoshal
OTHER PROJECTS			
37	Agri-Business Incubation centre (ABI) at CIBA, Chennai	**NAIF - ICAR**	**PI: Dr. T. Ravisankar** **Co-PI :** Dr. P.K.Patil
38	Intellectual property Management and Transfer/ Commercialization of Agricultural Technology Scheme (Up-scaling of existing components i.e. Intellectual property Right (IPR)	**NAIF - ICAR**	Dr. T. Ravisankar, OIC Dr.P.K. Patil, Coordinator Divisional Members Dr. R. Geetha, SSD Dr. T.N.Vinay, CCD Dr. Raymond Jani Angel, NGBD (Genetics) Dr. K.P. Sandeep, NGBD (Nutrition) Shri Dani Thomas, FCD

RESEARCH HIGHLIGHTS

BRACKISHWATER PRODUCTION SYSTEM RESEARCH

CRUSTACEAN FARMING

Shrimp aquaculture has been mainstay of Indian aquaculture sector that accounted for almost 70% of Rs 45000 crore seafood export revenue last year. Although shrimp farming sector has witnessed spectacular growth during recent decades, it has reached almost 0.6 million ton last year, this valuable industry is currently constrained due to multiple reasons. The institute continues to conduct research efforts to improve and refine this production system.

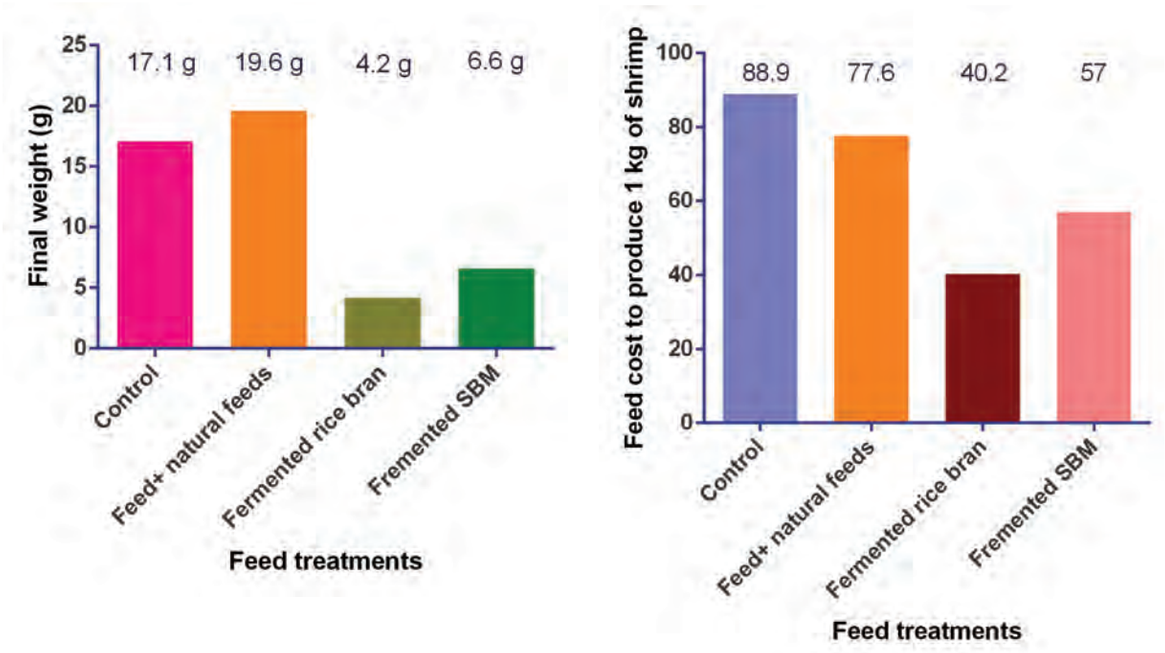
Penaeus vannamei

Exotic Pacific white shrimp was introduced to India in 2009, and thereafter this specific pathogen free and genetically improved stock dominated shrimp farming sector in India. Although growth of industry has been spectacular during this decade, currently *P. vannamei* production systems have been facing severe challenges due to multiple reasons ranging from emergent disease to fallen market prices. During this period we have been addressing several issues in vannamei production system.

Harvested white legged shrimp *Penaeus vannamei*

Growth performance *Penaeus vannamei* in simulated experimental system mimicking natural estuarine water

Farming methods of shrimp is rapidly evolving by adopting advancements in the aquaculture and allied sectors. Biofloc based farming is widely practiced in intensive shrimp farming. Although biofloc technology has been successful in many cases, the operating cost of the biofloc system is exorbitantly high, and further many misconceptions exist about the biofloc technology. A potentially more balanced approach is the use of biofloc and natural biota together, aquamimicry. To evaluate the potential of aquamimcry in shrimp production system a 90-day feeding trial with vannamei shrimp juveniles (70 shrimps/m^3) in outdoor microcosm was conducted. There were four treatments with different feeding regime; control (Clear water only with formulated feed), natural feed with formulated feed, fermented rice bran and fermented soybean meal. Rice bran and fermented soybean meal were used as carbon source for biofloc formation. Self-cleaning microcosm tanks served as rearing system. The shrimp which had access to biofloc & feed had a maximum final weight (19.58g) and survival (>90%) compared to the shrimp (4.19g) which had access to only biofloc generated by using ground rice bran as organic carbon source. The results of this study will be useful in further fine tuning the nutritional elements in the practical shrimp feed, and cost can be further reduced without compromising the growth performance of the shrimp.

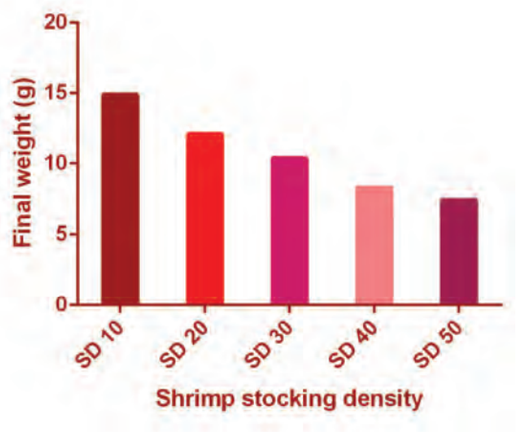


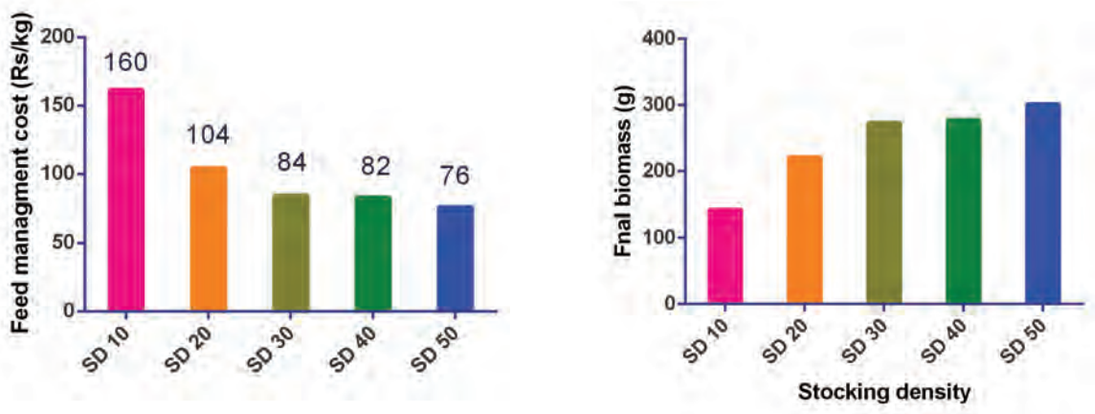
Growth performance and production cost per kg of shrimp under different feeding regimes

Aquamimicry: Effect of different shrimp stocking density

Shrimp stocking density is known to have much impact on the utilization of feed and growth performance of the shrimp. Farmers do shrimp farming in varying densities ranging from 30 to 90 shrimps per square meter. In this experiment we evaluated the influence of stocking density in the

absence of feed in the system which is rich in natural feeds. A 72 day feeding trial was conducted with shrimps post larvae of 18 days age. Stocking densities such as 10, 20, 30, 40 and 50 shrimps per meter square were evaluated. To have uniform natural feeds in the form of biofloc, mixture of SBM+ RB fermented for 24 hours was used as carbon source. Self-cleaning microcosm tanks served as rearing system. This study concludes that there is an apparent direct correlation between stocking density in the absence of feed. It indicates that natural feeds concentration available in the system could help only to realize a good growth performance in lower densities and not higher densities. Therefore, this study establishes





Growth performance of the shrimp at different stocking densities

that biofloc based natural feed not only play role in maintaining water quality in zero water exchange-based system, but also contribute to the nutrition of the shrimps reared. Planning of feed ration for this kind of systems should be adjusted considering the natural feeds to have cost saving.

Compensatory growth in *Penaeus vannamei*

Compensatory growth is already proved in fishes. However, the reports on such a compensatory growth in shrimp are clashing. In fact, this kind of compensatory growth is beneficial for the farmers in management point of view. Therefore, to confirm the presence or absence of compensatory growth this study was conducted with stunted shrimp from the aqua mimicry feeding trials. Here the shrimps were brought to normal feeding regime as our standard shrimp feeding chart. The growth performance was observed for another 55 days. Self-cleaning microcosm tanks served as rearing system. The stunted shrimps were found to have faster growth compared to the normal shrimps. The weekly weight gain in the stunted shrimps was more than 3 g per week, while it was only around 1.6 g per week in the normal shrimps. Compensatory growth in shrimp is evidenced from the results of this study.

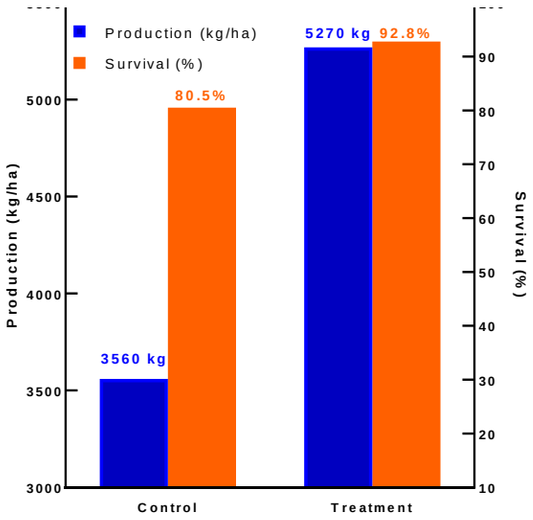
Cost effective plankton booster in shrimp production system

The recycling of the waste in the fish market and landing centres into useful product is one of the efficient management measures to improve the ecosystem health and diversification of livelihood

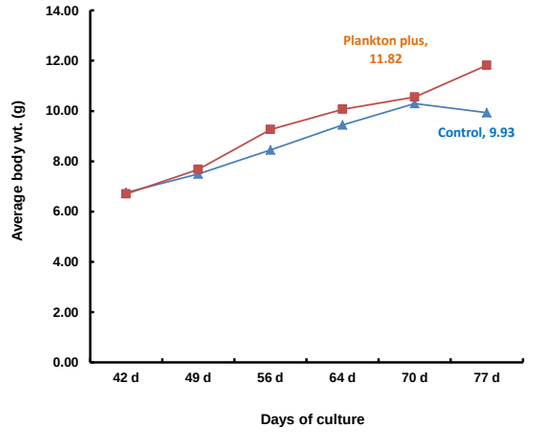
of coastal fishers. Almost 25 to 50% of fish in the fish markets becomes waste; the institute has made an efficient method to transform these wastes into a useful commercial product, a plankton booster ('Plankton ^{Plus}') in aquaculture ponds

A 77 days trial was conducted in *Penaeus vannamei* ponds at Bapatla, Andhra Pradesh, India to study the effect of Plankton ^{Plus} on augmenting plankton in shrimp culture pond. Plankton ^{Plus} was supplemented @ 10 ppm in split doses. Control ponds were supplemented with rice bran-yeast-mollases juice and dolomite as and when required to maintain the bloom and water quality. At the end of the culture period, average weight of shrimp was higher (11.82 g) in pond supplemented with Plankton ^{Plus} compared to control (9. 93 g). There was a significant increase (12.31%) in survival, and enhancement of yield to the tune of 1.71 t/ha in pond supplemented with Plankton ^{Plus} compared to control. Plankton ^{Plus} supplemented ponds were dominated by beneficial microalgae (Bacillariophyceae, Prasinophyceae and Dinophyceae etc.) and zooplankton. Enhanced growth performance of *Penaeus vannamei* might be due to the augmented density and diversity of phytoplankton and zooplankton in the Plankton ^{Plus} supplemented ponds.

Shrimps grown on plankton ^{plus}



Production performance in control and plankton ^{plus} treated pond



Growth performance in control and Plankton ^{plus} treated ponds

Plankton sampling: Productivity of Plankton ^{plus} treated pond

Biofloc based nursery rearing technology for *Penaeus vannamei*

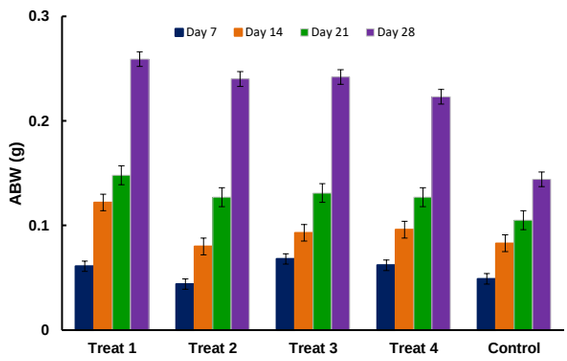
Biofloc technology has been an emerging alternative towards the environmental friendly aquaculture. This technology is characterized by reduced water exchange, reduced feed use and improved biosecurity. In order to develop a cost effective nursery system, the institute has conducted two demonstration trials at farmers' field in Odisha. *Penaeus vannamei* PL were reared at a stocking density3500 PL/m2 in 350 mt capacity nursery tank designed by the institute for a period of 28 days. Nursery reared animals were grown up to 0.92 ± 0.15 g with a survival of 94.20± 2.86 %)

In an another demonstration trials at Andhra Pradesh, two stage nursery system were demonstrated with first phase (N1) for 10days with high stocking (20000 to 30000nos per cum) followed by second phase (N2) for 15 to 20 days with stocking of up to 7000 individuals and finally harvested at ABW 250 – 350 mg within 4 weeks. The CN ratio manipulation with addition of carbon sources customized with biofloc consortium could induce bacterial flora to reduce the nitrogenous metabolites like TAN, Nitrite and Nitrate

Biofloc based nursery tanks at farmer's pond in Odisha

Effect of gut microbes on growth, water quality and enzyme activities

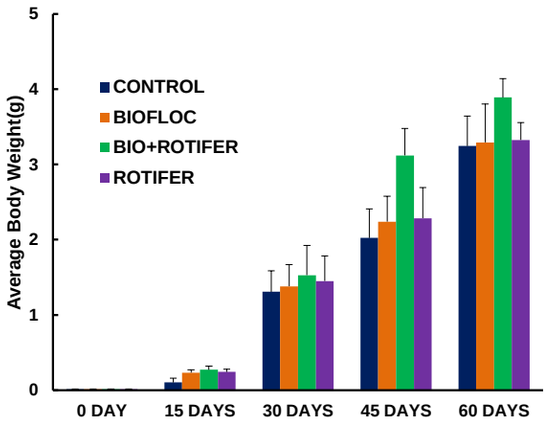
Experiment conducted with four different treatments: carbon sources with probiotic consortium, probiotic consortium without biofloc, sugar and probiotic consortium, mixed carbon sources without probiotic consortium and a set of control tanks were reserved without biofloc treatments. The result revealed that the survival rate of mixed carbon sources treated tanks were elevated (80%) contrasting other treatments (76%), while, control showing relatively low survival (67%). The ABW were relatively higher in biofloc treated tanks compared to control. The Biofloc treated shrimps were found to be colonized with beneficial bacteria in the gut region. Among the enzymatic microflora, amylase producer is common in all the treatments and control. Likewise, other enzyme such as protease, lipase, cellulase and xylanase producers were found high in biofloc treated tanks specifically higher in mixed carbon sources treatment. The gene expression study showed relative expression levels of potential immune genes were significantly up-regulated in shrimps grown in biofloc system, particularly with mixed carbon sources, than the control. The Biofloc system is advantageous and allows to colonized beneficial bacterial population in the gut region. Out of 94 strains screened, 36 strains were found to produce amylase enzyme, 20 strains protease, 27 strains lipase and 6 strains cellulase and 8 strains xylanase. Totally 21 isolates selected for further identification and different species of *Cobetia, Exiguobacterium, Bacillus, Marinilactibacillus, Staphyllococcus* and *Novosphingobium* genera from biofloc treatments were identified. In control strains of *Bacillus* and *Exiguobacterium* only observed. Among all, the genus *Exiguobacterium* identified in all treatments and control.



Average body weight of *Penaeus vannamei* post larvae reared in different treatments

Addition of Rotifer in the biofloc system: effect on growth performance and water quality

A RAS based nursery rearing was carried out with addition of carbon source and rotifer as feed supplement. The survival and growth was monitored every 15 days in each treatment. The treatments included as C: control, T1: only Biofloc, T2: Biofloc and rotifer , T3: only Rotifer. At the end of Experiment the rotifer with biofloc condition showed better growth (3.89±0.25) and survival (91%) which is significantly different from control animals(3.24±0.29, 85%). The rotifers culture added @ 2 litre/tank in two split dose, one at morning and other at afternoon. The rotifers were cultured with standard procedure by giving chlorella as feed. The rotifers collected by scooping with 200um mesh hand net from cultured tanks.



Evaluation of growth of *Penaeus vannamei* in biofloc system supplemented with Rotifer

Nutrient dynamics under different culture practices

Shrimp aquaculture is generally practiced in the coastal zone owing to the availability of the brackishwater. However, some of aquaculture ponds constructed in these areas are swampy or sandy, that type of soils do not hold sufficient water level. Further some of these soils are acid sulphate, which is characterized by low pH level Use of plastic pond liners are reported to be effective management scheme to separate the pond

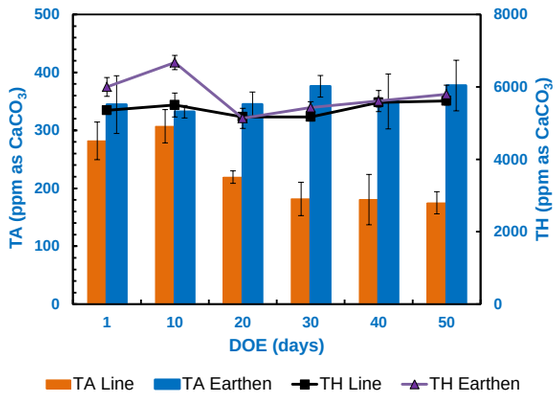
and soil. This study was aimed to evaluate the water quality and production performance of *P. vannamei* in a plastic lined system. *Penaeus vannamei* (~4 g) post larvae were stocked in 500 L simulated earthen and lined tanks (40 shrimps per tank) at 25 ppt salinity. The treatments were replicated thrice and no water exchange was carried out during the experimental period. After 50 days of rearing the growth rate was 21% high in earthen ponds. Dissolved oxygen was higher in lined tanks than earthen. In both the practices, the negative value of redox was recorded after 10 DOC and the values were comparatively high towards the positive side in lined ponds whereas, there was no trend in temperature. There was a significant decrease in total alkalinity (282-175 ppm as $CaCO_3$) as culture progressed in lined ponds. Total hardness varied from 5170-5610 and 5133 to 6673 ppm as $CaCO_3$ in lined and earthen ponds respectively. Increase in metabolites with DOC is comparatively lower in lined ponds.

Comparison of metabolites and nutrients under lined and earthen ponds

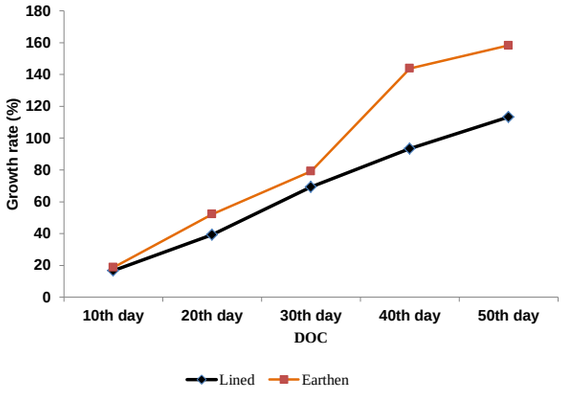
Characteristics	Lined pond	Earthen pond
DO (ppm)	5.3-6.4	4.9-5.9
TAN (ppm)	0.065-0.941	0.06-1.202
NO2 (ppm)	0.068-0.714	0.077-0.895
NO3(ppm)	0.7-1.5	0.7-1.8
PO4(ppm)	0.2-2.9	0.2-1.9

Adaptation mechanism of *P. vannamei* under various salinities

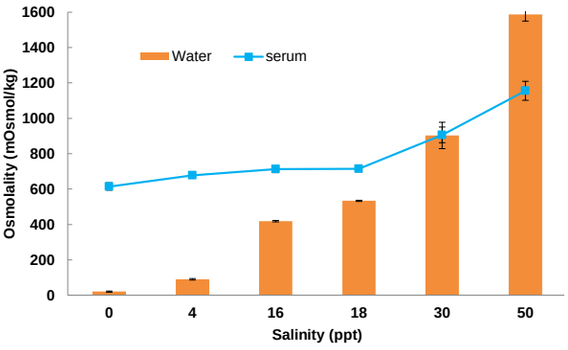
In order to evaluate adaptability of *P. vannamei* from fresh water to hyper salinity, animal samples were collected from shrimp culture ponds of varying salinity (0, 4, 16, 18, 30 and 50 ppt) at periodical intervals and osmolality was analysed in both water and serum. The mean water and serum osmolalities were 90, 534 and 1587 mOsmol/kg and 678, 714 and 1155 mOsmol/kg under 4, 18 and 50 ppt salinity, respectively. Due to the lower variation in serum osmolality despite wider variation in rearing medium and osmoregulatory capacity of *P. vannamei*, shrimp adapts to varying salinities and grows without much stress. The iso-osmotic point is 858 and it fits under polynomial 2nd order regression equation (R2: 0.9794).



Total alkalinity and total hardness in the lined and earthen ponds



Growth rate of *Penaeus vannamei* in simulated lined and earthen experimental system

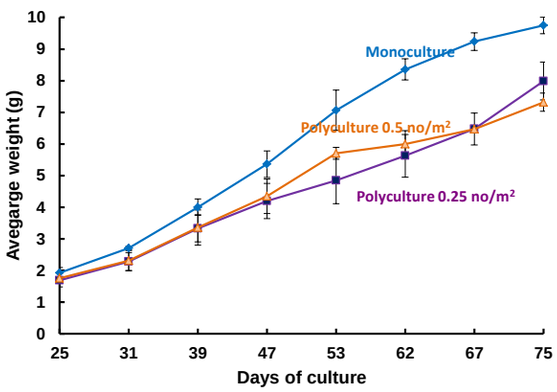


Effect of salinity on water and serum osmolality

Penaeus Indicus

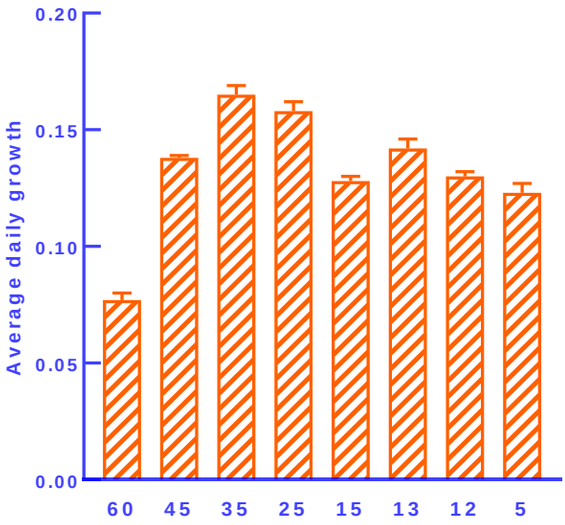
Polyculture of Indian white shrimp (*Penaeus indicus*) and milkfish (*Chanos chanos*)

Polyculture of shrimp has been proved to be viable alternative to reduce the nutrient waste from the aquaculture facilities and to optimize the economy shrimp farming. In order to evaluate the production performance of polyculture of *P. indicus* and *C. chanos*, a 75 day culture experiment was carried out at the earthen ponds in Kakdwip Research Centre of CIBA (KRC of CIBA). *Penaeus indicus* was stocked (25 PL/ m^2) along with milkfish at two stocking densities (0.25 ind/m^2 and 0.50 ind/m^2), and reared for 75 days. The production performance was compared with monoculture *P. indicus* at the same density. Highest survival (79.33± 1.88 %) and production (1451.28± 22.15 kg/ha) of shrimp was recorded in the pond which *P. indicus* reared with milkfish at a stocking density of 0.5 ind. /m^2, although significantly higher average body weight obtained at the pond stocked with milkfish at a stocking density of 0.25 m^2. No significant ($p < 0.05$) difference in the load of total heterotrophic aerobic bacteria (THAB) and total Vibrio (TV) was observed between polycultured and monocultured ponds. However, significantly higher TAN and NO_2-N were recorded in the control monoculture pond. This study indicates the potential of system diversification for optimizing economics of pond culture and to keep the environmental wellbeing of the pond system.



Average growth rate of *Penaeus indicus* in mono and polyculture systems

In order to evaluate the production performance of *Penaeus indicus* at different salinities, field levels trials were carried out at different coastal regions, where salinity ranges from 1 to 60 ppt. Production performance was almost similar at lower and higher salinities. Further, average daily growth rate (ADG) was found to be similar at all the salinities except 60 ppt, where adg was almost half compare to other salinities irrespective of lower and higher.



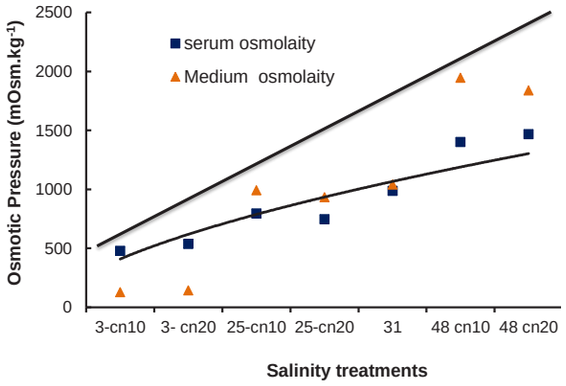
Average growth during culture of *Penaeus indicus* at different salinities

Demonstration of Indian white shrimp culture across different locations

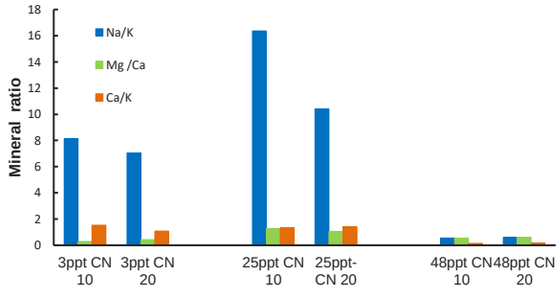
To further refine the performance of Indian White Shrimp *Penaeus indicus* with indigenous technology using 'indicus *plus*' (35% CP) feed, high density culture carried out in farmers' ponds ha in Andhra Pradesh. At the end of 100 -110 days of culture period, a final body weight of 17-19g with a survival up to 85--98 % and a production ranging from 3 to 4.5 tons/ ha was obtained in moderately high stocking density (30 to 35 pc/sq m) ponds, which was sold at a farm gate price of Rs 300/-.

Growth performance, osmolarity of Indian white shrimp juveniles reared at different salinity in C:N ratio manipulated system

Osmoregulatory capacity of penaeid shrimp and serum mineral profile aid in understanding about the physiological adaptation of Indian white shrimps related to ambient salinity that indirectly regulate growth performance of shrimps at different salinity. Keeping this in view, a 50 day experiment was carried out to study the growth performance, water quality , serum mineral profiles of *P. indicus* juveniles (0.4-0.5g) reared at different salinity in 100 L FRP tanks at 12 individual/tank using low protein feed (CIBA feed-30%) and fermented carbohydrate supplementation (CN 10 and CN 20). Osmolarity study reveals serum osmolarity changes proportionately with ambient water salinity- shows strong hyper-hypo osmoregulatory pattern (Osmolarity capacity-at low salinity-hyper OC and high salinity hypo OC). Minerals play an important role in osmoregulation. Among major minerals, calcium (Ca) and magnesium (Mg) are considered important for molting and new shell formation. The ratio of Na (Sodium) to K (Potassium) and Mg (Magnesium) to Ca (Calcium) in should be preferably 28:1 and 3:1 and Ca:K should be 1:1. Serum mineral profile ratio revealed that at low salinity



Serum osmolality (mOsmo. kg -1) and osmolality constant of *Penaeus indicus* reared at different salinities



Serum mineral profile ratio of Na K Ca Mg and CaK ration of *Penaeus indicus* at different salinities

3 and 25 ppt shrimp had Ca/K ratio were 1.3-1.5 whereas at 48 ppt ,it was only 0.5.

Nursery rearing of *Penaeus indicus* in the estuarine ecosystem as a livelihood activity

A nursery rearing model for Indian white shrimp, *Penaeus indicus*, has been demonstrated for self-help groups at Uyallikuppam village (Palar backwaters) near Kalpakkam (Tamil Nadu). *Penaeus indicus* (n= 400) of 1.5g size were separately stocked in 4 hapas (2 m x

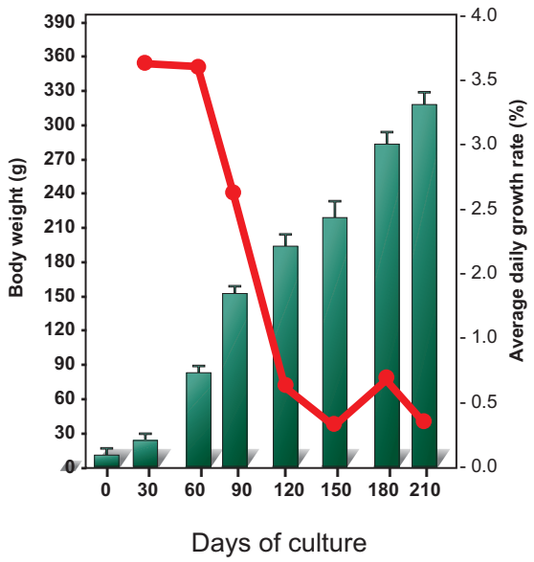
1m size) and reared for sixty days. The salinity, pH and temperature were observed from 21-28 ppt, 7.10 to 8.0 and 25- 28°C respectively. On an average of 8.50 g size of *P. indicus* were obtained with 90 % survival and a biomass 3.24 Kg

Mud crabs

Pen culture of *Scylla serrata* in mangrove ecosystem

Integrating pen culture of mud crab in mangrove habitats provide alternate livelihood opportunities for coastal communities through economic benefits of aquaculture and ensure participatory conservation of these vulnerable resources. The present study was therefore carried out to gather scientific data on production and economic feasibility of mud crab rearing in a mangrove based pen culture system. The culture site was located at Assolna village mangrove creek, Goa, India (Lat 15^{O} 10^{I} 39.29^{II} N, Long73^{O} 58^{I} 06.23^{II} E). Pen culture system was constructed in an intertidal area surrounded by mangrove trees and associated vegetation. The pen was constructed using 10 mm high density polyethylene netting (HDPE, twine size 2.0mm) stretched using casuarina poles driven to the creek bed. Lower margin of nets was buried 35 cm in to the lake bed and upper margin was stretched using a 10 mm polypropylene rope. A poly vinyl chloride sheet (PVC, width-20 cm) was tied to the free board area of netting to prevent escape of mud crabs. Dimensions of the pen were 50 m × 20 m, thus enclosing an area of 1000 m^2. Mud crabs, *S. serrata* with an average weight of 10.6 g were stocked in pen and reared for a period of 207 days.

Mud crab pen culture at a mangrove creek in Assolna village, Goa, India



Growth of mud crab in pen culture system

Mud crab harvest has been started from the system since 5 months from the stocking using scoop nets and baited circular traps. Only half of the stocked crabs were harvested in the first harvest due to the differential growth in the mud crab species. The harvested mud crabs were weighed and a representative sample of 100 individuals of both male and females were collected to determine the carapace width and body weight distribution. A total of 426 numbers (123.3 kg) of mud crab, 10 kg of penaeid shrimps, 10 kg pearlspot, 15 kg milkfish, 10 kg mullets, 10 kg red snapper, 3 kg silver biddies, 2 kg seabass, 13 kg crescent perches and 4.5 kg other fish species were harvested. The total returns obtained from pen pond including various species of fish and penaeid shrimp was Rs. 85,705. The total operational cost incurred for the culture system including labour was Rs. 45,825. The benefit-cost ratio was estimated at 1.87 for the current year.

Evaluation of formulated feed in box culture of *Scylla olivacea*

Mud crab (*Scylla olivacea*) is a native species of Sundarban, West Bengal and is known for its delicacy. Owiing to the h high export demand of this species particularly, gravid females, many farmers started culturing this species in pond and fiber

Culture of mud crabs in PVC boxes in Sundarban, West Bengal

boxes. Conventionally crabs are fed with low cost fish but major constraints are uncertainty in supply, price fluctuation and poor quality of raw fish. Pellet feed was prepared and offered to crabs maintained individually in 10 fiber boxes for a period of 28 days to observe its effect on growth and maturation. As a control, conventional low cost fish was offered in another 10 fiber boxes having individual crab. The increase in ovary wt. and gonadosomatic index of crab fed pellet feed was at par with low cost fish.

Performance of mud crab with conventional feed vs. formulated feed

Pellet feed	Control (low cost fish)	Formulated feed
Initial body wt., g	106.76±6.04	118.97±3.27
Final body wt., g	120.13±6.7	134.84±3.29
Survival %	70±00	80±00
Initial ovary wt., g	5.80±0.41	5.24±0.26
Final ovary wt., g	22.75±0.83	24.40±0.06
Initial GSI	4.51±0.39	4.12±0.23
Final GSI	15.51±0.85	16.59±0.44

Development of submersible cage system for mud crab grow out production

Mud crabs are benthic organisms, and therefore, pelagic/floating cages adversely affect the physiology of these animals owing to the relatively higher surface and sub surface temperature. In order to circumvent the issues of subsurface/floating cages, easy-to-manage submersible cages have been developed, and evaluated the culture performance with reference to the floating cages. In the submersible cage system, a rectangular PVC frame with a facility to fill-in and drain-out the water was constructed, and cages are installed on this frame. When animals are fed, the water in the PVC frame is pumped out, and after feeding and cleaning the cages, the water is pumped into the frame again and the entire system becomes submersible. Growth performance of crabs was compared between two systems after two months of rearing. Surface water temperature was observed as 34 – 35°C whereas bottom temperature was 4°C lower than surface at morning. Initial body weight of crabs for both systems was not significant ($p > 0.05$, independent samples t-test). Specific growth rate and average weight gain found significantly higher in submersible cages compared to floating system after two months of cultivation ($p < 0.05$, independent samples t-test). Average weight gain was >100 g in submersible system whereas it is significantly less in floating system (<15 g) indicating that submersible system outperforms traditional floating system.
It could be concluded that implementation of submersible cum floating crab culture system provide higher growth compared to conventional one for crab fattening.

Innovative rearing of mud crab in PVC cages which can customized for floating and submerged unnderwater

FINFISH FARMING

Seabass

Open water cage aquaculture as alternate livelihood and societal development in and around mangrove regions of Maharashtra

Sindhudurg accounts for 3% of Maharashtra's total mangrove cover but houses more of its coastal biodiversity than any other district in the state. Deforestation of mangroves timber for boat fabrication, firewood for human settlements, illegal aquaculture activities has also impacted on the nursery and breeding grounds of marine fishes, mammals, birds, etc. Hence to provide employment opportunities for improving income/livelihood generation, nutritional security, etc., ICAR-CIBA, Chennai in collaboration of Mangrove cell, Maharashtra have initiated three-tier seabass farming technologies such as nursery rearing, pre-grow out and grow out culture in and around of mangrove coastal waters in Sindhudurg district of Maharashtra with participation of self-help groups (SHGs). In such initiative, around six nurseries, a pre-grow-out and 33 grow-out cage cultures with the participation of SHGs comprising of male and female beneficiaries have been formed.

Asian seabass nursery and pre-grow out rearing in happas

For nursery rearing, happas (2 x 1 x1 m, 2 mm mesh size) were installed in a pond (0.8 ha) with a water depth of 1.5 m and salinity 25 ppt. Seabass seeds (1.2-2.0 cm) from CIBA fish hatchery were provided to SHGs in the range of 7200-10000 fishes and stocked at a density of 500 per happa-1. The fry was fed with CIBA formulated Seabass larval feed (0.2 mm-1.2 mm) @ 8-10% body weight two times a day. Regular grading was done at an interval of four days to separate shooters and to maintain uniform size. After 65-75 days, seed reached to fingerlings size of 6-12 cm and 10-14 g with an average survival of

Details of seabass nursery rearing and pre-grow out culture trials, and SHGs income generation in Sindhudurg, Maharashtra

SHG Name	Seed Supplied	Feed	Period	Fingerling production	Survival (%)	Income (Rs.)
Jai Ganesh Nivati, (6 W +2 M)	7600 (1.2-2.0 cm)	CIBA seabass feed (0.2 -1.2 mm)	65-75 days	5394 (10-12 cm)	71.0	Rs.1,07,880
Dolphin, Redi (6 W +2 M)	10000 (1.2-2.0 cm)		65-75 days	4394 (8-10cm)	44.0	Rs. 64,971
Jay Gajanan, Redi (6 W +2 M)	7200 (1.2-2.0 cm)		65-75 days	2179 (6-10cm)	30.2	Rs. 27,447
Samrudhi, Redi (6 W +2 M)	10000 (1.2-2.0 cm)		65-75 days	5513 (6-10cm)	55.13	Rs. 65,470
Chanak, Redi (6 W +2 M)	2500 (1.2-2.0 cm)		65-75 days	1513 (16-20 cm)	60.5	Rs. 50,656

Stocking of seabss seeds in hapas for nursery rearing

Collection of seabass seeds from hapa for grading

Women fisher women involved in grading of seabass seeds

Women fishers carry the graded seeds back in to hapa

52.16 %. The harvested fingerlings were sold @ Rs. 20 per fingerlings. In pre-grow out trial, a total of 2500 seabass (6-10 cm) fingerlings from nursery growers are stocked @ 400 fishes/net cage (6m^2). Farm made slow sinking pellet feed supplied @ 6-8% daily in two rations. After rearing of 60 days, fish reached to stockable fingerlings size of 14-18 cm and 20-25 g with the survival of 60.52 %. The harvested stockable fingerlings were sold @ Rs. 33 per fingerlings. The SHGs have generated a total revenue of Rs. 3.16 lakhs through Seabass nursery and pre grow out rearing work.

Grow-out farming in low volume cages

A total number of 33 cages of 4 x 4 x 2 m (32m^2) dimensions were fabricated using Galvanized Iron (GI) pipes (1.5" and 1.25") and were allotted to 8 SHGs units comprising of 90 men and 9 women of Sindhudurg. HDPE knotless cage nets were used for culture and to avoid cannibalism net is modified with an internal partition to make two internal compartments of 2 x 2 x 2 m inside the cage nets to facilitate re-stocking of two size graded seabass fishes in each compartment. The whole cage structure was

floated with six HDPE barrels each of 210 L capacity and anchored in creeks with 85 kg of mild stainless-steel anchors. From October 2018-February 2019, seabass fingerlings (6-18 cm & 4-14 g) procured from Seabass Nursery fish farmers of Andhra Pradesh and CIBA Nursery units, Sindhudurg were stocked in total 20 cages @1000 fishes/cage. The fishes were fed with CIBA seabass slow sinking grow-out feed of size

Open water cages at Talashil Village

Two units of open water cages at Kothewada Village

On-site fish grading by farmers

2-6 mm @ 8% body weight two times a day. The cage culture is in progress with the seabass have grown to the size of 40-200 g with an average survival of 42.5% and the harvest of 400-500g seabass is expected in mid-June 2019 with estimated total revenue generation of 10-12 Lakhs. In Maharashtra, this is one of the first kinds of activity which motivated the SHG's especially to women fishermen's to participate in seabass production and to generate the additional income through conservation of the ecosystem.

Integrated Multi-Trophic Aquaculture (IMTA) of seabass and green mussels in cages installed in open water

To develop and propagate family farming models of candidate finfish and shellfish species in the west coast of India, initiated IMTA cage culture in Gad creek of Malvan, Sindhudurg. Three families comprising of two men and one woman having a background of brackishwtaer fishing in creeks were selected from villages of Tondavali, Talashil, and Pan-Khol Juva, Taluka-Malvan, District-Maharashtra for IMTA culture of Seabass and Green Mussels in cages installed in creeks. Three pre-fabricated GI Pipes frame cages (8 x 4x 1.2 m), on 27 October 2018 two cages were stocked with seabass fingerlings (8-10 cm and 10-12 g). The fishes were fed with CIBA seabass slow sinking grow-out feed of size 2-6 mm @ 8% body weight two times a day. On 8 January 2019 Green mussel, *Perna viridis* (2-2.5 cm) attached to nylon ropes consisting of 200-250 green mussels (total weight of rope 650-950 g) were procured from fish farmers of Kumta, Karnataka and stocked to the outer periphery of each IMTA Cages at a density of 80 ropes/ cage. To achieve good fish growth, survival and to avoid cannibalism, regular fish grading at the interval of 15 days was carried out at each IMTA cage sites. During

IMTA cage at Talashi village

Fully grown mussel in ropes inside IMTA cages

the culture, regularly visited to each site for inspection of the cages, performance of the IMTA beneficiaries, scientific and technical inputs to the beneficiaries, monitoring, and sampling of the fishes to assess the growth and health status of seabass. The IMTA cage culture is in progress and mainly due to good cage culture management practices implemented by the IMTA families, the seabass have grown to size of 60-400 g with survival ranging from 79.30-90.03% and the harvest of 400-500g seabass is expected in mid-June 2019 with estimated total revenue generation of 2-2.5 lakhs to three IMTA families within

Milkfish

Seabass and milkfish farming in a pond on a polyculture approach

To propagate the polyculture of prominent candidate brackishwater aquaculture finfishes, conducted a trial of polyculture of Asian seabass, *Lates calcarifer* fingerlings and milkfish, *Chanos chanos* seed in Pond with the participation of local fish farmers (8 number) of Mayane village, Taluka-Vengurla, Sindhudurg, Maharashtra. The polyculture was conducted in the same pond where seabass nursery was functioning and an artificial partition by using crab fencing net was created to make one acre of the pond in 0.8 ha pond with a depth of 1.5 m. The milkfish after reaching to the fingerling size, a total of 550 number of stockable seabass fingerlings (18-25 cm, 150-300 g) procured from previous year IMTA farmers were stocked in a partitioned area of a pond and fed slow sinking pellet feed@3-6% bodyweight twice a day. A total of 166.5 kg seabass fish along with 750 kg of milkfish (300-1000 g) was harvested. The harvested medium and big sized seabass and milkfish realized a farm gate price of Rs. 150/Kg, 400/kg, and 100/Kg thus resulting in total revenue of Rs. 1,31,400 lakhs to the group of 8 farmers even after the escape of fishes during monsoon flood.

Harvest of seabass and milkfish from the polyculture pond

Harvest of milkfish from Goa fisheries departmental pond

Monoculture of milkfish in a pond in collaboration of fisheries department, Goa

To promote species diversification and sustainable aquaculture practices of important candidate brackishwtaer species in the west coast of India, conducted a trial of milkfish, *Chanos chanos* monoculture in collaboration with Fisheries Department of Goa. About 4000 milkfish seed (ABW 0.1-0.3g) were stocked in the departmental pond located at Ela-Dhauji, old Goa, Goa. Without nursery rearing, the seed were directly stocked in the 1.2 ha pond with water depth of 1.5 m and salinity 30 ppt. During the culture, the milkfish seed were fed with Indian Major Carp feed (28-30% protein) @ 3-5% body weight two times a day and salinity ranged from 5-40 ppt. After the culture of 11 months, a total production of 1.4 tonnes milkfish (ABW 400-750g) with survival of 80% was obtained. The harvested fishes were sold at the rate of Rs. 180-200/-kg in the retail market of Goa.

Juvenile milkfish could be a potential ornamental fish: Silverfish

Characters of juvenile milkfish such as milky white glittering, shining body, agility, semi-transparent V-shaped caudal fin, swift movement pattern, wide salinity tolerance, voracious gracing on tank algae and disease resistance qualifies milkfish juveniles as a potential ornamental fish called "Silverfish". Freshwater acclimatized milkfish Juveniles handed over to private aqua shop owners at Chennai to understand the acceptance by aquarium hobbyist in the sector. The initial response was positive and 10 pair of milkfish juvenile sold @ Rs. 50/-. Further initiatives are taken to popularize this fish as an alternative revenue generative species in the paradigm of ornamental fishes. Small experiments were conducted to know its compatible tankmates.

Compatibility of milkfish with other common aquarium fish

ISH	COMPATIBILITY	REASON
Tinfoil Barb	Compatible	Swims like milkfish
Red tailed shark/ Rainbow shark	Compatible	Bottom dweller; no competition
Black Shark	Compatible	Bottom dweller no competition
Tiger Barb	Incompatible	Caudal fin nibbling behaviour

Milkfish (*Chanos chanos*) sold as "silver fish" in aquarium shop

Popularization of milkfish farming in coastal districts of West Bengal and its acceptance as Decan Hilsa

Milkfish is fast growing herbivorous fish which has a similar outlook and culinary properties like hilsa. Considering demand and preference of milkfish by local Bengalis, CIBA took efforts to popularize milkfish as '*Decan Hilsa*' in West Bengal. About 8000 hatchery produced milkfish fry were distributed among four beneficiaries in Haldia block of East Midnapur district. For the first time seeds were distributed to beneficiaries through state fisheries machinery to achieve maximum visibility. Four different culture system was followed such as monoculture (Salinity 7-8 ppt), polyculture with *P. monodon* & *M. rosenbergii* (4 ppt), Nylon net cage culture (10-12 ppt) and polyculture with IMC (0 ppt).

Approximately 1.3 ton of milkfish was harvested. This culture demonstration was successful and created mass awareness among local communities and also in Bangladesh (Dhaka Times) as print media covered these trails extensively. It was very well accepted by the Bengalis by the name *Decan Hilsa* .

Farmed milkfish sold and popularized as Deccan Hilsa in West Bengal

Multiple stocking and multiple harvesting (MSMH) technique of milkfish culture

Milkfish is a suitable species for low input-based culture system easily adoptable by small and traditional farmers. For small farmers return from farming at regular intervals is most desirable to meet up their day to day needs. In this context, MSMH technique of milkfish culture could be suitable to these farmers. Moreover, this method could augment the productivity of a small pond by many folds. Therefore, to evaluate the performance of this technique in brackishwater ponds, a trial was conducted with two stocking densities (7500 and 15000/ha) as treatments. Milkfish fingerlings (6-8 g) were stocked and reared in fertilized ponds (500 m^2) provided with CIBA formulated feed (CP 30%; Price: Rs. 35/ kg) @5-3% of body weight daily. After 100 days, harvesting was started when the fish attained at least 150 g and ponds were restocked with the same quantity of advanced fingerlings (25-40 g) at 15 days intervals keeping the total number of fishes same to that of the initial stocking. This system exhibited higher production of 3.6 ton/ ha in the high density compared to 2.8 ton/ ha in the low density culture in 160 days suggesting the suitability of the former density.

ইলিশের বদলি মিল্ক ফিশ

যজ্ঞেশ্বর জানা
হলদিয়া, ৭ জুন

এবার পুজোতেই বাঙালির হেঁশেলে ঢুকছে 'মিল্ক ফিশ'। বিজ্ঞানসম্মত নাম 'চ্যানস চ্যানস'। আকৃতি, গন্ধে এবং স্বাদে অবিকল ইলিশ। পাওয়া যায় সমুদ্রে। ইলিশের মতোই চকচকে রুপোলি আঁশ। তবে ইলিশের তুলনায় পেটের দিকটা কম চওড়া। কাঁটা ইলিশের মতোই, বেশ সুস্বাদু। কয়েক শতাব্দী আগে ইন্দোনেশিয়া, তাইওয়ান, ফিলিপিন্সে এই মাছের চাষ বাণিজ্যিকভাবে শুরু হয়েছিল। আমাদের দেশে দক্ষিণ ভারতের রাজ্যগুলির সমুদ্র উপকূলে মিল্ক ফিশ পাওয়া যায়। এবার মিল্ক ফিশ চাষের সম্ভাবনা তৈরি হয়েছে পশ্চিমবঙ্গে। 'আক্কা' প্রকল্পে পুকুরে সমুদ্রের নোনা জল ঢুকিয়ে কৃত্রিমভাবে এই মাছচাষের পাইলট প্রকল্প গ্রহণ করেছে হলদিয়া ব্লক মৎস্য দপ্তর। ব্লকের মৎস্য সম্প্রসারণ আধিকারিক সুমনকুমার সাউ বলেন, 'মৎস্য দপ্তরের উদ্যোগে ইতিমধ্যেই পুকুরের মিষ্টি জলে ভেটকি, কাতলা ও মৃগেল মাছের উৎপাদন বাড়ানোর কাজ শুরু হয়েছে। পাশাপাশি রাজ্যের পুকুরে নোনাজলের মাছ চাষ করে মাছের উৎপাদন বৃদ্ধির লক্ষ্যেই এমন উদ্যোগ নেওয়া হয়েছে।'

মাস দু'য়েক সময়ের মধ্যে মাছের আঙুলদ ১৫ গ্রাম। হলদিয়ার মৎস্য সম্প্রসারণ আধিকারিক সুমনকুমার সাউ বলেন, 'জাতপাতের ব্যাপারে খানিকটা ইলিশ আর মিল্ক ফিশ খুব দূরের প্রজাতি নয়। মায়ের

হলদিয়ায় মিল্ক ফিশ। পাশে দাঁড়ানো ইলিশ।

একেকটি চাষমাছ ৪০০-৬০০ গ্রাম ওজনের হবে এবং এক গন্ধরে ৮০০-৯০০ গ্রাম ছাড়িয়ে যাবে। দাম হবে কই-মৃগেলের দুই বা আড়াই গুণ। এই পেটের না ছোঁক, দুধ-সাদাকে ইলিশের মাংসতুতো ভাই বলাই যায়। এখন যে বাদি পোনা জলে ছাড়া হল, সেগুলি পুজো-নাগাদ বড় হয়ে যাবে। তারপরেই রফতানির জন্য বাজারির পাতে হাজির হবে চলতে মিল্ক ফিশ।'

ব্রেকাইয়ের সেন্ট্রাল ইনস্টিটিউট অফ ব্রাকিশওয়াটার অ্যাকোয়াকালচারের প্রধান কার্যালয়ে এই মাছের পোনা উৎপাদন করা হচ্ছে এবং এই সাফল্যে বিজ্ঞানীদের প্রযুক্তিগত পরামর্শেই চাষ করা হচ্ছে। স্বাদে বৈচিত্র্য আনতে নোনাজলের মাছকে পরিষ্কার জলে রেখে কয়েক সপ্তাহ ধরে আনার চেষ্টাও করছেন বিজ্ঞানীরা। পুকুর-জলাশয়ের মিষ্টি জলেও এই মাছের উৎপাদন বাড়ানো সম্ভব। বৃহস্পতিবারই চেন্নাই থেকে বিমানে চারাপোনা আনা হয়েছে হলদিয়াতে। এদিনই মোট আট হাজার মিল্ক ফিশের বাদি পোনা চার জন মৎস্য-উদ্যোক্তা মানস বসু, শম্ভুনাথ দিন্দা, প্রণতি ভৌমিক এবং কৃষ্ণপ্রসাদ সামন্তের পুকুরে ছাড়া হয়েছে। নতুন মাছ চাষ শুরু হওয়ায় চাষিরাও খানিক উৎসাহিত।

News in meadia on farming of milkfish in West Bengal

Demonstration of low input-based milkfish culture in Sundarban

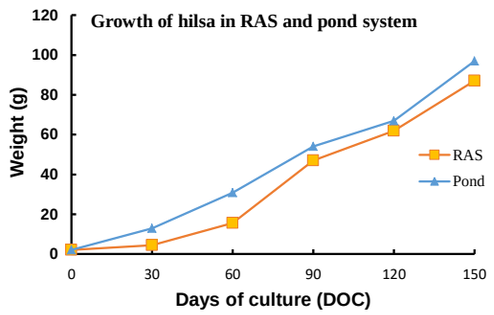
To promote milkfish farming scientifically, CIBA has developed seed production technology of milkfish by achieving the first breakthrough on captive breeding in June 2015. As an activity to popularize this species in traditional farming systems of Sundarban, a low input-based culture demonstration was conducted in a collaborative research mode. CIBA provided hatchery-bred 2800 number milkfish fingerlings (8 g) after conducting a nursery rearing phase at its Kakdwip Research Centre to an enterprising fish farmer, Mr. Animesh Das from Debichak, Ramganga. Milkfish fingerlings stocked in a 0.14-ha brackishwater pond provided with nylon net fixed vertically at epilimnion as a substrate for periphyton growth. Additionally, fish were fed with a floating feed (CP: 28%) at 2-3% of biomass daily. This culture yielded 600 kg (4.2 ton/ ha) in 6 months with a production cost of Rs. 90/ kg and selling price of Rs. 160-180/ kg, and was economically viable.

Milkfish harvest from a pond using cost effective feed in Sundarban region

Hilsa

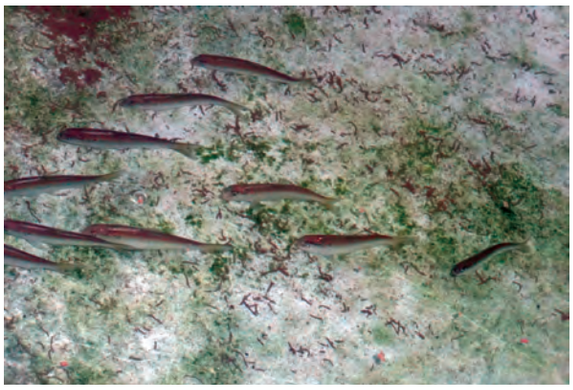
Growout production

Hilsa has good market potential in West Bengal, and there is a huge demand for table size hilsa. However, the demand needs to be fulfilled by the wild catch, and there is no farming attempt so far in a commercial scale. In this backdrop, two months old nursery-reared fingerlings of 34 numbers (4.8 to 5 cm; 2.2 to 2.4 g) were equally stocked in two different system viz. earthen pond (1000 m^2) and RAS (8 m3) in the



Growth of Hilsa in RAS and pond systems

Pond reared Hilsa



Hilsa fish reared in RAS

month of May. In both the systems, fishes were fed with pelleted feed (38% protein and 8% lipid) @ 5% of biomass. At 15 days interval, lime and GNOC was applied @ 150 and 50 Kg ha-1, respectively. At fort night interval regular water quality such as dissolved oxygen (6.5 ppm), pH (8.2) and salinity (6 to 8 ppt) were measured. After 11- months of culture, the growth performance of hilsa was visible good in pond system than RAS.

Mystus catfish

Effect of feeding frequency in nursery rearing of *Mystus catfish* in net cages

Brackishwater catfish, *Mystus gulio* has good market demand as a high-value species in Eastern India.

Mystus catfish reared in hapa

Standardized homestead hatchery technology of this species has been popularized among farmers. The hatchery produced 10-15 day old fry are further reared in the nursery to produce fingerlings suitable for stocking in grow-out system. To refine the nursery rearing method in hapa system, a trial was conducted to find out suitable feeding frequency. Among different feed management strategies, feeding frequency plays an important role in regulating the feed intake, growth, survival and waste outputs of fish. Twelve-day old fry (0.01-0.02 g/ 9-12 mm) were stocked in net cages (hapa: 2×1×1 m) at 250 no./ hapa. The fry were fed @ 10 to 4% of body weight with CIBA formulated diet (CP 30%, CF 6%; Price: Rs. 35/ kg) at four feeding frequencies (1, 2, 3 and 4 times/ day) as treatments. After 50 days, fry attained significantly higher growth of 1.29±0.41 g at 4 times feeding a day compared to other groups ($P<0.05$). Moreover, higher survival in 2, 3 and 4 times feeding differed significantly from that of 1 time feeding a day ($P<0.05$). Therefore, a feeding frequency of 4 times daily is suggested for nursery rearing of *M. gulio* in hapa system.

Effect of feeding frequency on growth and survival of Mystus gulio during nursery rearing in hapa.

Feeding frequency (FF)	Final length (mm)	Final wt. (g)	Survival (%)
1	46.8±2.15	0.95±0.18b	79.2±1.2b
2	48.02±2.70	1.05±0.27b	92.8±1.6a
3	48.01±2.26	1.02±0.36b	89.6±2.5a
4	49.44±2.96	1.29±0.41a	90.4±2.4a

Means with different superscripts in a column differ significantly ($P<0.05$); values are mean ± SD of two replicates.

Rabbit fish

Wide salinity tolerance of streaked rabbit fish, *Siganus javus* the impact of salinity on growth, survival and serum osmolality

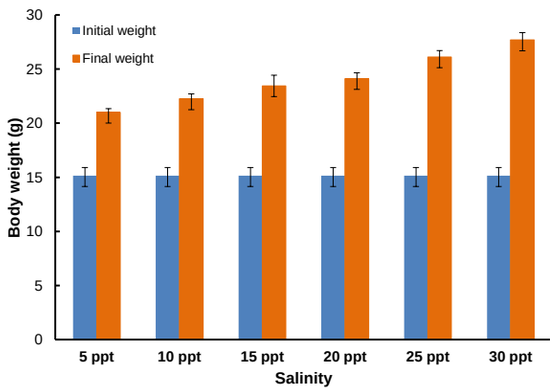
Streaked spine foot Rabbit fish, *Siganus javus* , is considered as important food fishes because of their fast growth rates, herbivorous food habits, and economic value. The study was carried out to determine salinity tolerance of streaked spine foot rabbitfish, *Siganus javus* with varying salinity and its impact on growth, survival and serum osmolality. A total of 270 nos *Siganus javus* juveniles (10.45±0.26 cm and 15.15±0.76 g) were stocked in 300 l tanks containing 30 ppt seawater to have 15 juveniles in each tank. Later the salinity was reduced by 5 ppt at every 12 hrs intervals to have a final salinity of 5, 10, 15, 20, 25 ppt with three replication per salinity treatment. The experiment was carried out for 30 days and the fishes were fed with artificial feed @ 5 % of the biomass. At the end of the trial, the serum osmolality was significantly varied among the salinity levels highest osmolality in 30 ppt (control) and lowest in 5 ppt (380.11±2.72). The mean body weight and the total length of fish also varied significantly among the treatments ($P<0.05$) as presented in the table. Overall, better growth performance was shown by the fishes reared in the higher salinity compared to the lower ones. However, survival was not affected by salinity. This experiment for the first time documented the wide salinity tolerance of *Siganus javus*, a potential herbivorous food fish for brackishwater farming.

Serum osmolality of *Siganus Javus* for a period of 30 days

Salinities (ppt)	Water osmolality	Serum osmolality
5	(mmol kg-1)	(mmol kg-1)
10	138.91±1.81	380.11a±2.72
15	281±2.75	390.33b±4.40
20	433.75±2.81	391.67b±2.75
25	565.33±4.88	395.44b±3.21
30	689.58±8.92	402.67c±1.90
	859±3.60	421d±2.23

Mean value with same superscript did not show any significant difference ($P>0.05$)

Streaked spinefoot (Rabbit fish) *Siganus javus*

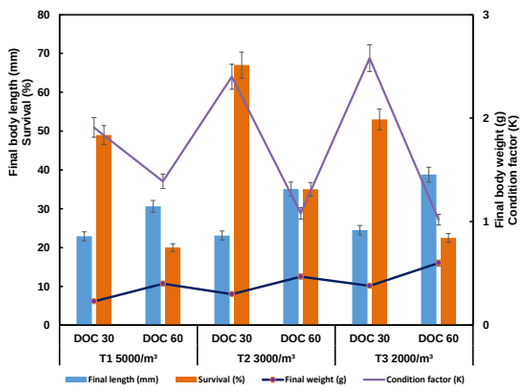


Growth performance of *Siganus javus* in different salinities for thirty days

Ornamental fishes

Optimum scat fry stocking density for their nursery phase for sustainable juvenile production in the pond and open water systems

Scat juveniles (2 – 5 cm) have huge demand in ornamental trade due to its spotted rhombic appearance and easy upkeep in aquaria. Being an herbivore fish, its nursery rearing can be popularized as low cost and short-term income generation activity by fisher / tribal groups. Hapa based nursery rearing mode was adopted in the pond and open water systems to optimize the rearing density for enhanced survival. Thirty days post-hatch hatchery-produced larvae with initial T.L. 10 ± 0.2 mm were stocked at three different stocking density (5000, 3000, 2000 nos/m3) in hapa (2 X 1 X 1 m) in a fertilized pond. Feeding was done with 30 % crude protein crumbled floating feed at the rate of 5 % body weight twice a day. Larvae reached marketable size 35.1 ± 1.19 mm with the highest 35 % survival after 60 days of rearing in 3000 nos/m3 density. Highest larval size 38.8 ± 5.1 mm was achieved in density of 2000/m^3.



Survival and growth performance of scat juveniles in hapas placed inside ponds

Another trial was conducted in the open water of village Kuvathur (Kancheepuram district) with tribal fisher folks. Hapas (2 X 1 X 1 m) were tied inside a pen structure and stocked with two stocking densities of 500/m^3 and 200/m^3 60 days post-hatch larvae of T.L. 22.9 ± 2.03 mm. Feeding was done with 30 % crude protein crumbled floating feed at the rate of 4 % body weight twice a day. Hapas were cleaned fortnightly. 100 % survival and 44.1 ± 7.18 mm T.L. was achieved after 45 days of rearing in 300/m3density. These juveniles were sold @ ₹ 15/fish to ornamental traders. Both the nursery rearing models were found to be suitable for rearing scat in cost-effective way.

Juvenile scat produced from pond based nursery system

Captive reared orange chromide with famers participation

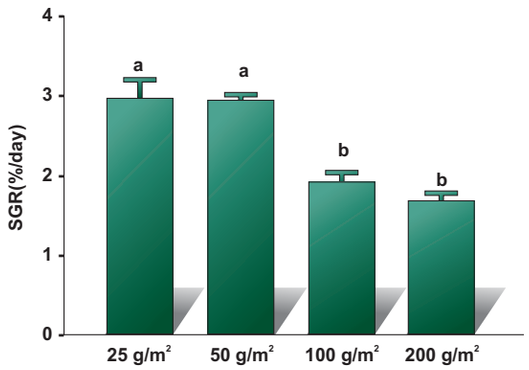
Mass production of orange chromide with farmers participation

Orange chromide has good demand in the domestic as well as in the international ornamental fish market. Fry produced in our hatchery were presented to the coastal fisher women's Uyyalikuppam near Kalpakkam and Kuvathoor near Kovalam, reared up to market size and sold to the aquarium shops. Initial Average length & Weight of Orange Chromide was 3.87 ± 0.20 cm, 1.085 ± 0.163 g respectively at 32 ppt salinity. After 3 months of rearing the average length & Weight was 5.87 ± 5.21 cm, 4.8 ± 1.0 g respectively at 30 ppt salinity and Survival was 89.1%.

Sea weeds

Cultivation of *Gracilaria tenuistipitata*

Cultivation of seaweed has been one of the predominant forms of aquaculture in the world aquaculture scenario. *Gracilaria tenuistipitata* is economically important seaweed, which is extensively cultivated in South East Asian countries. This species survives well below 20 ppt salinity. The present study was therefore carried out at the tide-fed brackishwater pond system of Kakdwip Research Centre of CIBA with the objective of estimating the optimum initial biomass intensity to be stocked. The experimental trial was conducted with four initial stocking intensities: 25, 50, 100 and 200 g/m2 at water depth of 0 – 0.3 m (identified as the most suitable culture depth by the experimental trial 1) in nylon net bags (1 m x 1 m, mesh size 2 mm) in a tide-fed pond of 600 m2 from July 2018 to December 2018 in triplicate. Seaweed biomass was measured once a month Significantly hihger SGR was found at the lower stocking densities (25 and 50 g/m^2) compared to higher stocking densities.



Specific growth rate of *Gracilaria tenuistipitata* at different stocking densities

Comparison of aeration requirements in bio floc -based system and earthen pond systems

Bio floc shrimp culture systems are gaining importance for cost-effective production where water is limited or land is expensive. Aeration requirement in bio floc-based systems were analysed based on the primary data collected from the biofloc based shrimp culture ponds at Tamil Nadu and Andhra Pradesh and compared with the aeration use in earthen ponds. Air diffuser systems operated using air blowers have been widely used in bio floc systems (Fig.), whereas different types of surface aerators are used in earthen ponds. Findings revealed that the aeration requirements in biofloc system vary from 6.2-12 HP/ m3 volume of water. Assessment in the farmers ponds indicated that the aeration requirement per cubic meter water in earthen pond varied from 2.3 to 4.5 HP/ m^3 volume of water. Study indicated that bio floc systems require around 170 % of higher aeration compared to earthen pond culture as aeration is needed continuously to keep solids in suspended in the water column at all times and bio flocs (algae, bacteria, protozoans, and other kinds of particulate organic matter such as feces and uneaten feed) also consumes dissolved oxygen.

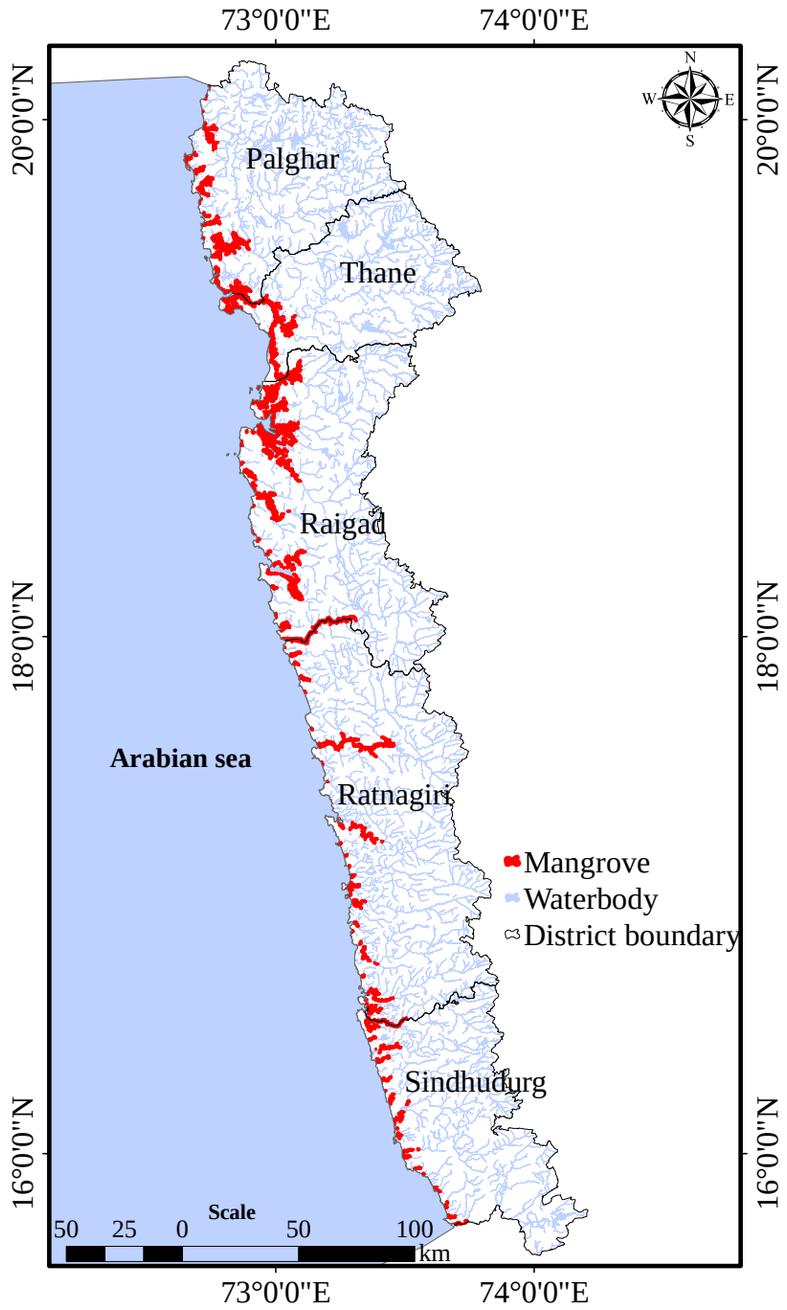
Evaluation of solar based aerator systems at Muttukadu Experimental station of CIBA

The model solar aerator was developed and installed (Fig.) at Muttukadu pond, with four panels supporting 1 HP aerator. Variable frequency drive has been installed for the automatic switchover to electrical current based to run the aerator during a power failure. On-farm trials of the Hybrid system powered aerators indicated that it can run the aerator for six hours. The battery capacity for four hours was incorporated in to system during power failure. Hence the technical feasibility of providing aeration in night hours and economic feasibility has been evaluated considering the dynamic nature of the sector and long-term investment in the solar energy systems.

Solar based aerator installed in experimental pond

Mapping of resources for aquaculture in Maharashtra

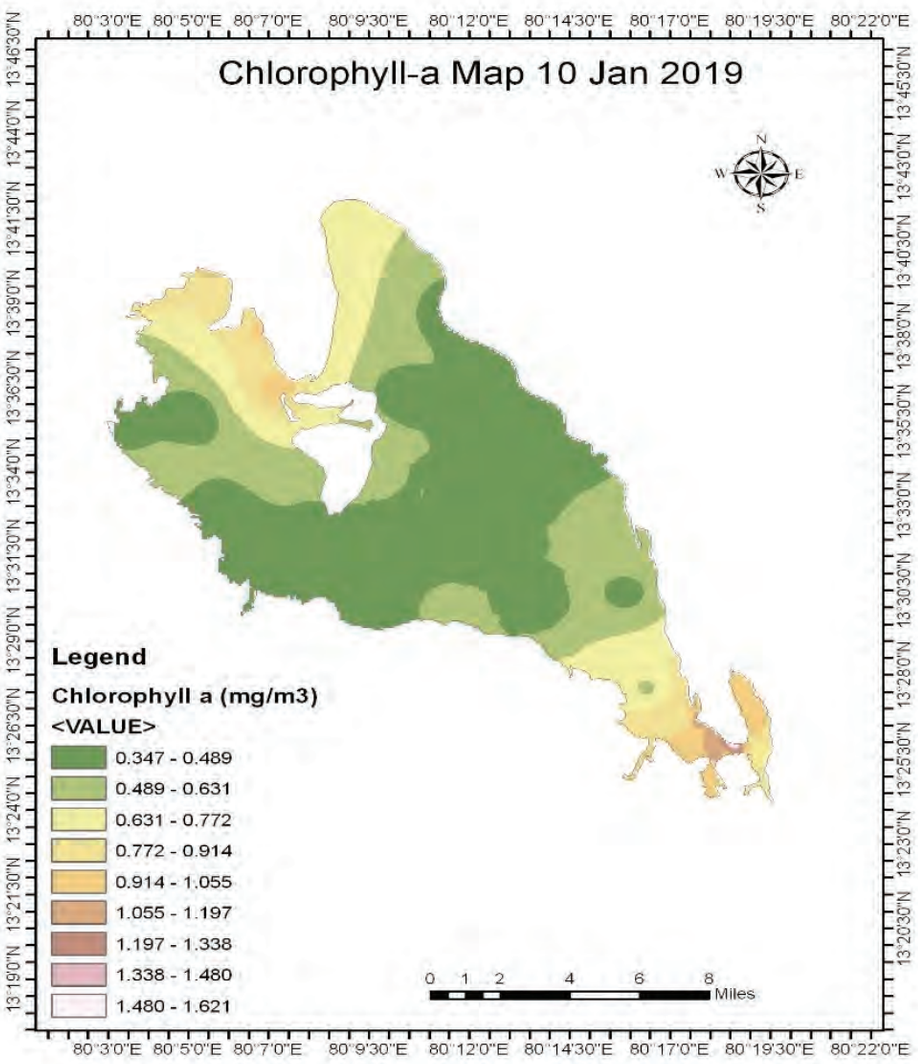
Assessment of coastal resources using remote sensing techniques and the ground truth survey in the coastal districts of Maharashtra was carried out to assess suitable land and water resources for aquaculture and also the seasonal variation of water quality characteristics. The mangrove extent and its spatial spread in the coastal districts of Maharashtra was mapped from the Sentinel data of the year 2018, indicated the mangrove extent of 13.71 ha, 37.58 ha, 141.21 ha 36.80 ha, 46.43 ha in Sindhudurg, Ratnagiri, Raigad, Palgar and Thane districts. The comparison with forest survey of India data indicated the increase in mangrove extent from 238 ha in 2017 to 278.73 ha. in 2018.



Coastal area map of Maharashtra, India

Mapping of Primary productivity in Pulicat Lake using GIS and Remote sensing

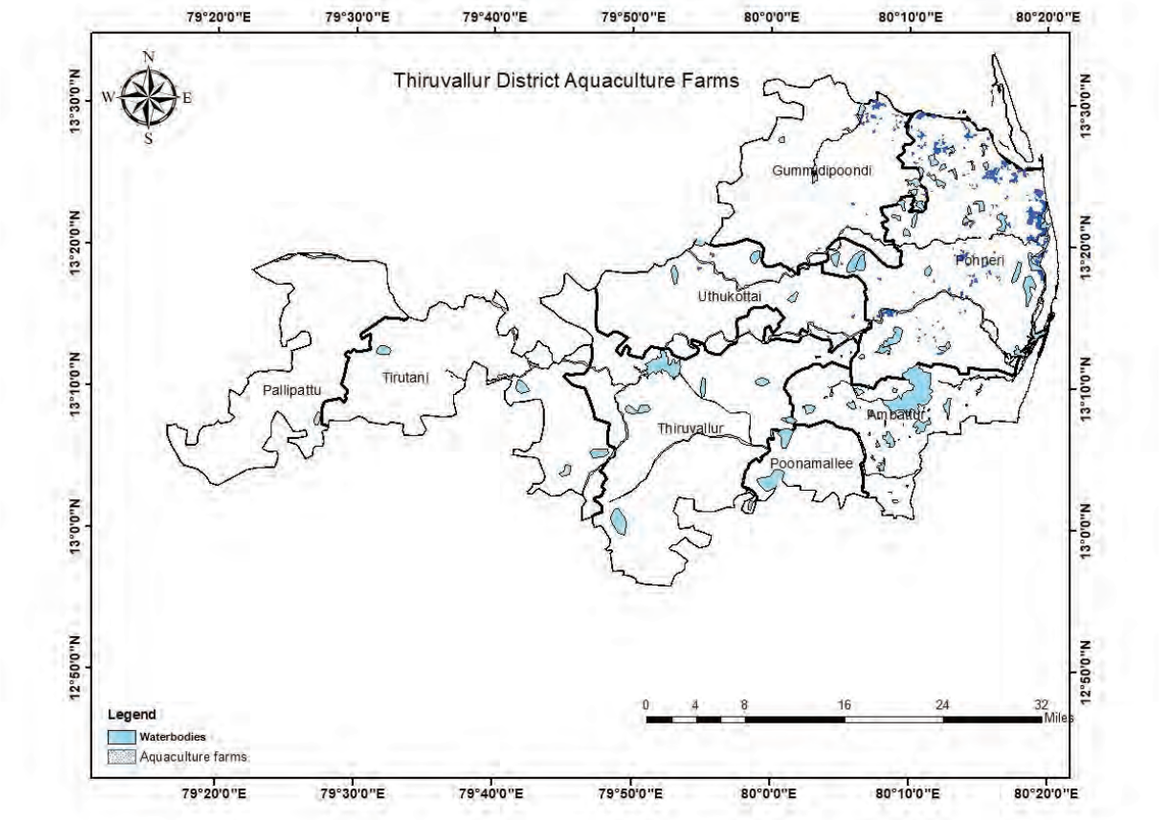
Water Samples have been collected at periodic interval from October 2018 to December 2018 from twenty-five-point locations in Pulicat lake covering a distance of 400 km stretch from mouth of the lake to Jameelabad at the upstream of the lake. Regression models for chlorophyll-a, turbidity and salinity were developed using remote sensing reflectance extracted from Landsat 8 OLI and observed water quality parameters. Results indicate that the dual band ratio of Rrs483/Rrs865 (R^2=0.7677) was most effective in estimating chlorophyll a whereas for turbidity and salinity single band algorithm was effective with Rrs655 (R^2=0.7938) and Rrs655 (R^2 =0.7669) respectively. The regression models are shown in figure 2. Spatial map of empirically estimated water quality parameters is shown in figure 3.4, 3.5 & 3.6. This model is used for estimating post monsoon water quality parameters and the model differs for other regions. Water depth varies from 92 cm to 320 cm during 2017 and 90 to 210 cm during 2018.



Pulicat map, distribution of chlorophill

Thiruvallur District Aquaculture farm Mapping

Thiruvallur district is located between 13°8′26.16′ North 79°54′21.6′ East and it covers an area of 3423 km2. There are five rivers flowing in Thiruvallur district which are Kosathalaiyar River, Cooum River, Adyar River, Arani River and Nadari. Aquaculture farms in Thiruvallur district has been mapped using Geo eye 1 satellite image in ArcGIS 10.2. Around 1337.62 hectares are under shrimp farming and most of them falls under Ponneri and Gummidipoondi taluk.



Thriruvalluvar district, Tamil Nadu Aquaculture map

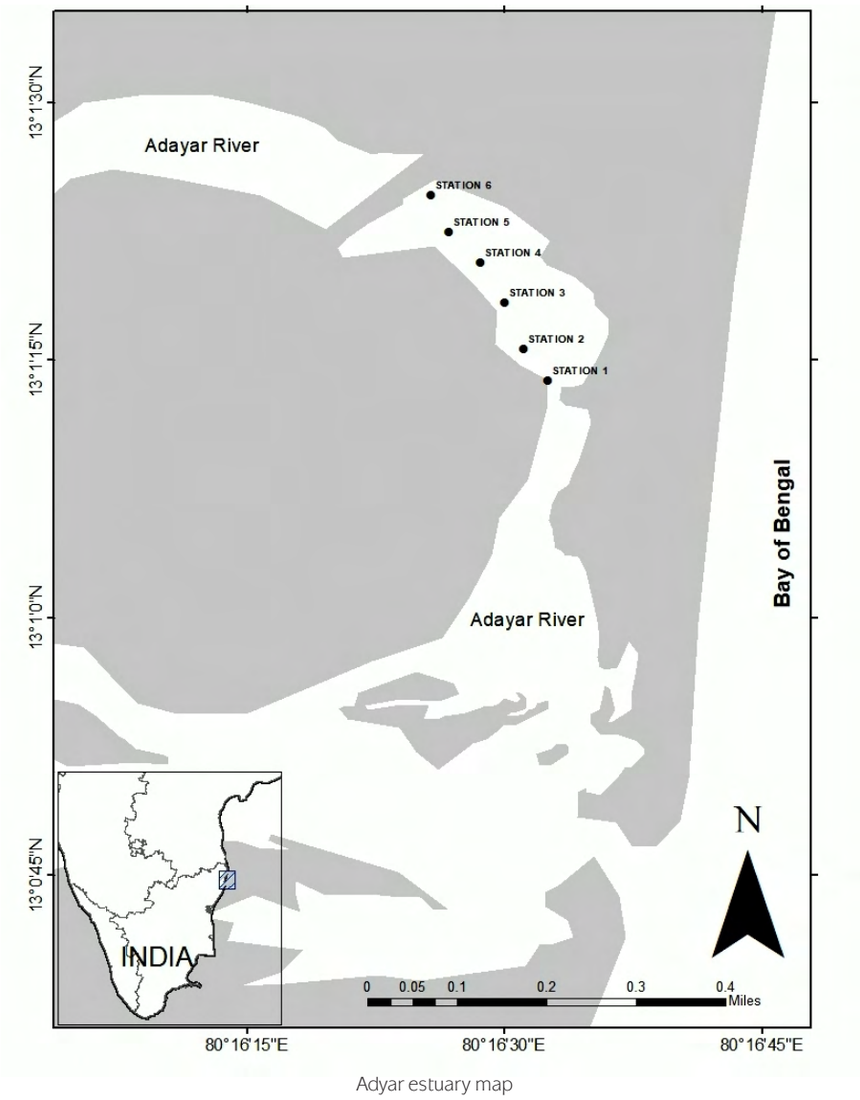
Thiruvallur District Aquaculture farm Mapping

Thiruvallur district is located between 13°8′26.16′ North 79°54′21.6′ East and it covers an area of 3423 km2. There are five rivers flowing in Thiruvallur district which are Kosathalaiyar River, Cooum River, Adyar River, Arani River and Nadari . Aquaculture farms in Thiruvallur district has been mapped using Geo eye 1 satellite image in ArcGIS 10.2. Around 1337.62 hectares are under shrimp farming and most of them falls under Ponneri and Gummidipoondi taluk

Phytoplankton and zooplankton diversity and seasonal dynamics in Adyar estuary

Due to the rapid urbanization and human settlement, Adyar creek and estuary, Chennai, has become one of the most polluted riverine ecosystem. Recently,

Chennai River Restoration Trust has taken massive effort to restore this important ecosystem. As a first step to optimally utilize this ecosystem for brackishwater aquaculture for diversification of livelihood, ICAR CIBA has taken steps to evaluate the health of ecosystem by studying the dynamics of phytoplankton and zooplankton of this estuary. Knowledge on primary and secondary productivity of any natural ecosystem is fundamental to assess the site selection for cage and pen culture. Plankton sample was collected from 6 stations located in Adyar creek, Srinivasapuram during January to December 2018. Phyto and zooplankton density was counted fortnightly and analyzed using PRIMER 7 software. Overall results conclude that among the phytoplankton, *Chlorella* sp, *Thalassiosira* sp, *Coscinodiscus* sp and *Chaetoceros* sp is dominating in all stations and Rotifers and Copepod was dominating among zooplankton (Fig 11). Maximum density of phytoplankton was observed during Monsoon with an average cell density of 1000 cells/mL and maximum density of zooplankton was found during Monsoon 100 individuals/mL of water sample respectively. Maximum diversity was observed during pre-monsoon period followed by Monsoon > Summer > Winter. Among 6 stations, maximum diversity was observed at Station 3 and Station 2 with optimum water quality parameters though out the study period. Hence it can be conclude that Station 3 and Station 2 can be selected for brackishwater farming practices.

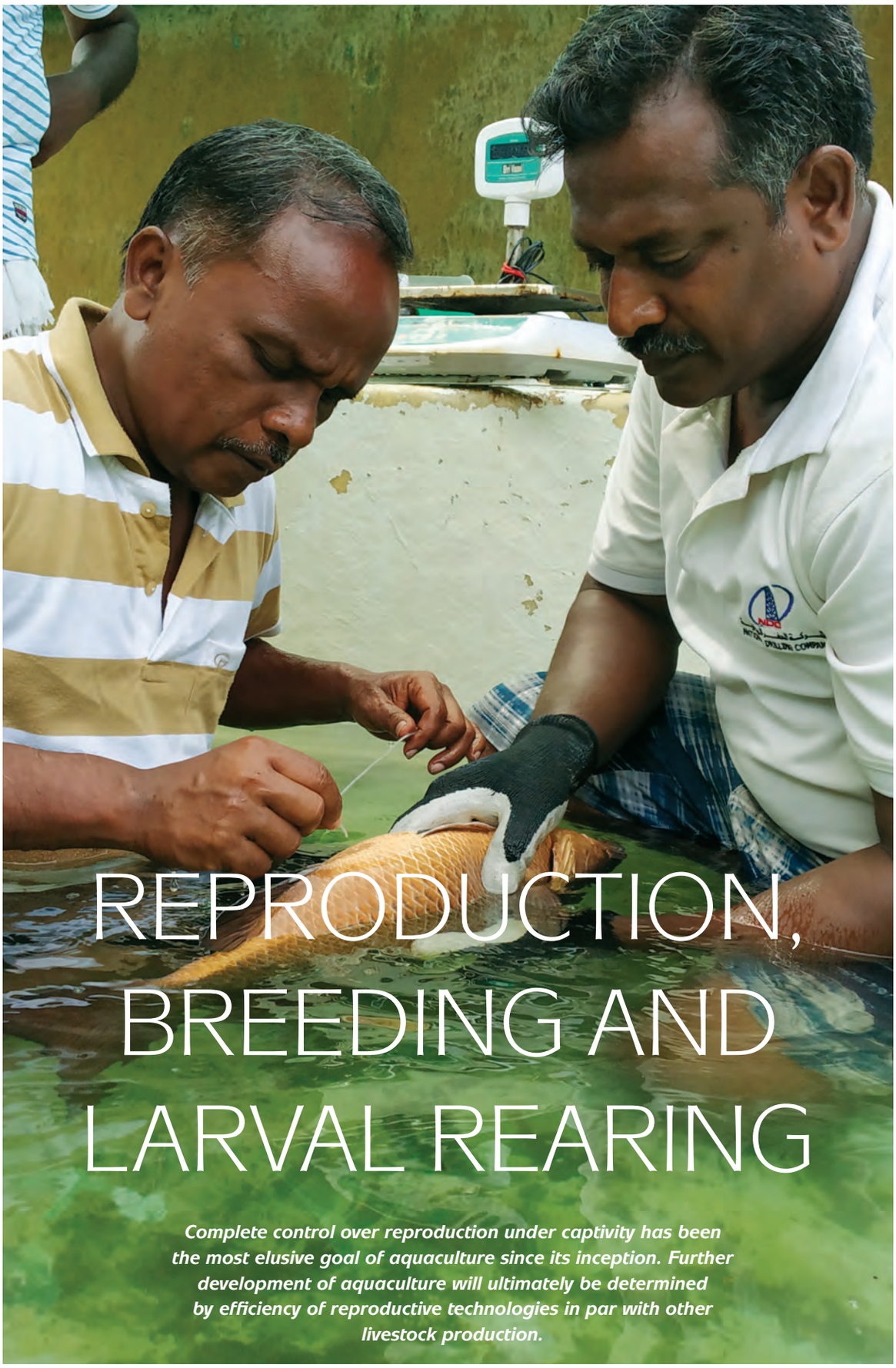


Adyar estuary map

Indigenous Automatic Feed Dispenser for Shrimp Farming Solar powered feeder – refinement

Refinement of the existing design by rectifying minor drawbacks and utilization of DC motor for energy efficient direct usage of solar power was done. Three units have been fabricated for on farm trials and on farm demonstration of the refined indigenous automatic feeder was done at *P. Vannamai* farm, Kattur during Feb 2019 as the farming season has started then. Weekly observation is being carried out for soil quality, water quality and feed conversion ratio parameters for refined auto feeder installed pond and a control pond viz., manual feeding pond at the same farm, Feed dispersion distance was 30 m diameter and Quantity of the feed dispensed is 500g in 7 sec. Based on the body weight of the shrimp farmers themselves adjusted the timer and operated the automatic feeder, Solar power was utilised by installing one solar panel along with control unit and 2 nos of 65 AH battery for store solar energy and utilise in the absence of solar energy time.

Solar based Autofeeder installed in farmer's pond



REPRODUCTION, BREEDING AND LARVAL REARING

Complete control over reproduction under captivity has been the most elusive goal of aquaculture since its inception. Further development of aquaculture will ultimately be determined by efficiency of reproductive technologies in par with other livestock production.

Diversification of farmed species has been well acknowledged as a tool for sustainable development of aquaculture. Indian brackishwater aquaculture is almost synonymous to penaeid shrimp aquaculture, particularly farming of exotic *Penaeus vannamei*. An aquaculture industry based on a single non-native species has always been constrained by inherent limitations, for example: limited source of supply, issues of emerging diseases and decline in the quality of broodstock. Development of potential native species is one of the options to resolve the issues related to exotic *P. vannamei* culture. Indian white shrimp, *P. indicus* has been identified as the national priority species for domestication and genetic improvement. With respect to faming of new species, several issues have to be resolved, particularly issues in captive reproduction and hatchery production. For the last five years the institute has been focusing on captive reproduction and domestication of candidate species for brackishwater aquaculture.

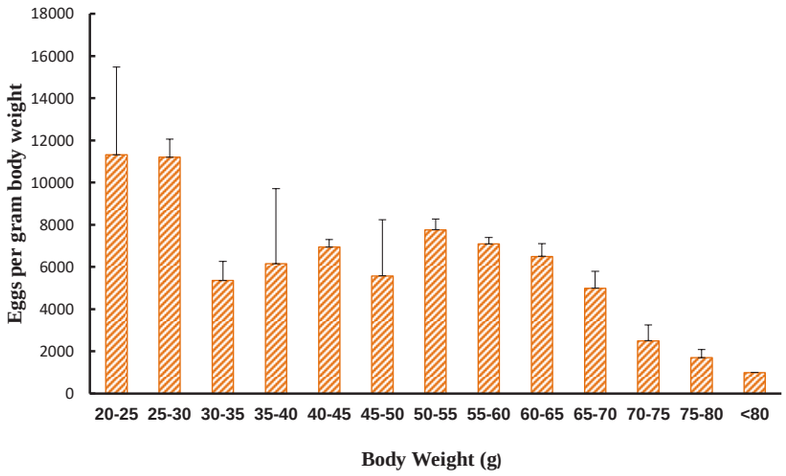
Penaeus Indicus

Development of captive reared broodstock of Indian white shrimp, *Penaeus indicus*: This research program was aimed to develop captive reared brood stock for *P. indicus*. More than 700 wild-caught *P. indicus* brooders were screened for WSSV, and seven experimental hatchery cycles were carried out using WSSV negative brooders. Although absolute fecundity was higher in highest size group (> 80 g), relative fecundity, eggs/gram body weight was highest in the lowest size group (20-25 g).

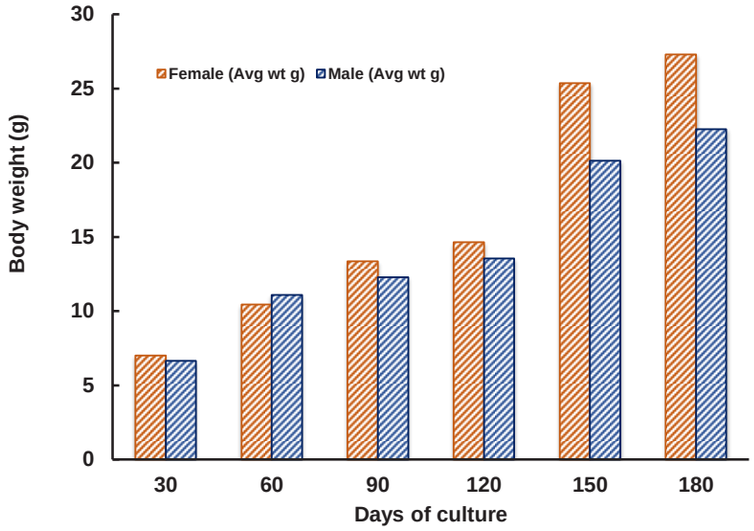
Eggs per gram body weight (mean ±SD) of Penaeus indicus brooders spawned during study period

Juveniles of *Penaeus indicus* (0.16±0.02 g) were reared in a polythene lined pond of 800 m^2 area at a stocking density of 5 ind./m^2 as well as in indoor cement tanks of 8 tonne capacity in 15, 30 and 60m^2 stocking density for 180 days. Growth characteristics were recorded in an interval of 30 days and sexual differentiation was possible in animals of 6-7 g average body weight by observing the secondary sexual characteristics. In the males, fully joined petasma and presence of spermatophores in terminal ampoule was observed in 11-12 g size class. Superior growth trend was observed for females from 90 days of culture onwards. Towards the end of the 180 days of culture, early maturing females were observed but accounted only 10% of the total female population. The tank reared animals exhibited poor growth and survival, which made sexual dimorphism visible post 140 days of culture. Significant difference was not observed in the final average bodyweight in the three different stocking densities after the completion of 180 days of culture at $P<0.05$. The tank reared females and males did not exhibit any sex related growth pattern, but fully developed spermatophores in the terminal ampoule was observed in males.

The pond reared females were further reared until reaching 30-45 g size, and noticed 100% mating and impregnation. Seventy percent of the impregnated females from pond reared stock were showed gonad development between advanced second stages to 3 rd stage of ovary development after 7 month



Fecundity (eggs per body weight) of *Penaeus indicus* brooders



Average body weight of male and female *Penaeus indicus* reared in plastic lined ponds for a period of 180 days

pond rearing at 1 no/sq.m. The matured female had an average weight 36.11±5.5 g , 15.38±0.48 cm, 3.61±0.34 CL. Female were subjected to unilateral eyestalk ablation and 16% female showed advanced gonad development after 3rd day of eye stalk ablation with 8% had spawning. Further to standardize the role of reproductive hormone in P. indicus brooders, 17β-estradiol was administered at a dose of 200 µL/female. Seventy percent of female at 2+ stage of ovary development stage spawned (fecundity: 75,000) with 80% hatchability.

Comparative evaluation of the spermatophore quality of *Penaeus indicus* in wild caught and reared in captivity (pond and cement tanks)

A comparative evaluation of the spermatophore quality was done in 180 days old cement tank reared and pond reared *Penaeus indicus*. The spermatophores were collected from both the groups and sperm count, spermatophore weight, viability etc. was analyzed. Both the experimental groups had the same age group but the body weight of the pond-reared animals were significantly higher. Additionally spermatophores qualities of wild caught males were also studied. Although spermatophores weight of the wild and pond reared males are similar, number of sperms in the wild male was significantly higher than the pond reared animals. The sperm count was

Male genital tract of *Penaeus indicus*

significantly lower in the cement tank reared animals but significant difference was not observed in the normal morphology of the sperm. The no of dead sperms was significantly higher in the tank reared animals (Table).

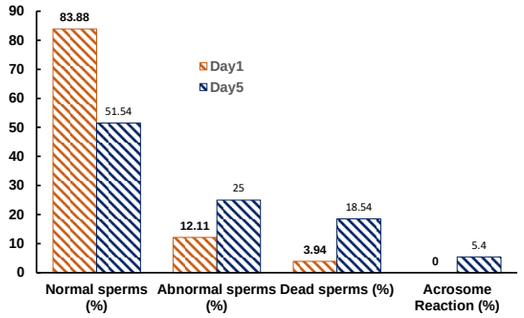
Comparative spermatophore quality parameters of *Penaeus indicus*

Variable	Tank	Pond	Wild
Body weight (g)	11.17±0.38[a]	20.63±1.34[b]	30.18±1.76 [c]
Spermatophores without sperm (%)	10	Nil	Nil
Spermatophore weight (mg)	79±0.3[a]	142±0.01[b]	144±0.02 [b]
Sperm count (106 Cells)	0.94±0.17[a]	19.87±3.22[b]	43.05±8.04 [c]

Data expressed as Mean ± S.E. Observations having different alphabet in the same row are significantly different at P<0.05.

Effect of short term chilled storage on the spermatophores quality of *Penaeus indicus*

To study the effect of short term chilled storage, spermatophores were collected in calcium free saline from inter-molt stage male *Penaeus indicus*. The collected spermatophores were stored at 4 °C and spermatophore quality characteristics such as viability, normal morphology and acrosome reaction was analysed. Number of normal sperms was significantly higher in the first day of sampling than the fifth day of sampling at P<0.05. Acrosome reaction was also observed in the stored spermatophores at five days of preservation. Beyond five days, the sperm cells were disintegrating and viability was also not observed. This study proves the applicability of chilled storage as a preservation method for spermatophores.

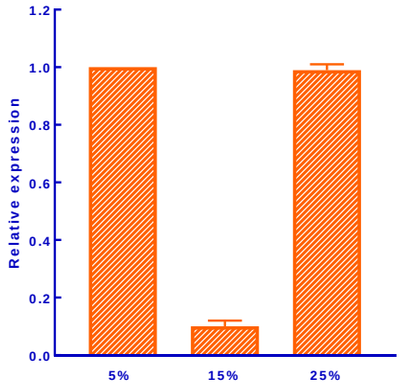


Percentage of normal sperms, dead sperms and abnormal sperms in the chilled stored spermatophores

Effect of various feeding regimes on the physiological characteristics of captive *Penaeus indicus* broodstock:

This study was carried out to evaluate the effect of different levels of maturation diet and captive rearing on physiological changes such as growth, molting rhythms and maturation hormone levels of captive *P. indicus* broodstock. Wild caught *P. indicus* brood stocks (TL-155±5 mm; BW-32.0±3g) were reared for 45 days at stocking density of 1:1 male and female ratio under standard hatchery conditions. The feeding regime of each treatments were maintained as 5%, 15% and 25% of body weight in triplicate with clam meat and formulated feed two times a day. After 30 days of rearing, the weight gain and specific growth rate of the each animal was measured. Mean weight gain of animals feed with 5%, 15%, and 25% were 0.45±0.12g, 1.11±0.9g, 0.72±0.35g respectively

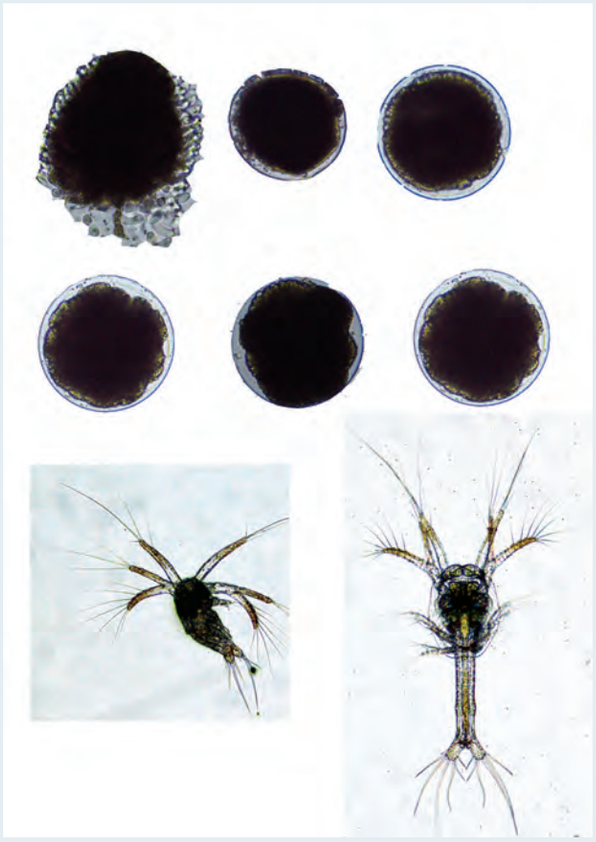
> ***Male spermatophores of Penaeus indicus can be preserved at 4 ° C without losing the viability***



Relative expression levels of GIH mRNA in the eyestalk of female Penaeus indicus reared under captivity

IN-VITRO FERTILIZATION AND HYBRIDIZATION POTENTIAL OF INDIAN WHITE SHRIMP, *PENAEUS INDICUS*

Management of reproduction of farmed shrimps under captive condition is the essential tool for developing selective breeding programs as well as for the interspecies hybridization procedure. Although reproductive biology of the shrimp has been studied in considerable details since the inception of commercial shrimp farming, mechanism of fertilization in penaeid shrimp has not been addressed in detail. The objectives of this study were: 1) to evaluate the feasibility of fertilizing capacity of preovulatory oocyte in vitro and trace the events of fertilization in *Penaeus indicus,* and 2) to examine the potential of hybridization of *P. indicus* with *P. monodon.* In the first experimental trial, females with ripe ovaries were dissected out, and ~1 million oocytes were mixed with 1 ml of sperm suspension. Fertilization and embryonic development were evaluated at every 15 minutes. The study shows that pre ovulatory eggs are capable for egg activation and fertilization. Hatching rate was calculated as 4.8% from the total number of egg fertilized, and 29% of nauplii developed up to PL stage. In the second trial, hybridization potential of *P. indicus* with *P. monodon* was evaluated using the procedure developed in the first trial.



Various steps of embryonic and larval development

Successful intra specific fertilization was obtained, although percent of fertilization was low (10%). The results suggest that the in vitro fertilization has been an effective tool in selective breeding and hybridization in penaeid shrimps. Further the study demonstrates that hybridization between interspecific species is possible even with evolutionary distant species, and that could be effective non transgenic tool for producing hybrids with improved aquaculture traits

which indicate that the adult stage animals would not grow, and the moulting may not for the growth of the animal. The moulting frequency of both male and female varied significantly from each feed group where the 15% BW showed higher moulting frequency 2 times in 30 per animal. Further, the feeding regime showed indirect relationship to the moulting stage and positively correlated with the moulting frequency. After the 45 days rearing GIH mRNA reduced to the minimum level at the treatment group where animals fed at the rate of 15% of body weight.

Effect of soil based substratum on impregnation in female shrimp

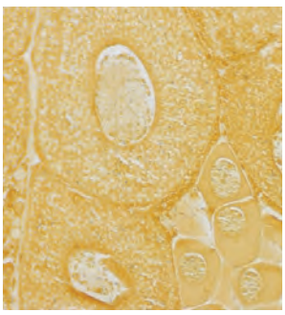
Captive rearing of *P. indicus* broodstock to close the life cycle is one of the major thrust areas of research to develop breeding program. Successful mating in confined indoor is a one of the challenge in breeding cycle of closed thelycum shrimps as impregnation is important for gonad development After 8-9 month indoor tank reared female reached average body weight 15.4±0.89g (14-16 g) carapace length, 2.82±0.15cm, and male 13.13±1.18 g (12-14 g) with carapace length 2.71±0.12. The male and females were restocked for maturation in soil based tanks system at 1:0.75 ratio and maintained photoperiod (18D:6L).The shrimps were fed with maturation feed (60%) and 40% live feed (mussels and Artemia). After 30 days , 57.14% male had milky white developed spermatophore and 60% of female were impregnated.

Effect of sex steroid E2 (17β-estradiol) on maturation and spawning in *Penaeus indicus*

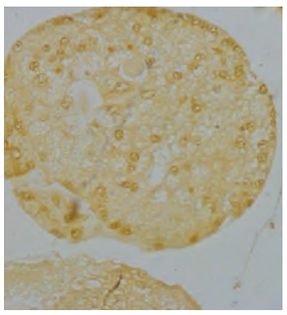
Artificial reduction of gonad inhibiting hormone (GIH) titre by unilateral eyestalk ablation has been the most widely used inducement method for spawning in commercial shrimp hatcheries. The success of this procedure largely depends on the physiological status of the animals. In order to optimize the induced maturation procedure, we have refined this technique by using downstream reproductive hormones such as 17β-Estradiol in addition to the eyestalk ablation. Administration of 17β-Estradiol (200µL/female) in ablated spawners triggered spawning with 75,000 fecundity and above 80% hatchability.

Maternal transmission of WSSV in wild *Penaeus indicus* spawners

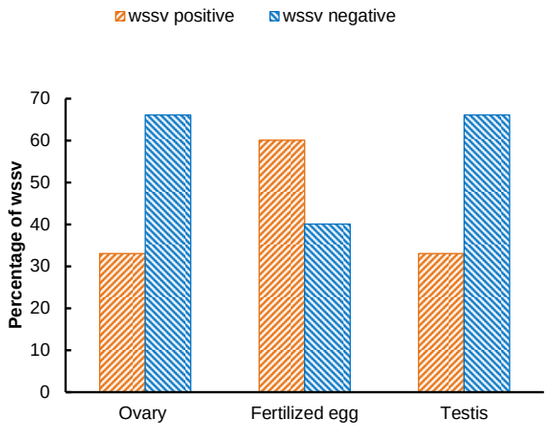
Indian white shrimp, *Penaeus indicus,* has been identified as the species of national priority for domestication and genetic improvement program in India. The viral pathogen, white spot syndrome virus (WSSV) is the most economically important virus that has been challenging the shrimp industry for the last two and half decades. WSSV prevalence were recorded during 2018-19 in different season revealed an average WSSV prevalence 45% and above 90% of the wssv positive brooders were only second step positive. Fertilized eggs and gonad tissue of the infected brooder were analysed further to quantify and tissue localization through real time PCR, *insitu* hybridisation and H&E stain. The preliminary WSSV quantification revealed low level infection with WSSV DNA copies below 50-70 copies /µL. Only 36% of gonad tissue, ovary and testis found to be infected whereas fertilized eggs recorded 60% WSSV positive while *insitu* hybridisation study of the fertilized infected egg and ovarian tissue did not give WSSV positive localization.



WSSV infected ovary



WSSV infected eggs In situe hybridization



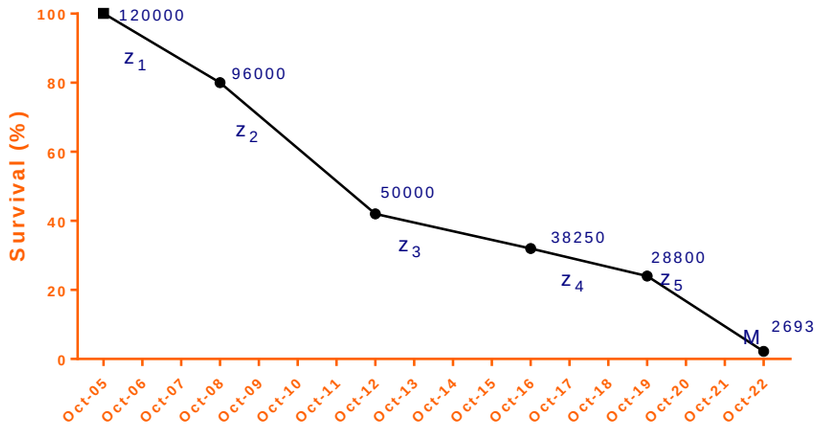
Percentage of WSSV infection in ovary, testis and fertilized eggs of *P.indicus* wild spawner

Mud crab

Mud crab, *Scylla serrata* has been the focus of diversification of brackishwater aquaculture in India. Salient observations of the research work carried out during this year are: A total of four hatchery runs were carried (and three were successful) out with a production of 2600 to 3200 megalopa per one unit of production system with a capacity of 4 mt with an average survival of 3. 2%.

Hatchery performance of mud crab *Scylla serrata*

Stage	Batch 1	Batch 2	Batch 3
Hatched	500000	1800000	4400000
Larvae reared	120000	156000	158000
Megalopa	2693	3200	2660
Megalopa/ larvae X 100	2.2	2.1	2

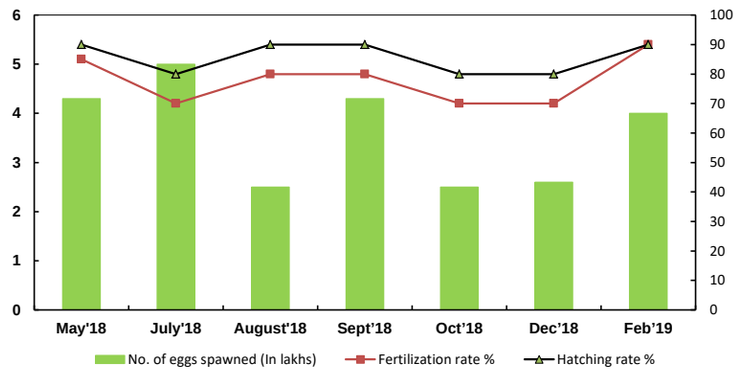


Larval survival of in a representative hatchery run of *Scylla serrata* (Z1 to Z5 Zoea 1 to 5 stages; M Megalopa)

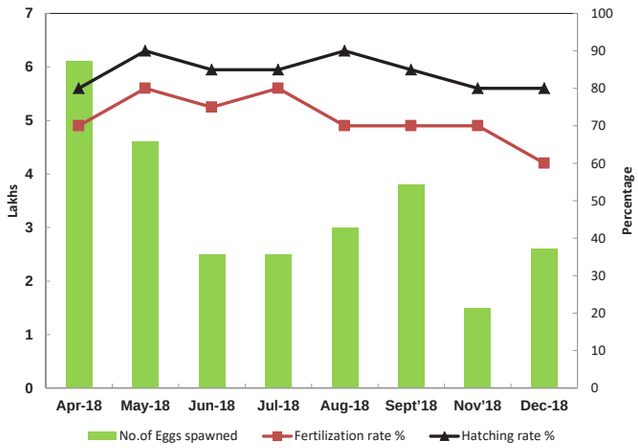
Seabass

CIBA's capacity in seabass seed production accomplished newer heights with the increasing demand for seeds from the farming sector

After the breakthrough in captive breeding and seed production of seabass by CIBA in the early '90s, farming seabass went through several stages of success and failures due to several technical and non-technical reasons. CIBA continue to support seabass as a diversified potential candidate for farming in brackishwater. In recent years, there is good progress in expansion seabass farming in both ponds and open water cages, using indigenous formulated feed. Realizing feed and seed are the two key drivers in the expansion of seabass farming, CIBA is putting enormous effort with advanced science to back



Performance indicator of Induced spawning in *Lates calcarifer* during 2018 -19



Performance indicator of natural spawning in *Lates calcarifer* during 2018-19

up these two areas. A total of 43 numbers of seabass broodstock is being maintained in different systems, viz. 20 numbers in open 100-ton RCC tanks, 18 numbers in two maturation units under RAS and five numbers in earthen pond. Eight broodstock procured from Machilipattinam, Andhra Pradesh were added to the existing stock during the year 2018-19. Further, CIBA is preparing to add broodstocks of diverse genetic make-up to the existing stock and to maintain them in open water cages as back up for the future. In breeding seabass under captivity, CIBA had succeeded in both natural spawning without hormonal induction and induced breeding with hormones. Nearly half of the spawning occurred in the last year was natural ones, in the optimum rearing conditions, almost throughout the year. A total of 5.53 million eggs were spawned, 2.66 million eggs spawned from spontaneous spawning and 2.87 million from induced spawning. We observed that the number of eggs spawned and the fertilization rate was higher in spontaneous spawning compared to the induced one using hormones.

To ensure the supply of disease-free seeds to the farmers, hatchlings were screened for VNN by nested PCR, and negative hatchlings only were further reared and sold to farmers.

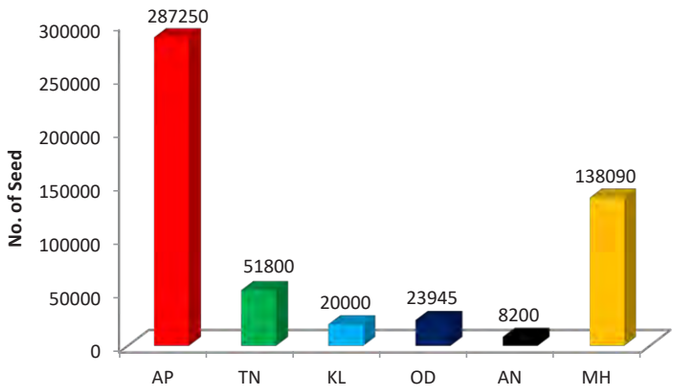
Highlights in the seed production and sale last year

An all-time high of 0.59 million fry seeds were sold in the year 2018-19 and a revenue of Rs. 1.72 million was realized from the sale.

For the first time, more than 1.20 lakhs seeds were completely weaned for artificial feed in the tank-based nursery, reared to more than 2 cm size and were supplied to Mangrove cell project being operated in Sindhudurg, Maharashtra.

A total of 32 farmers were supplied with seabass seeds during the year with about

54.27% seeds sold to Andhra Pradesh farmers followed by Mangrove cell Project, Maharashtra (23.5%).



Highlights in the sale of seabass seed production during 2018-19

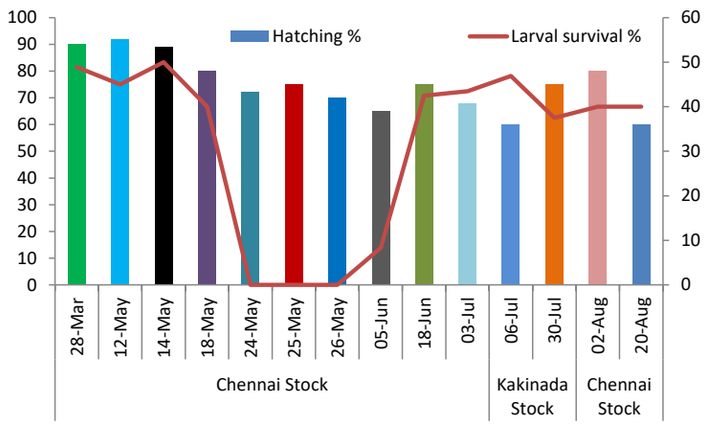
Milkfish

Captive breeding of two different geographical stocks of milkfish (*Chanos chanos*)

CIBA continue to do further fine-tuning and optimization of the captive breeding of milkfish after the first-time breeding of milkfish under captive conditions achieved on 8th June 2015, at our Muttukkadu fish hatchery. To evaluate the difference in reproductive performance of broodstock from two geographical locations in the east coast (Chennai (Avg. body weight 5.47 kg) and Kakinada (Avg. body weight 4.36 kg)), experiments were conducted simultaneously with the regular seed production process. Chennai stocks showed an extended breeding horizon for eight months (Feb-September) in 2017, compared to the broodfish sourced from Kakinada. Five does of combined hormone pellet were administered in both the stocks following similar breeding protocol and resulted in 14 total spawnings for six months (March-August) out of which two spawnings was from Kakinada population during month of July. It appears that the lunar cycle positively influences the milkfish spawning in Chennai population compared to Kakinada and the highest numbers of spawning occurred around 3.16 days around the new moon or full moon. Total 5.68 lakh hatchlings produced from 7.41 lakh fertilized eggs collected from both the population and under improved larval rearing protocol maximum larval survival achieved till 45 %. The milkfish fry were distributed among farmers and state fisheries departments of Kerala, West Bengal, Goa, Maharashtra, Gujarat, and Tamil Nadu. Total of Rs. 3, 74,084 revenue was generated from seed sale. Extended and multiple spawning of milkfish from both the population gives the possibility to overcome the challenges of year-round seed production, and pave the way to initiate satellite seed rearing centers outside CIBA hatchery.

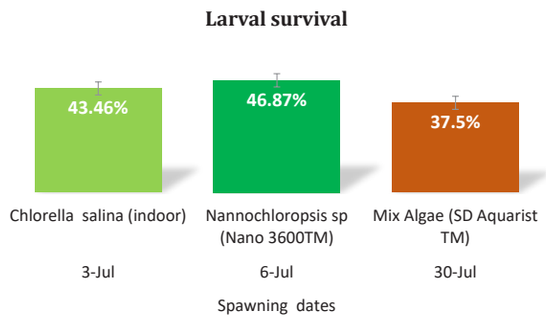
Enriched rotifer and length-based size gradation to manage differential growth in milkfish larvae

Uniform healthy larvae are success indicator in hatchery production of milkfish. Milkfish larvae show differential growth after three weeks of rearing. Differential size variation causes slow growth, the emergence of shooter, and price drop in commercial milkfish hatchery. An initiative was taken to compare the potential of live chlorella , commercial algal paste of *Nannochloropsis oculata* (Nanno 3600 TM , 68 billion cells/ml) and mix cocktail of six marine microalgae (SD Aquarist™) – *Isochrysis,Pavlova, Tetraselmis, Chaetoceros calcitrans, Thalassiosira weissflogii* and *Thalassiosira pseudonana* as rotifer enrichment source for larvae. Mass cultured *Brachionus plicatilis* (140 – 210 µm) were collected and enriched with frozen green commercial algae paste *Nannochloropsis oculata,* and fresh *Chlorella salina* (1:1 ratio) in a 100 L volume container overnight and were supplied as initial feed to the larvae @ 20-30 numbers ml-1 from 3 dph to 21 dph. Similar enrichment protocol carried out for SD Aquarist. *Nannochloropsis oculata* enrichment showed better survival (46.87%) compared to the other two sources, although size variation was evident in all the groups.



Breeding response of milkfish from two geographical population

Three size groups of milkfish larvae arise after third week i.e. large: 1.68-1.70 cm, medium: 1.09-1.11 cm and small: 0.74-0.76 cm. Larvae were collected from 8 t LRT and manually graded in commercially available sieves to uniformly stock in 1t LRT without altering previous feeding regimes. The initial result suggests 15 days post grading (till 30-32 dph) larvae achieves homogenous growth pattern of 1.9 to 2.5 cm and can be sold @ Rs. 4.0 /- per seed. Stakeholders can easily accept this practice without establishing a costly algal culture unit while undergoing satellite seed rearing.



Different algae for rotifer enrichment and larval survival

Grey mullet

Upright progress in captive breeding of grey mullet using farm reared parental stocks

Grey mullet *Mugil cephalus* is one of the most significant candidate brackishwater finfishes priced for its roe in global markets and valued as a high-value food fish in domestic markets. An increasing concern is being raised over the dwindling natural seed resources, which have affected the traditional fishermen and grey mullet farmers alike. As an innovative approach, since 2017, CIBA is attempting to use a low volume RAS based breeding system for captive reproduction of the species within the farm premises and then transporting the fertilized eggs to a hatchery facility for further hatching and rearing. During June-July, 2017, five successive breeding trials resulted in larval production and the fertilized eggs were transported to CIBA's pilot-scale hatchery at Muttukadu for further rearing. Larvae survived only for 8 days post-hatch.

Developmental statges of grey mullet larvae

In 2018, despite a drastically low salinity of 4 ppt in the pond system, three breeding attempts resulted in mass larval production. Female fish with average oocyte diameter of 535-550 µm were used. After a latency period, 15-16 h, 0.7 - 1.1 million eggs were obtained by dry stripping. Fertilization rate was observed to be 60%, and the size of fertilized egg and oil globule was 790- 810 µm and 290-300 µm respectively. Size of newly hatched larvae was 2.1 mm. At hatchery site, 1.25 lakh larvae were reared, using rotifer, *Brachionus plicatilis,* 5-20 no ml/ml, copepods and *Artemia* nauplii. Nanochloropsis, 1-2 lakhs cells per ml was used as the background phytoplankton. With all these differential efforts compared to the last year attempt, we obtained good survival up to 20dph this year as significant progress in captive breeding of mullet. Critical periods were recorded at 8 DPH and 13-15 DPH. Further refinements in larval rearing are in progress to standardize the captive breeding protocol of grey mullet in the near future.

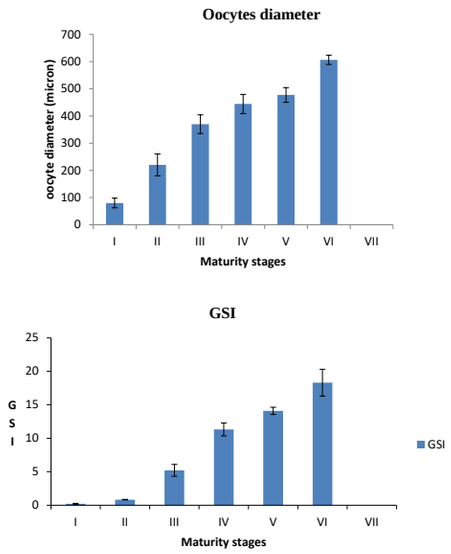
Geographically isolated grey mullet stocks display asynchrony in season and extent of spawning in captivity

Globally grey mullet aquaculture is carried out without any distinctions between the groups of the grey mullet species complex. However, some recent studies show that biological differences may also have significant economic implications for aquafarmers. Our observations from captive reproduction conducted in east and west coast show that the peak spawning period of the two geographical groups is asynchronous. Grey mullet stocks from east coastal waters and reared in captivity spawned in the beginning of November, while stocks from west coast showed active spawning during between mid-June and mid-July. We also noticed there is a significant difference in the extent of spawning season in relation to the wild and captive stocks irrespective of the origin. In the east coast and west coast, spawning in wild happens during captivity October to January and May to July respectively. This indicates that captivity affected the onset and duration of spawning periods differently in grey mullets. Our attempts at captive breeding between 2016-18 using these two geographical stocks of grey mullet have yielded varying results, some of these may indicate their biological differences.

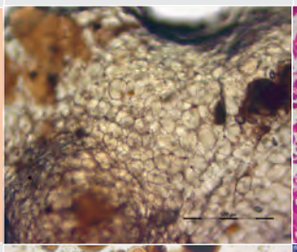
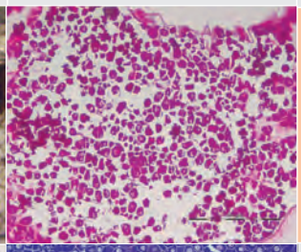
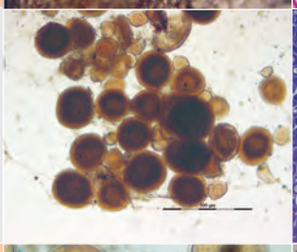
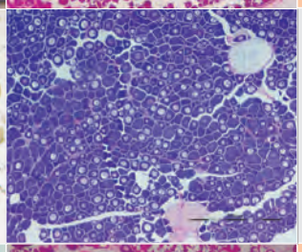
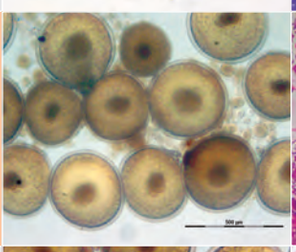
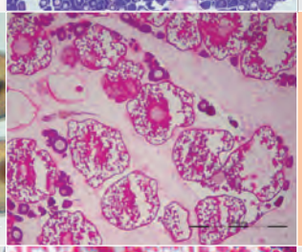
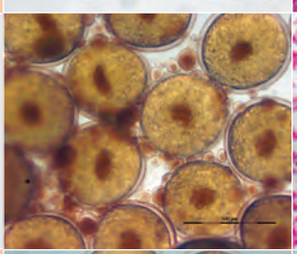
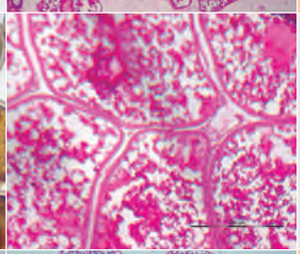
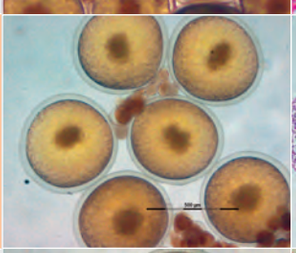
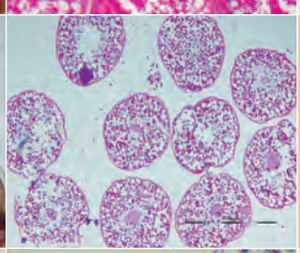
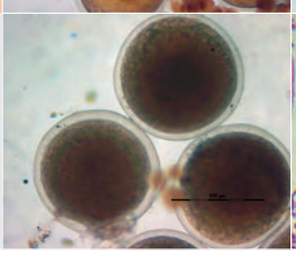
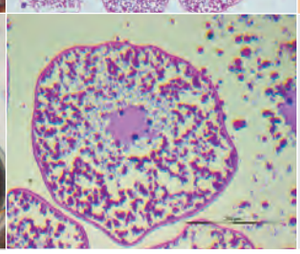
Goldspot mullet

Gonadal development of *Liza parsia* reared in brackishwater pond

A total of 300 sub-adult and adult Goldspot mullet, *L. parsia* (size: 50 to 110 g) were stocked in pond and fed with broodstock diet (32% protein and 8% lipid) @ 5% body weight twice daily. During the breeding season (November to January) gonad development is studied. During spawning season, dissolved oxygen, salinity, Ph was 6.4, 7 ppt and 8.2, respectively. Female fish (size: 70-110 g, n= 6) of different maturity stages were collected from the pond. Different maturity stages were defined as: immature (stage I &II), early maturing (stage III), late maturing (stage IV), mature (V) and ripe (stage VI). Gonadosomatic index and oocyte diameter of different maturity stages are shown in figures. The result showed that stage I, II and III have central GV; Stage IV have migrating/ eccentric GV; Stage IV have peripheral GV; Stage V showed germinal vesicle breakdown (GVBD); Stage VI showed ovulated oocytes. Further, it is observed that oocytes having less than 100 µm in diameter are non-vitellogenic in nature and *Liza parsia* attained the maximum GSI and oocytes diameter of 606.55±17.02 and 18.31±2.0, respectively in captive condition. This observation evident that broodstocks of *Liza parsia* could be easily developed using the the apt feed in pond based system, and there won't be any much trouble in getting brood fish for captive breeding.



Oocytes diameter and GSI at different maturity stages Gold Spot mullet

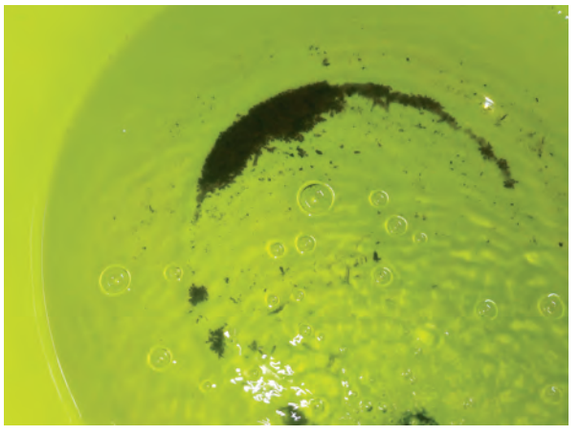
Stage of maturity	Oocytes	Histology	Vitellogenesis
Stage I (Immature-I, <100 µm)			Non-vitellogenic
Stage II (Immature-ii, Stage oocyte dia- 100-350 µm)			Previtellogenic
Stage III (early maturing, Oocyte dia- 350-400 µm)			Previtellogenic
Stage IV (late maturing oocyte dia- 400-450 µm)			Mid-vitellogenic
Stage V (Mature, (oocyte dia-450-500 µm)			Post-vitellogenic
Stage VI (Ripe, oocyte dia-500-600 µm)			Non-vitellogenic

Maturation pattern of pond reared *Liza parsia*

Pearlspot

Farmers adopt seed production of pearlspot *Etroplus suratensis* for additional income generation

Pearlspot fish culture has been constrained by the availability of quality seeds in the required quantity. Fish seed costs have been increasing over the years and range between Rs 4-10 per fish based on the size. Because of complex parental care and low fecundity, pearlspot could be an ideal species for homestead farming models and seed production. Year-round seed production provides an avenue to the farmers for additional income generation with simple infrastructure. Mr. Keerthiram, Alappuzha a fish farmer from Alappuzha signed MOU with ICAR-CIBA for adopting ICAR-CIBA's model for pearlspot seed production. He has successfully been producing pearlspot fry repeatedly from pairs of parent fish (breeding interval, 17- 35 days) through larval separation at the wriggler stage. He has been conducting larval rearing using *Artemia nauplii* and the fry produced has been used for stocking in his farm and sold to neighboring farmers. Farmers Mr. Baiju, Thrissur also successfully conducted homestead pearlspot seed production. Mr. Unni, from Ernakulam, has also initiated the activity after learning from them. This model may be promoted widely in Kerala, where this fish fetches good price.



Seed production of pearlspot in a homestead model

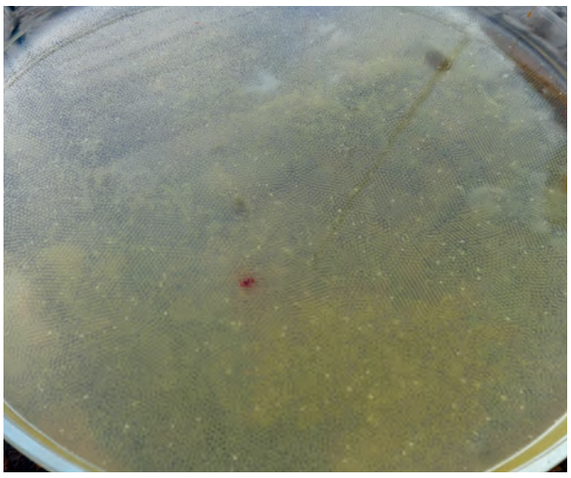
Hilsa

Captive breeding and nursery rearing of Hilsa, *Tenualosa ilisha* in an earthen pond system

Hilsa, *Tenulosa ilisha* is an important commercial fish of the Indo-Pacific region, especially Bangladesh, India, and Myanmar. At present, the total catch has declined in these countries due to obstruction of natural migration for breeding, overfishing, water pollution and sedimentation in rivers. Therefore, to conserve and develop aquaculture of this species domestication and development of captive stock is essential. Wild mature migratory fishes were breed through dry-stripping, and larval rearing methodology was developed by using earthen ponds. Oozing male (270±5.0 g) and female (780±15 g) fish during its spawning migration (February to April) were captured from Hooghly River at Godakhali, and breed through dry stripping. Fertilized eggs were incubated and after hatching three different age group of larvae such as:

Artifical fertilization of hilsa-stripping of females

3 days post hatching (dph)-before yolk sac utilization, 5 dph- after yolk sac utilization and 12 dph-before oil globule utilization were stock in well prepared nursery ponds (100 m2). Stocking density in each pond were approximately 100000 individuals. During nursery, larvae were fed with *Artemia nauplii* (2 g Artemia cyst in each treatment) along with powder feed (20 g). At weekly interval, fermented GNOC (100 g) was applied in each pond. After 60 days of the nursery, it is found that the significantly higher survival (5%) and low average weight (0.8 g) in 3 dph than the other two groups. However, the average size was significantly larger (1.8 g) in 12 dph group than the other two groups. Using this methodology, we were able to produce 5000 hilsa fry, and further reared to observe its performance in captivity.



Feritilized eggs of hilsa

Early larval developmental stages of fish hilsa

Late larval developmental stages of fish hilsa

12dph larvae (little oil globule)

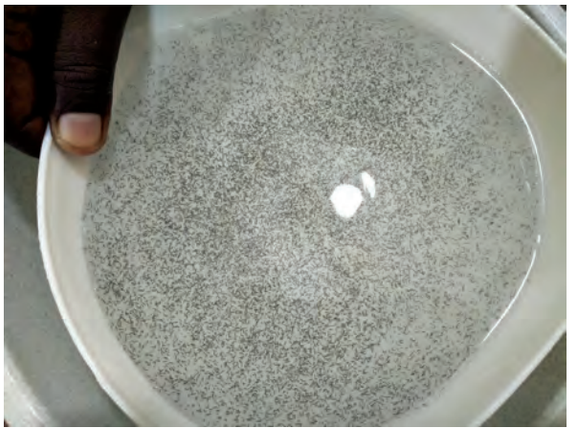
Young fry of fish hilsa

Juveiles of hilsa fish stocked in ponds

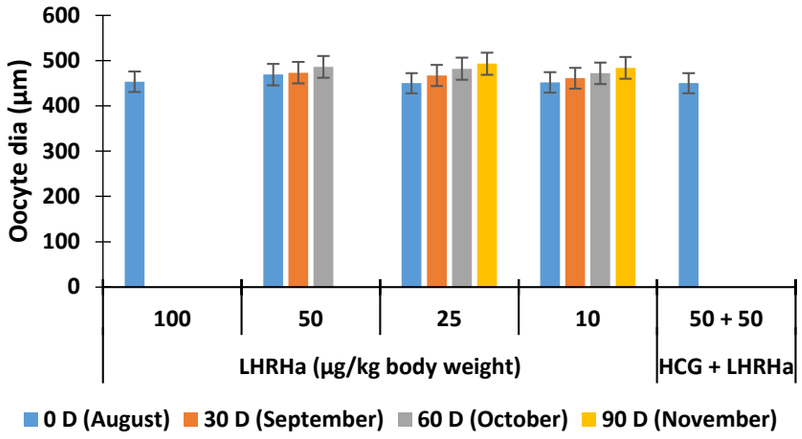
Ornamental Fish

Induced maturation and volitional spawning of spotted scat: In RAS based homestead fish breeding model

Spotted scat is a well-known euryhaline species which is valued as ornamental and food fish. Simplified Induced maturation and breeding techniques in captivity will boost the seed production by small scale farmers in their backyard or in simple, compact hatcheries cater to the growing market demand. A Recirculatory system of 3000 L capacity and 12.9 m^3/ day flow rate with central drainage was fabricated. Pairs were kept at 1:1 stocking density in each maturation/spawning tank. Females were induced either with varying doses of LHRha (100, 50, 25, 10 µg/kg body weight) or combination dose of LHRha + HCG (50 µg/kg b.w.+50 IU) which were delivered intramuscularly via cholesterol-based pellet. Males were induced with combination hormone dose of LHRHa + 17-αMT (25 + 25 µg/kg body weight). Experiment was successfully conducted for four months where hormone dose of 25 and 10 µg/kg could sustained the gradual increment of oocyte size. Oocyte size increased from initial dia of 450 ± 38.12 µm to 493 ± 18.5 µm with monthly LHRHa dose of 25 µg/kg and later led to successful spawning. Sperm density in males also increased from initial 17.68 ± 5.17 (X 10^9 spz/ml) to 25.21 ± 3.18 (X 10^9 spz/ml). Female scat brood fishes could be successfully induced to spawn with 25 µg/kg b. w. LHRHa monthly dose whereas combined dose pellet of 25 + 25 µg/kg of LHRHa + 17-αMT was helpful to increase sperm density in males. These optimized doses would be useful for attaining volitional spawning for larval production under RAS based captive conditions.



Just hatched scat larvae

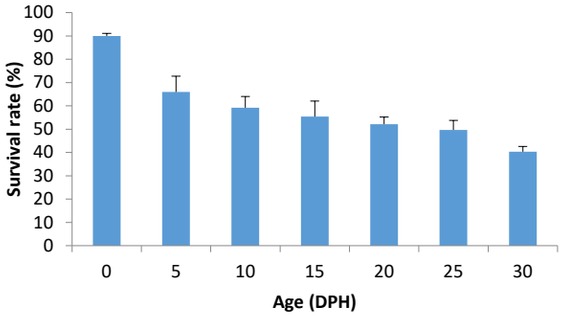


Effect of different hormone doses (Pellet) on oocyte diameter of female spotted scat

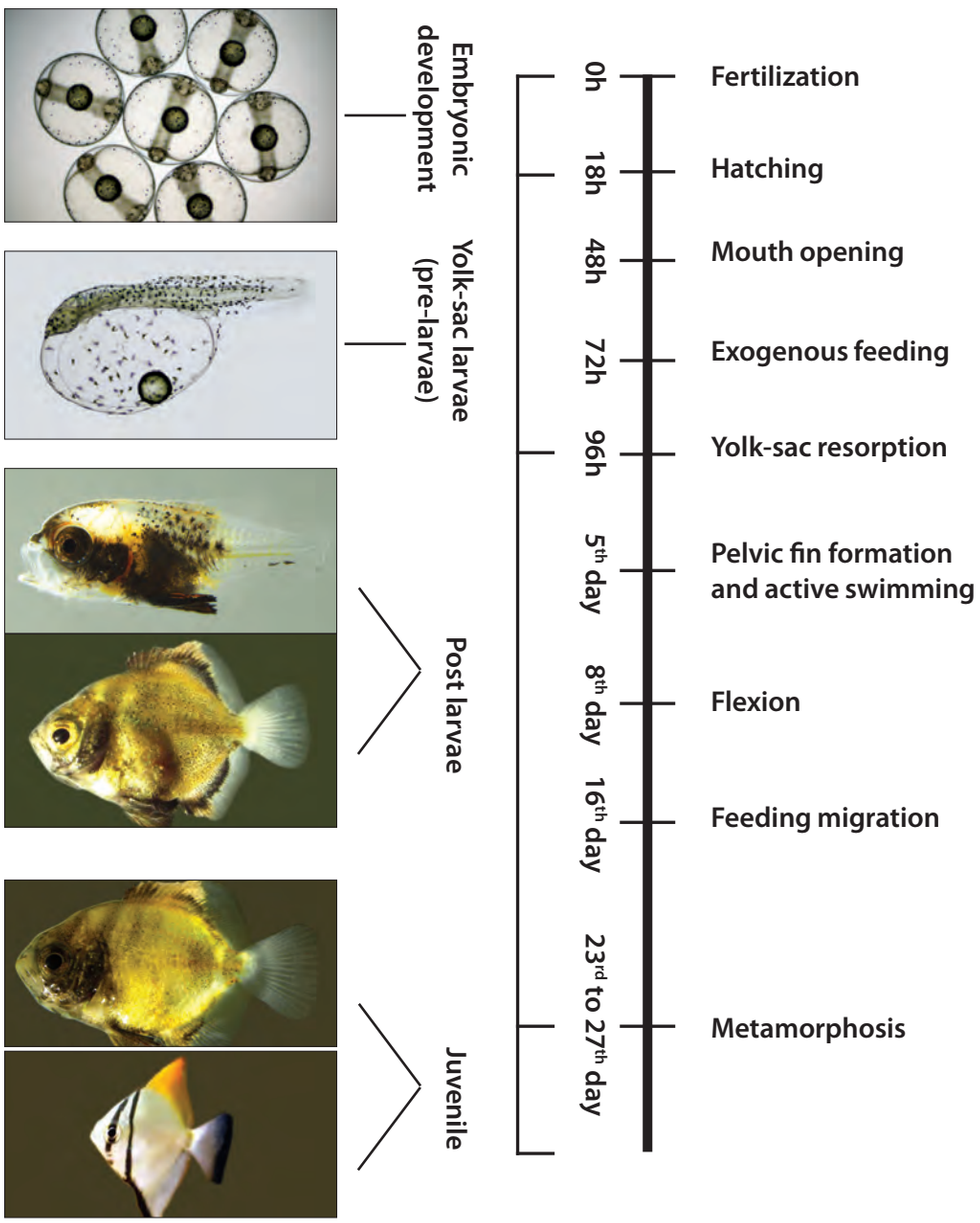
Captive breeding of Silver moony, Monodactylus argenteus a potential fish for brackishwater aquariculture

Silver moony, *Monodactylus argenteus* is a species of high demand in the international ornamental fish industry. CIBA for the first time attempted the broodstock maturation, induced breeding and larval rearing of silver moony in captivity for the first time. Sub-adults of silver moony collected from

Vennangupattu backwaters, Tamil Nadu, India (n=200 avg weight, 50 ± 7g) were maintained in fixed cages in pond system at Muttukadu Experimental Station on formulated broodstock feed (2mm, CP: 52%, CL: 10%) and *Artemia* biomass and monitored for sexual maturation in captivity. The breeding system consisted of FRP tanks, capacity 500 l (salinity 31ppt, temperature 28^{0}C,) provided with hideouts. Female with oocyte diameter > 500 µm and males with oozing milt were selected to maintain a sex ratio of, male: female; 2: 1 in the breeding tank. Hormonal



The survival rate of *Monodactylus argenteus* during the larval rearing



The main events of larval development in *Monodactylus argenteus*

induction for breeding was done using LHRHa. Natural spawning and fertilization were observed after 36 h of hormone administration. The fertilized eggs were transparent, pelagic, non-adhesive with single oil globule. The diameter of the egg was 860 ± 14.11 µm. Fertilized Incubation was done in 200 l black, cylindroconical tanks. The incubation period was observed to be 18 h, and the hatching percentage was 90%. Newly hatched larvae were 1.60-1.67 mm.

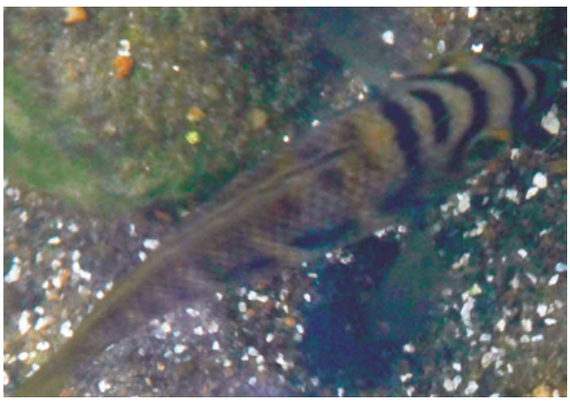
Development of seed production in captivity of silver moony will pave the way for the transition of ornamental fish trade of this species from wild caught stocks to more sustainable breeding based mode.

Broodstocks development of Canara Pearlspots, and Orange Chromide under captive conditions

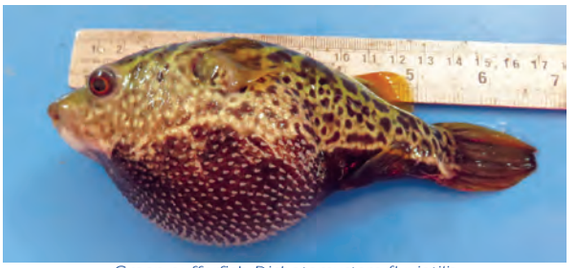
Canara Pearlspot and Orange Chromide are high values chromides highly preferred in the ornamental fish industry. Broodstocks development of Canara Pearlspots, *Etroplus canarensis* and Orange Chromide, *E. maculatus* were carried out at MES, Muttukadu. Adults of Canara Pearlspots, *E. canarensis* were subjected to different brackishwater condition. But there were no spawning notices in brackishwater conditions. But there was continuous spawning in freshwater conditions. We are expecting there will be in spawning in brackishwater after exposing the fish for generations in brackishwater. In orange chromide, spawning is noticed in all the salinities.

potential brackishwater ornamental fish species from Sundarban to explore the chances of captive breeding

Brackishwater ecosystem is the natural habitat of several ornamental fish species. Among them, only a few are being traded and have captive breeding protocols available. However, efforts in developing and popularization of seed production of untapped indigenous species will go a long way for building a robust ornamental fish industry in India. For this purpose, an 800 m^2 pond was prepared with crab and bird fencing as broodstock pond at KRC. Three different species, green pufferfish, *Dichotomyctere fluviatilis* (2 no.), mudskipper, *Pseudapocryptes elongatus* (215 no.) and Boddart's goggle-eyed goby/ mudskipper, Boleopthalmus boddarti (105 no.) were collected from Hooghly estuary and stocked at the broodstock pond. This stock is being strengthened further for captive breeding purpose.



Brood parents of Canara Pearlspots



Green pufferfish *Dichotomyctere fluviatilis*

Mudskipper, *Pseudapocryptes elongatus*

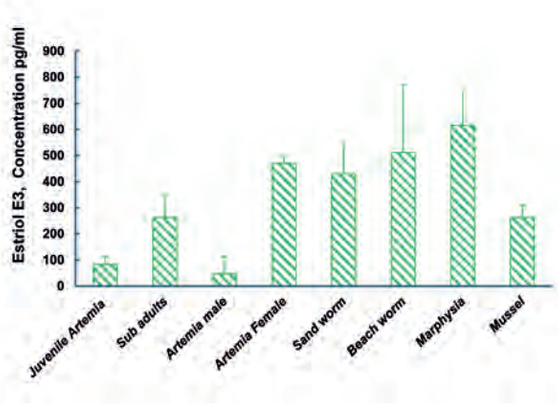
Boddart's goggle-eyed goby/ mudskipper, *Boleopthalmus boddarti*

Live feed

Although *Artemia* is not a natural diet of any of the aquacultured species, it is most convenient, least-labor-intensive and most widely used live feed in aquaculture facilities. *Artemia* has been one of the major focuses of research of CIBA for the last decades. The current year we have explored the potential of *Artemia* biomass as a maturation diet and as a vehicle for hormone delivery. Further, as a part of the diversification of live feed organism, we have studied the potential of copepod and nematodes. Copepod constitute the major part of the diet of early life stages of many finfishes, and crustaceans, however, use of copepod as a live food organisms in the aquaculture facilities is still limited. To address this issue, the potential for mass culture possibility of copepod has been explored during the current year.

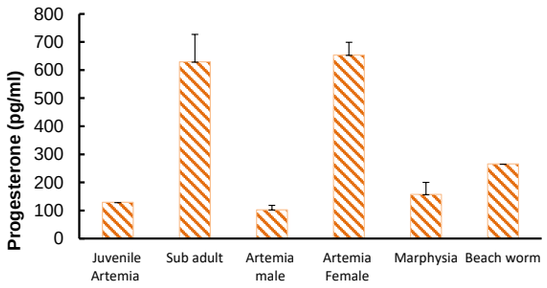
Artemia Biomass as a quality broodstock diet and biovehicle for hormone delivery

To understand the role of *Artemia* biomass as a quality broodstock diet for penaeid shrimps, presence of vertebrate sex - steroid hormones, for example: progesterone and estradiol in different life stages and sexes of *Artemia* was studied and compared with conventional maturation diets (e. g. polychaetes: sand worm, Neries sp., Blood worm, *Marphysia*, beach worm and mussesls: *Perna virdis*). The level of estriol E3, major metabolite of estradiol, was found to be highest in in adult female Artemia 471±24.60 pg / ml E3 However, among the all tested maturation diet,



Concentration of Estriol E3, (mean ±SD) noticed in different life stages of Artemia and different taxa of polychaete worms.

polychaete Marphysa spp had highest E3 titre (616 ± 131 pg / ml) To understand its role as a vehicle for hormone delivery, Artemia was enriched with 20 mg estradiol/3 ml alcohol. After enrichment, 22 fold increases in estriol bio encapsulation efficacy was noticed. The preliminary studies indicated the potential for replacing polychaete with Artemia biomass.



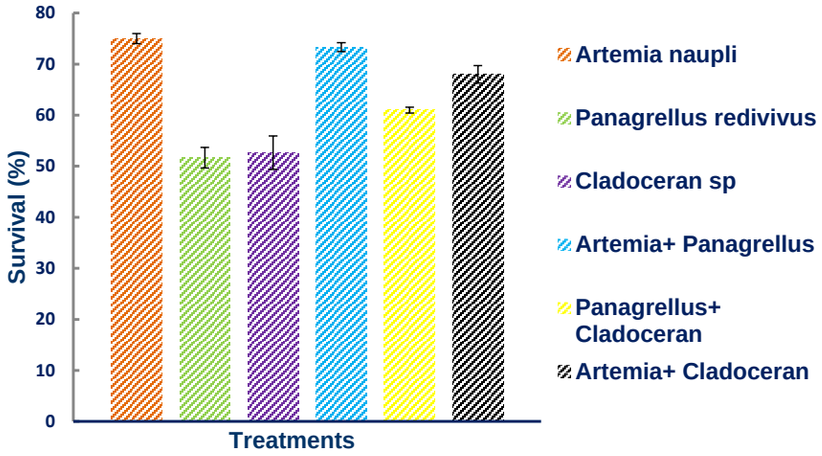
Concentration of progesterone (mean ±SD) in different life stages of Artemia and different taxa of polychaete worms.

Artemia biomass production in indoor system recorded highest biomass 3.29±0.5 kg/m^3 at 500 nos/L followed by 1000 (2.69±0.3 kg/m^3) and 2000 nos/L (2.59±0.5 kg/m^3). At lower density more than 90% of population attained maturation

Copepods: Copepods are important crustacean live feed, and it has been increasingly used as a live prey in finfish and crustacean larviculture. Several experiments were carried out to develop a commercially viable mass culture procedure for copepods. The growth performance of three species of copepods: *Dioithona* sp (Cyclopoida), *Pseudodiaptomus annandalei* (Calanoida) and *Evansula pigmaea* (Harpacticoida) were evaluated under different combinations of microalgae for a period of 20 days. Highest density was observed in the treatment with *Dioithona* sp (4000±155nos/l) with in a period of 7 days with a combination of *Nannochloropsis* sp and *Isochrysis* sp (cell density of 35000 cells/ml) followed by *Pseudodiaptomus annandalei* (2700±78 no /L) with in a period of 10 days using a combination of *Chaetoceros* sp and *Thalassiosira* sp and *Evansula pigmaea* (1800± 65 nos/L) with in a period of 8 days with a combination of *Chaetoceros* sp and *Isochrysis* sp. *E. pigmaea* had smallest nauplii (48±1.1µm), and *P. annandalei* had the largest *nauplli* (75±2.6 µm).). Among 3 copepod species, maximum density can be produced within short duration is *Dioithona* sp

Potential of Nematode and Cladoceran as live feed with reference to conventional Artemia based live feed: Ninety percent of *Artemia* cysts used in the global aquaculture industry comes from a single source (Great found lake, USA), where climatic changes would generate unforeseen issues in exploiting the wild Artemia cyst. At this background, potential of live feed such as Nematodes and Cladocerans were evaluated as shrimp larval feed with reference to the conventional Artemia based live feed. Nematode can survive up to 60ppt salinity, and can be cultured easily using yeast media and reached a maximum density of 0.1 million/ml within 2 days of culture period. An experiment was conducted using nematode species (*Panagrellus redivivus*) and Cladoceran species during the mysis stages of *P. indicus*. Experiment was conducted in 20 L plastic tubs with *P. indicus* zoea 3 with a stocking density of 100 numbers. *Artemia* naupli and Cladoceran species was fed at a rate of 10 no/ml and nematode at the rate of 100 no/ml and also in combination (1:1). No significant difference was observed among the treatments with control and combination of *Artemia* naupli and nematodes. Over all result indicate that microworm can be effectively used along with *Artemia* naupli during the mysis stage of *P. indicus* to reduce the cost of production.

Panagrellus redivivus could be a potential live feed in aquaculture as a alternate for atemia

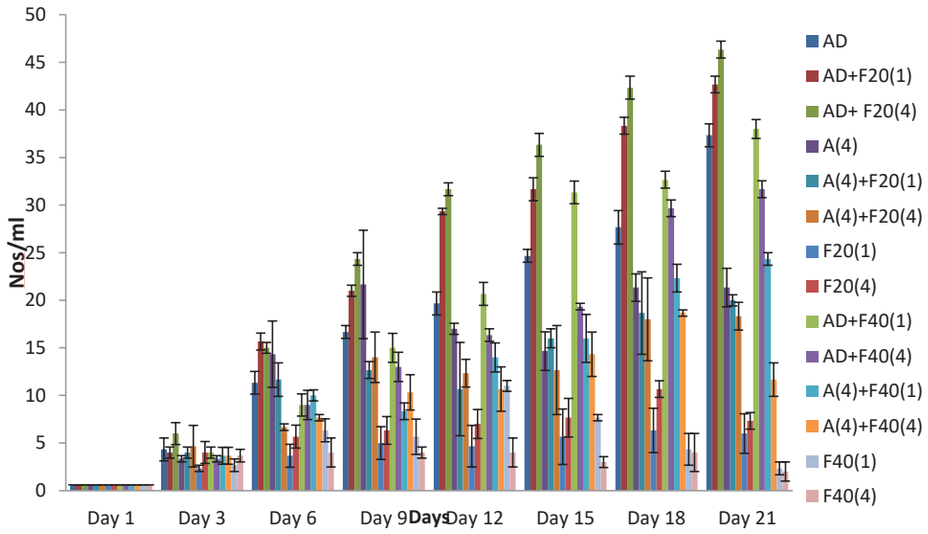


Percentage survival of *P. indicus* larvae fed different live feeds

Fish Trimming Hydrolysate (FTH) as Plankton booster for Copepod sp

An experiment was conducted using Cyclopoid copepod added with Fish Trimming Hydrolysate (FTH) at concentration of 20 and 40 ppm on daily basis and 4 days interval in combination with *Thalassiosira* sp and *Nannochloropsis* sp for a period of 20 days in 20L Plastic tubs. Copepod was added at the rate of 600 nos/l and counting was done in 3 days interval. Maximum density (Fig 3 & 4) was observed in the treatment added with 20ppm FTH on 4 days interval (46±0.9 nos/ml) followed by treatment with single dose (20ppm) i.e. 43±0.9nos/ml followed by treatment with single dosage of 40ppm

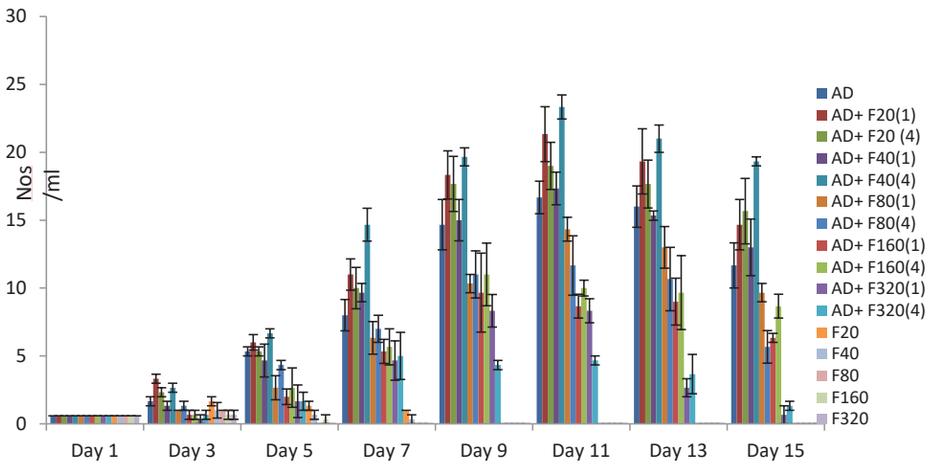
i.e.38±1nos/ml with daily inoculation of algae and control treatment (37+1.2nos/ml). There is a significant difference was observed between in control and treatment added with 20ppm FTH on 4 days interval dosage ($p<0.05$). Minimum density was observed in the treatment with FTH alone (Fig 5). Over all result indicates that FTH can be used as plankton promoter in combination with microalgae at a concentration of 20ppm.



Density of copepod/ml in different experimental treatments

Fish Trimming Hydrolysate (FTH) as Plankton booster for Cladoceran sp

An experiment was conducted using Cladoceran sp (*Eurycercus berinji*) FTH at a concentration of 20, 40, 80, 160 and 320ppm on daily basis and in 4 days interval in combination with *Thalassiosira* sp and *Nannochloropsis* sp for a period of 20 days. Cladoceran was inoculated at a rate of 600 nos/L and counting was done on 2 days interval. Maximum density was observed in the treatment added with 40ppm FTH (23+0.9nos/ml) on 4days interval dosage>FTH at 20ppm on single dose (21+2.02nos/ml)> FTH at 20ppm on 4 days interval (19+1.7nos/ml)> control (17+1.2nos/ml) with daily dosage of algae on 11th day. Minimum density was observed in treatment with FTH alone. Overall result found that FTH can use as plankton booster for Cladoceran species in combination with microalgae at lower concentration (40ppm on 4 days interval).



Density of Cladoceran in different experimental treatments


भाकृअनुप
ICAR
CIBA
Seebass Plus
genous Seabass feed of ICAR-

NUTRITION AND FEED TECHNOLOGY

In any aquaculture, feed and its management cost often range from 40 to 60 % of the cost of production and a key factor in determining the profitability to the farmer. India's aqua feed sector was more vibrant with current production around 2 million metric tons of feed, and it is expected to grow further. Our dependency on overseas companies for the hatchery feeds is expensive recurring cost. Envisaging these situations, CIBA's nutrition research focus more on issues directly applicable to the stakeholders such as cost-effective grow-out feeds, indigenous hatchery feed technology, live feed, feed management options considering natural feeds etc.

Evaluation of newer feed ingredients for use in aquafeeds

Weevil infested Sweet potato meal as a novel ingredient in shrimp feed

Sweet potato weevil is the most serious pest of sweet potato, with reports of losses as high as 97% in areas where the weevil occurs resulting in huge loss of the crop. This weevil infested sweet potato meal (WSPM) is unfit for human consumption and is disposed of as waste. In order to ascertain its potential as an ingredient in the diet of *P. vannamei*, nutritional composition was analyzed and feeding experiment was conducted for 60 days in vannamei juveniles (4.26± 0.21) by using WSPM at 5,10,15, 20, and 25% replacing wheat, a commonly used carbohydrate source, on (W/W) basis in the shrimp diet. The sweet potato meal contains higher NFE, indicating the nutritional richness of available carbohydrate. As the level of weevil infestation increases, there is a slight increase in crude protein. The chemical analysis indicated that weevil infested sweet potato could be explored as an alternate ingredient to wheat. The results also revealed that WSPM could be effectively used up to 10% in the vannamei diet without affecting growth and FCR.

Nutrient composition of Weevil infested sweet potato meal

Nutrient	Low infestation	Medium infestation	High infestation
			
Moisture	11.23	11.66	11.78
Crude Protein	4.13	4.21	5.1
Ether Extract	1.11	1.3	1.62
Total Ash	3.65	4.02	5.15
Crude Fibre	4.56	4.54	7.34
NFE	75.32	74.27	69.01
AIA	0.59	0.69	0.86

Effect of yeast fermentation of ground nut oil cake on nutrient digestibility, growth and nutrient utilization in *P. vannamei*

Ground nut oil cake (GNC) was fermented with yeast, *Saccharomyces cerevisiae* at 60-65% moisture for three days. The fibre fractions are not much influenced by yeast fermentation in ground nut oil cake except the reduction of cellulose fraction (8.77 to 7.78%). The nutrient digestibility in terms dry matter and protein were determined by ingredient substitution method in *Penaeus vannamei* (Average initial weight 12.87g). The apparent dry matter and protein digestibilities increased from 56.92 to 60.87 and 79.07 to 85.12%,

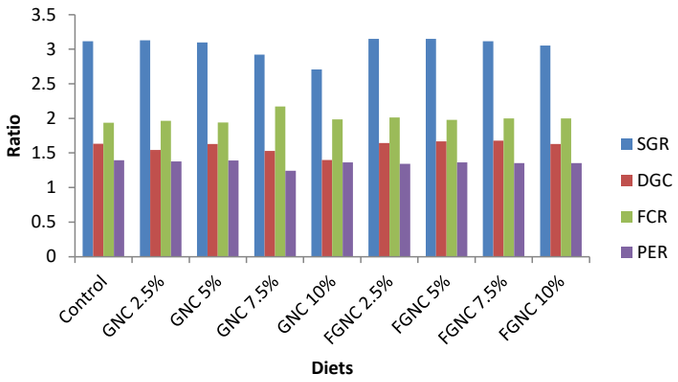
respectively from raw ingredient to fermented ingredient. For optimization of the inclusion level in shrimp feed, nine test feeds having 0, 2.5, 5.0, 7.5 and 10% levels of raw and yeast fermented GNC were prepared by replacing fishmeal. The results indicated that yeast fermented GNC can be included up to 10% whereas raw GNC could be included up to 5% in *P. vannamei*.

Effect of fermentation of mangrove leaves on proximate and mineral composition

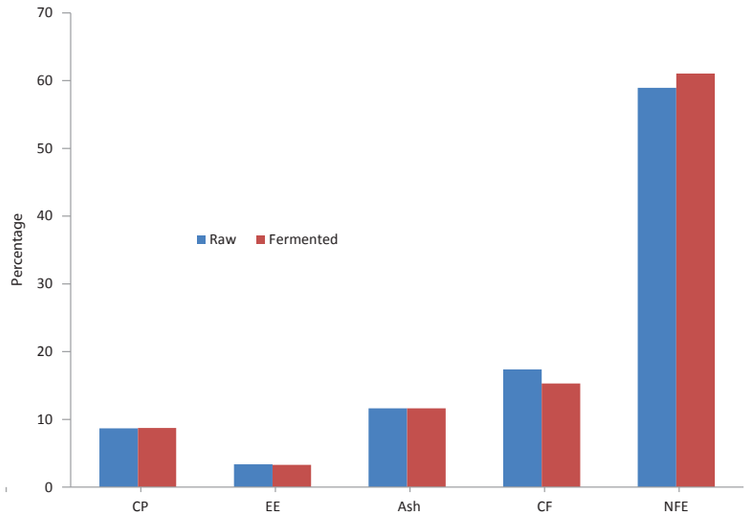
In order to utilize the mangrove leaves as an ingredient in aquafeeds, the mangrove leaves, *Avicennia marina* were collected from Nagayalanka, A.P. The proximate and mineral profiles were analysed. These leaves contain 66.8, 2.88, 1.12, 3.86 and 5.77% of moisture, crude protein, ether extract, total ash and crude fibre, respectively on as is basis. The mangrove leaves contained 173, 245, 149, 805, 4.2, 2.7 and 0.5 mg/100g of Ca, K, Mg, Na, Fe, Mn and Zn, respectively. The effect of fermentation on changes in proximate composition has indicated not much variation except for slight reduction of crude fibre levels.

Seaweed as a source of natural binder in shrimp feed

Seaweed, *Gracillaria tenuistipitata* has been selected as a potential natural binder and its effect was studied in the diet of *P. vannamei* feed. Seaweed was included at 0 (negative control), 2, 4 and 6% in the CIBA Vanami^{Plus} feed and compared against the standard control diet containing synthetic binder as a positive control. Experimental feeds prepared were subjected for hardness and bulk hardness studies using TA. XT plus texture analyzer. Feed was compressed with 2 mm (for hardness) and 32 mm



Effect of fish meal replacement with varying levels of unfermented and yeast fermented ground nut oil cake in the diets of *P. vannamei* on growth and nutrient utilization



Effect of yeast fermentation of mangrove leaves on proximate composition

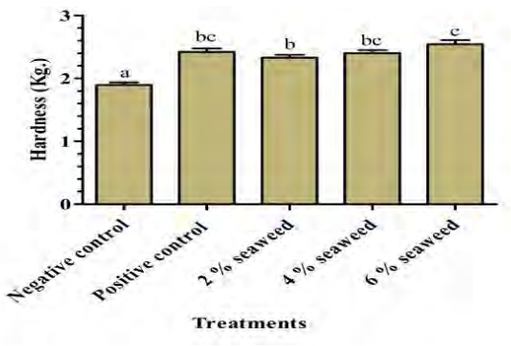
diameter (for bulk hardness) cylindrical probes with 60 % compression, 1mm/sec speed, and 0.001 g trigger force. Results indicated that hardness of the pellets of different treatments was significantly different ($P < 0.05$). Hardness (2.54 kg) and bulk hardness (21.22 kg) in 6% seaweed incorporated feed were similar with commercial feed (2.42 kg) indicating the potential of seaweed as alternate for the synthetic binder in shrimp feed preparation. In addition, seaweed is also known to offer other nutraceutical benefits for the farmed shrimp.

Proximate and mineral composition of wild and cultured Gracilaria tenuistipitata

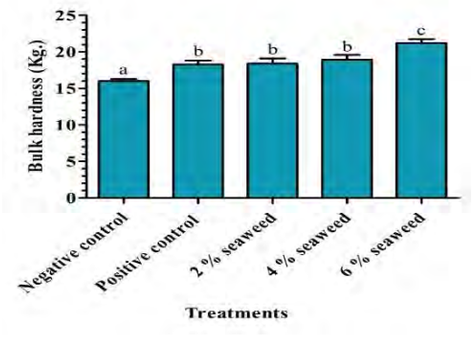
Comparative study was conducted to assess the nutrient composition of wild and cultivated seaweed. Crude protein was significantly higher in cultured Gracilaria compared to wild Gracilaria. Na, K, P, Mn and Se content were significantly higher in cultured compared to wild seaweed. Results indicated that cultured Gracilaria could be of use as a potential ingredient for aquafeed preparation.

Nutrient profile of marine macroalgae

Six species of marine macroalgae, Red algae (*Gracilaria corticata, Champia compressa*), Brown algae (*Turbinaria conoides, Dictyopteris*) and Green algae (*Halimeda macroloba, Caulpera racemosa*) were analysed for proximate, fatty acid and mineral compositions. Biochemical composition of collected seaweeds species revealed that crude protein, total Ash, crude fiber ranges from 5.03 to 9.17%, 37.31 to 70.22%, 8.1 to 14.56%, respectively on dry matter basis. Total lipids range from 420 to 1660 mg/100g while PUFA content was 52.41 to 376.70 mg/100g on dry matter basis. Mineral profile revealed that high Ca



Hardness of feed pellets containing different levels of seaweed (Mean ± SE, n=10).



Bulk density of feed pellets containing different levels of seaweed (Mean ± SE, n=10).

(g/kg) content was observed in *Halimeda macroloba* (141.43) and lowest was in *Gracilaria corticata* (8.321) while Se (g/kg) was high in *Halimeda macroloba*, *Gracilaria corticata* (0.91) and low in *Turbinaria conoides* (0.68) and Zn ranges from 0.02 to 0.26 g/kg. Seaweeds are rich source of minerals, low in crude protein, total lipids and PUFA. Among collected seaweed species *Halimeda macroloba* has shown higher mineral profile. Cultured *Gracilaria tenistipitata* contain lower Ca and Fe (0.235, 0.555) and higher P

Proximate composition (%) of wild and cultured seaweed

Proximate composition (%)	Wild	Cultured
Moisture	88.10 ± 0.04	90.16 ± 0.21
Crude protein	19.42 ± 0.14[a]	22.57 ± 0.08[b]
Crude lipid	0.55 ± 0.01	0.51 ± 0.06
Crude mineral	37.62 ± 0.02[a]	38.61 ± 0.03[b]
Insoluble mineral	8.47 ± 0.45	8.56 ± 0.84
Crude fiber	7.35 ± 0.15[a]	6.39 ± 0.15[b]

Mineral composition (%) of wild and cultured seaweed

Mineral composition (g/kg)	Wild	Cultured
Calcium	2.31 ± 0.023[a]	2.23 ± 0.009[a]
Magnesium	6.28 ± 0.036[a]	6.38 ± 0.035[a]
Sodium	26.33 ± 0.007[a]	27.46 ± 0.009b
Potassium	107.48 ± 0.006[a]	108.48 ± 0.005[b]
Phosphorous	2.11 ± 0.052[a]	3.83 ± 0.004[b]
Iron	2.38 ± 0.005[a]	1.89 ± 0.667[a]
Copper	± 0.00[a]	0.01 ± 0.001[a]
Manganese	0.11 ± 0.001[a]	0.37 ± 0.007[b]
Zinc	0.31 ± 0.005[a]	0.18 ± 0.004[b]
Selenium	4.10 ± 0.057[a]	7.55 ± 0.008[b]
Crude fiber	7.35 ± 0.15[a]	6.39 ± 0.15[b]

Each value represents Mean ± S.E, n = 3. Values in the same row with different superscripts are significantly different (P < 0.05)

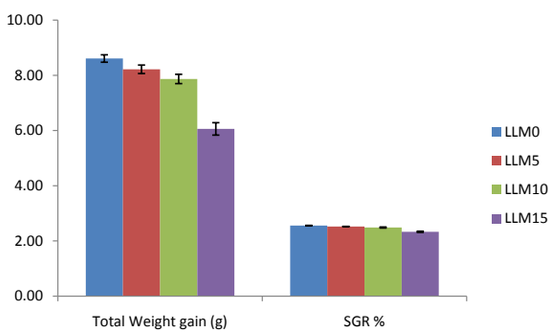
and Se (3.825 and 7.532 g/kg) in cultured seaweed samples compared to wild (2.863 and 2.371; 2.02 and 4.001 g/kg, respectively).

Leucaena leucocephala as a low-cost feed ingredient in milkfish fingerlings

Leucaena leucocephala is a fast-growing leguminous plant which can be grown on dry lands. It is a cheap source of protein (CP-21.06 %) with high nutritional value. To reduce the cost of the feed this study has been conducted. Four iso-nitrogenous diets (CP-29%), with *Leucaena* leaf meal (LLM) at 0, 5, 10 and 15 % were formulated and tested on milkfish in a 49 days trial. No significant difference in average body weight gain was observed between control and 5 % LLM fed group. Body weight gain reduced (P<0.05) when LLM was incorporated above 5 % level. Histopathological observation revealed no effect on liver tissue at 5% level but degenerated nucleus and vacuole formation found at 10% and 15% level which indicates LLM can be incorporated safely at 5% level without affecting growth and survival of milkfish.

Availability of marine protein sources in Sundarban, West Bengal

Fish is an important part of the regular diet and is a cheap source of protein for the peoples of West Bengal. About 78% of total fish catch is consumed in fresh condition, 6% is used as dry fish and rest is used as frozen fish. Around 20% of the dry fish are used for fish meal/poultry feed. A survey was conducted during November 2018 to January 2019 to have information on availability of dry fish and common species used for making dry fish in Namkhana, Kakdwip and Sagar block of South 24 Parganas of West Bengal. Available dry fish species were *Trichurus russelli* (1.5 t), *Harpodon nehereus* (11 t), *Setipinna phasa* (8 t), *Coilia ramkarati* (10 t) and *Atrobucca nibe* (16 t). The highest protein content was found in Atrobucca nibe (CP-69.25%) whereas other species contained protein ranging from 62 to 64%. Total 15000 t of dry fish at Frazerganj, 18900 t at Kalisthan, 200 t at Kakdwip, 10150 t at Sagar and 450 t of Acetes at Mousumi were produced during last winter.

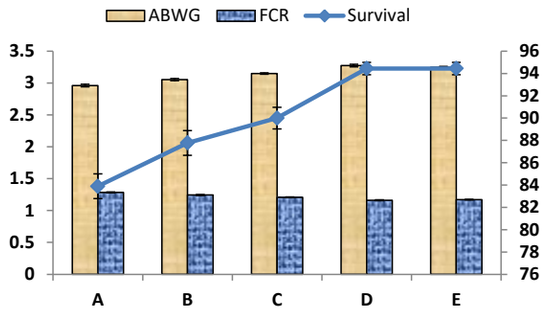


Growth performance of milkfish fed different level of *Leucaena leucocephala* in the diet

Feed additive

Effect of dietary C-Phycocyanin in growth and health of *Penaeus vannamei*

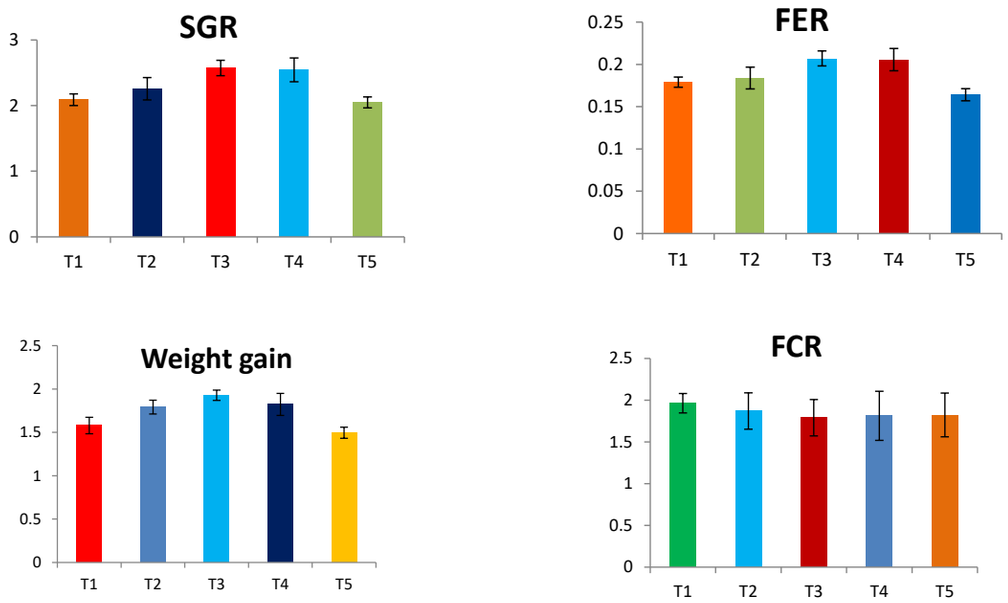
C-Phycocyanin, an intense blue pigment extracted from locally isolated spirulina, *Arthrospira maxima*, used to formulate shrimp feed with different concentrations. A significant increase ($p<0.05$) of average body weight gain, survival rate and better FCR was observed in *Penaeus vannamei* juveniles fed with feed containing 750 and 1000 mg C-Phycocyanin/ kg of experimental diet compared to other treatments (250 and 500 mg/kg C-Pycocyanin inclusion) and control (0% C-PC) in a 45 days trial. A challenge study with pathogenic *Vibrio parahaemolyticus* for 5 days post feeding trial revealed that the animals fed with higher concentrations of C Phycocyanin (750 and1000 mg/kg) had better survival and less haemolymph vibrio load. Study revealed that C-Phycocyanin extracted from spirulina can be incorporated in the shrimp feed formulations for boosting growth and immunity.



Growth perfomance of Penaeus vannamei fed different levels of C-Phycocyanin

Krill oil as feed additive

A study was conducted to evaluate the effect of Krill oil supplementation on growth and immunomodulatory potential of *Penaeus vannamei* juveniles. Krill oil was included at 0.1% (T1), 0.2% (T2), 0.4% (T3), 0.8% (T4) and compared against the control diet without krill oil supplementation (0.0%). After feeding trial, shrimps from each treatment group were challenged with 0.1 ml of virulent *V. parahaemolyticus* suspension at a concentration of 10^7 CFU ml^{-1}. The post-challenge sampling was performed after 7 days of injection. The growth and survival rate of shrimps fed with krill oil diet was significantly ($p<0.05$) higher as compared to control group. Study revealed that 0.4 % krill oil may be incorporated in diet of *Penaeus vannamei* juveniles for getting better growth and survival.



Growth and nutrient utilization of Pacific white shrimp fed krill oil.

Optimization of nutrient requirements

Early weaning of seabass larvae with improved indigenous seebass Larvi *plus*

A suitable micro-particulate feed is critical input for attaining optimal growth and survival after weaning the larvae from live feeds. A 12 day feeding experiment was conducted in triplicates for testing indigenous larval micro-diet in Seabass larvae. Experiment was conducted in 500 L capacity circular FRP tank. Seabass larvae, 21 dph (10.52±0.45 mg) stocked at a density of 500 larvae/tank were fed at 10% body weight twice daily. The final avg. body wt. and total length after 12 days were found to be 127.29±11.14 mg, 2.3±0.3 cm, respectively. Survival (%) was found to be 80.03%. The relatively lower feed cost and higher growth performance with indigenous larval feed indicates its potential as an alternative to commercial feed for larval rearing of seabass. Further studies are required for optimization of larval nutrient requirements and feed management practice to further reduce the feed cost and enhance the returns.

Optimization of level of taurine in diet of milkfish larvae

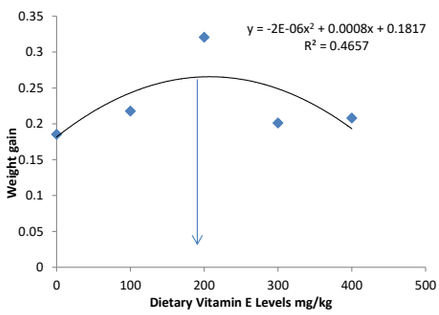
For optimization of taurine level in diet of milkfish (*Chanos chanos)* larvae, isoproteinous (CP-47 %) isolipidic (EE-9 %) feed was prepared with varying level of taurine i.e., 0, 0.25, 0.5, 0.75, 1.0 and 1.25 %. *Chanos chanos* larvae (Av. Body wt. 0.061±0.005 g) were randomly distributed in 18 glass tanks (90 L water each) of recirculatory aquaculture system (RAS) @ 20 larvae per tank and the feeding trial was carried out in triplicate for 60 days. Average daily gain, Weight gain percent, specific growth rate were higher and FCR was lower in *Chanos chanos* supplemented with 1 % taurine. Survival (%) was higher (P>0.05) in all taurine supplemented groups though statistically not significant. Survival was maximum in group supplemented with 1.0 % taurine. Experiment revealed that 1.0 % taurine supplementation was found to be optimum in diet of *Chanos chanos* larvae.

Vitamin E requirement for milkfish Larvae

A forty five day study was conducted to examine the effect of dietary vitamin E supplementation on growth of milkfish larvae. Five iso-nitrogenous and iso-energetic (550 g protein per kg and 120 g lipid per kg) experimental diets were prepared with varying levels (0, 100,200,400 ppm) of vitamin E (α-tocopheryl acetate) supplementation. Milkfish larvae with a mean body weight of 48.25± 5.32 mg were fed with experimental diets in triplicates following a completely randomized design. Study revealed that milkfish fed with diet supplemented with 200–300 mg/kg of vitamins E showed enhanced ($p < 0.05$) growth performance, and survival. The results of the feeding experiment based on the second-order polynomial regression analysis revealed that the dietary vitamin E requirement for optimal growth of *C. chanos* larvae was estimated to be in the range of 196–218 mg α-tocopheryl acetate per kg.

Mobilization of fatty acids in Hilsa during different stages of maturity

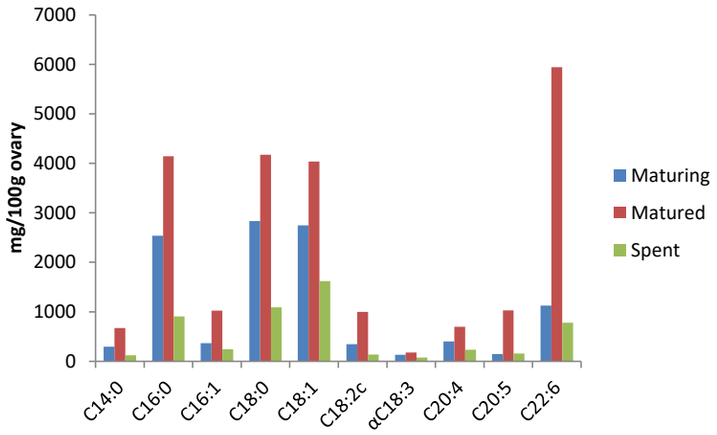
Hilsa, *Tenualosa ilisha* is a highly valued anadromous clupeid distributed in the Ganga-Brahmaputra-Meghna river. In order to develop a suitable brood stock feed, the mobilization pattern of fatty acids were analysed in pond reared brood stock at varying stages of maturity. The muscle of immature fish contains



Estimation of dietary vitamin E requirement for optimum growth of C. chanos larvae using second-order polynomial regression analysis

2466, 796, 953, 1308,176, 284 and 1450 mg/100 g of C16:0, C16:1, C18:0, C18:1, C20:4, C20:5 and C22:6, respectively. The matured ovary contained 4141, 1021, 4174, 4038, 695, 1028 and 5940 mg/100g of C16:0, C16:1, C18:0, C18:1, C20:4, C20:5 and C22:6, respectively.

The fatty acids like C14:0, C18:1, C18:2c, C18:3 have been reduced by more than 95% in matured fish

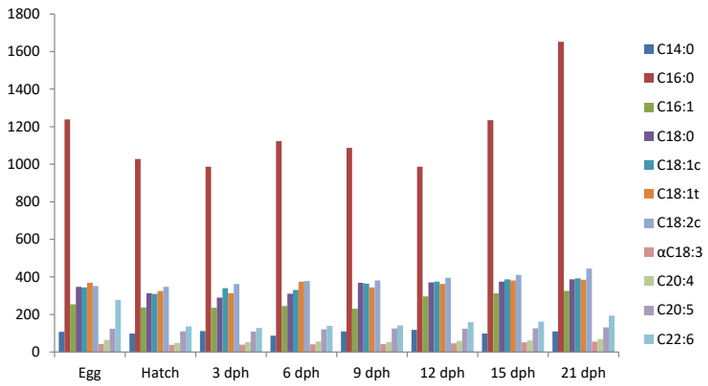


Fatty acid profiles in the ovary at different stages of maturity in Hilsa

muscle compared to immature fish muscle. Whereas the fatty acids like C16:0, C18:0, C20:5 and C22:6 were reduced by ~90% and C20:4 by 71%. The retention (%) of mobilized fatty acids in the ovary varied significantly among the fatty acids. Even though C20:4 is the least mobilized fatty acid from the muscle it is the highest retained (96%) in the ovary whereas the C16:1 is the highest mobilized fatty acid but its retention in the ovary is the lowest (22.7%). The variation of retention (%) of fatty acids might be due to utilization of certain fatty acids like C16:0, C16:1 for energetic purposes and certain fatty acids like C14:0, C18:0, C20:5, C22:6 and C20:4 are selectively retained. This information will be a base for developing broodstock diets for captive breeding of hilsa.

Fatty acid profiles of milkfish egg and larval stages

Hatchery produced milkfish egg, larvae (0, 3, 6, 9, 12, 15 and 21 day) are analysed for fatty acid profiles. The DHA content of egg, hatch and 21day old larvae are 277, 136 and 194 mg/100 g. The reduction of fatty acids like DHA (51%), ARA (26%) and EPA (24%) is very high in hatchling, indicates their significance during the embryogenesis of milkfish egg. The changes in amino acid and mineral profiles are also studied.



Fatty acid profiles in different stages of milkfish larvae

Feed management options

Effect of delayed initial feeding on growth and survival of milkfish larvae

This study investigated the effect of delayed initial feeding on growth and survival of milkfish larvae under controlled conditions. Growth parameters were evaluated by assessing morphometric characteristics of the larvae. Two experiments were conducted at different initial feeding time i.e., at 24 h, 48 h, 72 h, 96 h and 120 h. Milkfish larvae initiated first feeding at 120 h after hatching have achieved comparatively lesser growth in total length and total weight than that of 24 h and 48 h. The morphometric characteristics (total length, head depth, body depth, eye diameter, gut height, musculature height, yolk volume) of 5 DPH larvae had significant differences between 24 h and 120 h initial feeding. Similarly, significant differences were noticed between 24 h and 72 h initial feeding for all the morphometric characteristics. There was no significant difference in the yolk volume utilization of 1 DPH and 2 DPH larvae among different treatments. Experiment on the effect of delayed initial feeding on the survival of Milkfish larvae revealed that after 21 days of rearing, survival was higher in milkfish larvae initiated feeding at 24 h (40.86%) compared to 72 h (19.28%) and 96 h (7.72%). Complete mortality was recorded on 6 DPH for the larvae initiated feeding at 120 h. The present study suggests that the feeding of milkfish larvae must be initiated at 24 h post hatching for getting better growth and survival.

Compensatory growth in shrimp vannamei

Compensatory growth is already proved in fishes. However, the reports on such a compensatory growth in shrimp are clashing. In fact, this kind of compensatory growth is beneficial for the farmers in the management point of view. Therefore, to confirm the presence or absence of compensatory growth this study was conducted with stunted shrimp from the aqua mimicry feeding trials. Here the shrimps were brought to normal feeding regime as our standard shrimp feeding chart. The growth performance was observed for another 55 days. Self-cleaning microcosm tanks served as rearing system. The stunted shrimps were found to have faster growth compared to the normal shrimps. The weekly weight gain in the stunted shrimps was more than 3 g per week, while it was only around 1.6 g per week in the normal shrimps. Compensatory growth in shrimp is evidenced from the results of this study.

Penaeus vannamei-milkfish co-culture with low protein feed

Penaeus vannamei (40 no./m^2) was co-cultured with milkfish stocked at two densities (0.2 and 0.4 no./m^2) for 107 days in 0.15 ha ponds. CIBA made low protein feed (CP-32%) was used for the culture. Milkfish was stocked (ABW-5 g) after 15 days of vannamei stocking. Culture of *P. vannamei* with the lower density milkfish (0.2 no./m^2) yielded better production (shrimp- 5.8 ton/ ha, milkfish 0.5 ton/ha) and survival (Shrimp-68%, milkfish- 100%).

Performance of vannamei and milkfish in co-culture with low protein feed

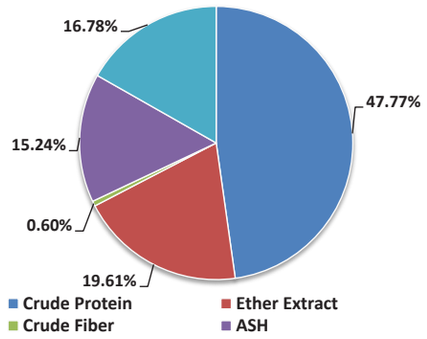
	Vannamei with milkfish (0.2/ha)	Vannamei with milkfish (0.4/ha)
Final wt, g (Vannamei)	21.25±0.07	23.15±1.12
Final wt, g (Milkfish)	250.00±0.10	210.00±30.00
Feed Conversion Ratio	1.16±0.03	1.30±0.22
Productivity, kg/ha	5773.5 ±106.5	4676.5±636.5
Operational cost, Rs.	115300±200	109150±2450
Gross income, Rs.	271057±4795	228059±31563
Benefit Cost Ratio	1.67±0.0.02	1.77±0.09

Conversion of fish processing trimmings to valuable products for use in aquaculture (Plankton ^{Plus}) and horticulture (Horti ^{plus})

Fish trimmings represents 25-50% the total fish/ shrimp while processing for human consumption. Due to lack of proper disposal of the waste from the fish industry and fish market it creates sanitary and environmental problems. An effort was put by CIBA to convert this processing waste to a more valuable products under the "Swachh Bharat" mission. A liquid product developed was branded as Plankton^{Plus}, which can be used for boosting plankton in aquaculture pond or as ingredients for feed formulation. The residual solid product can be as manure (Horti^{plus}) for agriculture/horticulture crops. Plankton^{Plus} has been tested for its efficiency in boosting phytoplankton and zooplankton. Its effect on growth performance in fish and shellfish showed promising results.

Nutrient profile of Plankton ^{Plus}

The Plankton ^{Plus} has protein content of 47-49% and lipid of 20-22% and is rich in lysine, cysteine, histidine, glutamic acid, docosa hexaenoic acid and eicosa pentaenoic acid. It is also a high source of calcium (Ca-4.03%), phosphorous (P-1.43%) and iron (Fe-3.54 %).

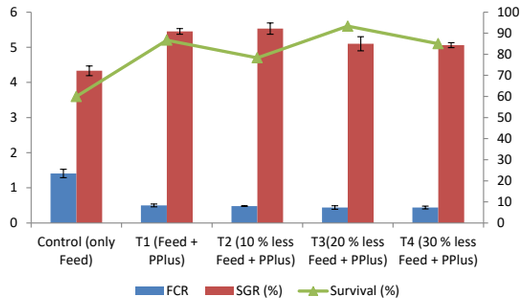


Proximate composition of Plankton^{Plus}

A waste to wealth concept- Conversion of valueless fish trimmings to valuable Plankton^{Plus}

Study on the potential of Plankton^{Plus} on reduction of feed requirement in *P. vannamei*

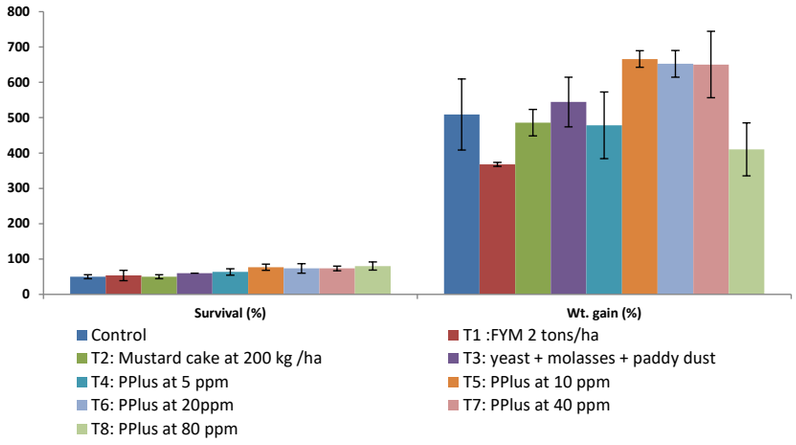
A 45 days outdoor experiment was conducted to study the potential of Plankton^{Plus} on reduction of feed requirement in *Penaeus vannamei* culture without any water exchange. There was five treatments in the experiment; Control (only feed), T1 (Feed + PPlus), T2 (10 % less Feed + PPlus), T3 (20 % less Feed + PPlus), T4 (30 % less Feed + PPlus).The experiment revealed that Plankton^{Plus} supplementation @20 ppm significantly ($P<0.01$) increased the average daily gain (ADG), specific growth rate (SGR), total biomass gain and survival of *P. vannamei* even when significantly less feed was offered. Irrespective of dosages, a clear dominance of beneficial microalgae, *Isochrysis galbana* was noticed in all Plankton^{Plus} supplemented tanks. Weight gain was maximum when Plankton^{Plus}@20 ppm was supplemented without any reduction of feed quantity.

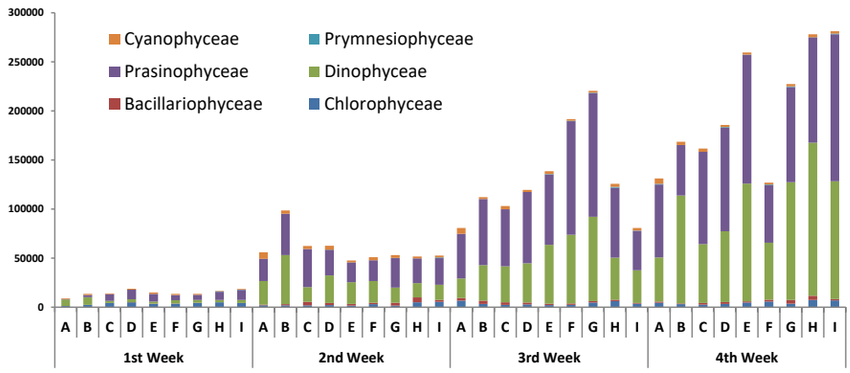


Effect of Plankton ^{Plus} on growth, survival and feed utilization in P. vannamei

Study on effect of Plankton^{Plus} application on plankton status and growth performance of *Peaneus indicus* in tank rearing system

Effect of Plankton^{Plus} (PPlus) supplementation at different dose (5, 10, 20, 40, & 80 ppm) on plankton status and growth performance of *Penaeus indicus* (ABW 0.32±0.01g) was studied and compared with other conventionally used materials (Cattle manure 20





Number of cells of microalgae groups in PPlus tanks

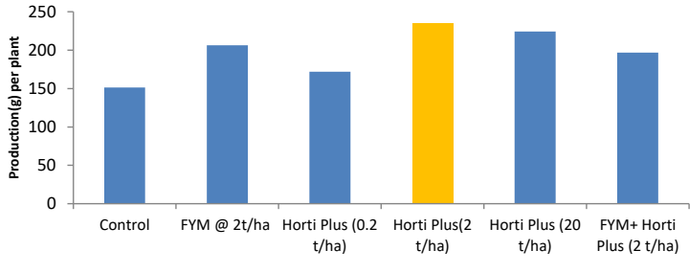
g/100 L, Mustard cake 2 g/100 L, Juice prepared with fermentation of yeast 0.04 g+ molasses 0.3 g+ paddy dust 0.6 g / 100 L) for boosting plankton in tank rearing system. Weight gain and survival of shrimp was found to be higher in Plankton^{Plus} supplemented (10, 20 & 40 ppm) groups. Prasinophyceae group of phytoplankton (*Tetraselmis* sp and *Halosphaera* sp) dominated in Plankton^{Plus} supplemented groups and abundance was increasing with increased concentrations of Plankton^{Plus}. Cyanobacterial percentage was invariably less in all Plankton^{Plus} supplemented tanks.

Potential of Plankton^{Plus} on reduction of Feed requirement in fish

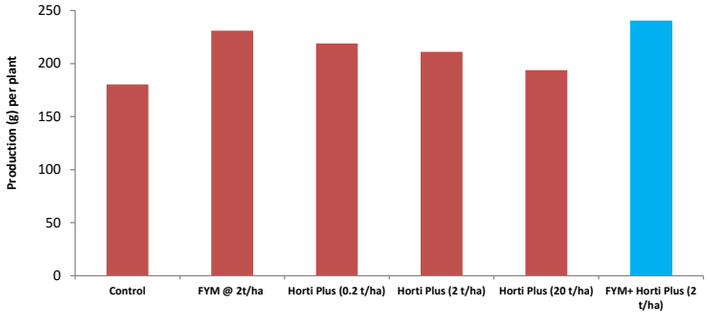
A 45 days outdoor experiment was conducted to study the potential of Plankton^{Plus} on reduction of feed requirement in milkfish (*Chanos chanos*) culture without any water exchange. The experiment was conducted in 3^2 factorial design where, factor 1 was Plankton^{Plus} supplementation (at three levels 0, 20 and 40 ppm) and factor 2 was feed supplementation (at three levels 0, 50 and 100 %). Study revealed that at both 20 and 40 ppm Plankton^{Plus} supplementation with 50 % feed expressed similar average daily gain (ADG), specific growth rate (SGR), and biomass gain in *Chanos chanos* when compared with group received 100% feed but without Plankton^{Plus} supplementation. There was clear dominance of microalgae like *Isochrysis* sp, *Chlorella* sp, *Tetraselmis* sp, *Nitzschia* sp etc in Plankton^{Plus} supplemented tanks and chain Blue Green Algae (BGA) was negligible. Therefore, it can be concluded that Plankton^{Plus} supplementation either @ 20 and 40 ppm can save 50 % of feed without affecting growth performance and survival of *Chanos chanos*.

Fish waste hydrolysate residue (Horti ^{Plus}) as manure for horticulture crops

The powdered form of fish waste hydrolysate residue was used as a manure and branded as Horti ^{plus}. Performance of Horti ^{plus} was tested in a pot experiment to determine its efficiency on the yield of vegetable crops, ladies finger (*Abelmoschus esculentus*) and brinjal (*Solanum melongena*). The treatments chosen for the study were Control i.e., Farm Yard Manure (FYM) @ 2t/ha, Horti plus @ 0.2 t/ha, Horti ^{plus} @ 2 t/ha, Horti ^{plus} @ 20 t/ha, FYM @ 2t/ha + Horti ^{plus} @ 2t/ha (mixed dose). Higher yield of brinjal was found when Horti ^{plus} was applied @2t/ha. Yield of ladies finger was higher when Horti ^{plus} @2 t/ha along with FYM @ 2 t/ha was used. Study revealed potential of Horti ^{plus} as promising manure to be used for raising horticulture crops.



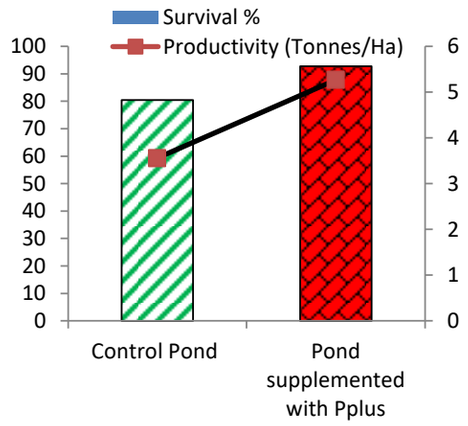
Effect of Horti^{Plus} on production of brinjal

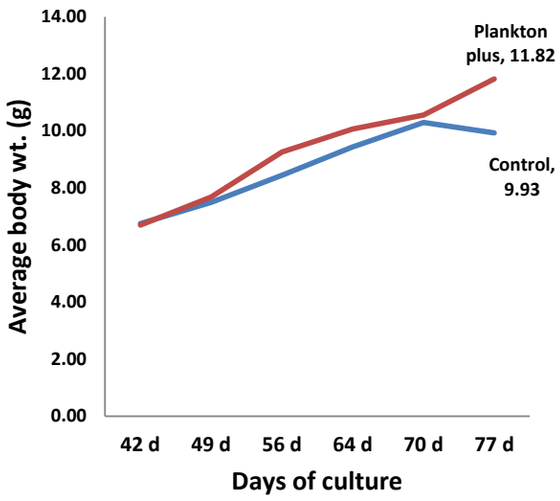


Effect of Horti^{Plus} on production of ladies finger

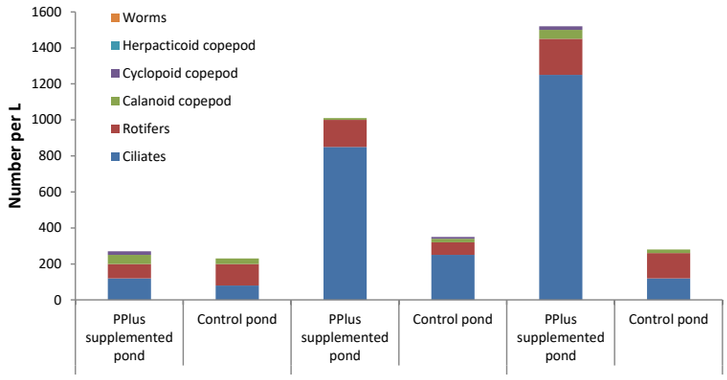
Plankton^{Plus} as cost effective plankton booster – a demonstration in farmers pond

A 77 days trial was conducted in shrimp (*Penaeus vannamei)* ponds at Bapatla, Andhra Pradesh, India to study the effect of Plankton ^{Plus} (PPlus) on augmenting plankton in shrimp culture pond. PPlus was supplemented @ 10 ppm in split doses. Control ponds were supplemented with rice bran-yeast-mollases juice and dolomite as and when required to maintain the bloom and water quality. At the end of the culture period, average weight of shrimp was higher (11.82 g) in pond supplemented with PPlus compared to control (9. 93 g). There was a significant increase (12.31%) in survival, and enhancement of yield to the tune of 1.71 t/ha in pond supplemented with Plankton ^{Plus} compared to control. Plankton ^{Plus} supplemented ponds were dominated by beneficial microalgae (Bacillariophyceae, Prasinophyceae and Dinophyceae etc.) and zooplankton. Enhanced growth performance of *Penaeus vannamei* might be due to the augmented density and diversity of phytoplankton and zooplankton in the Plankton ^{Plus} supplemented ponds.

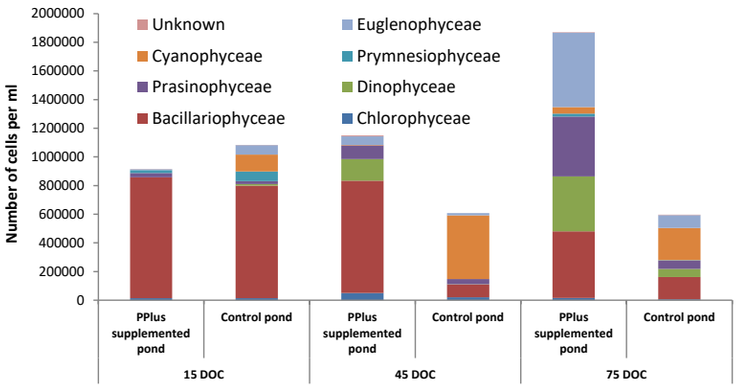




Healthy looking shrimps from farmers pond where Plankton Plus was used



Status of Zooplankton in shrimp culture pond supplemented with Plankton Plus

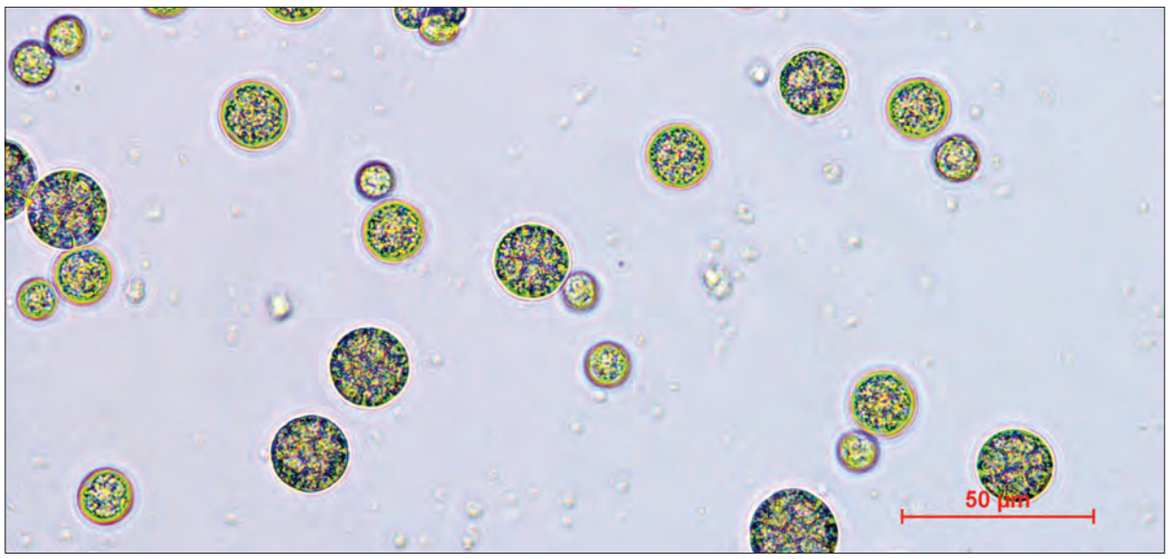


Status of Phytoplankton in shrimp culture pond supplemented with Plankton Plus

Live feed

PUFA enrichment in artemia using protist, *Thraustochytrids*

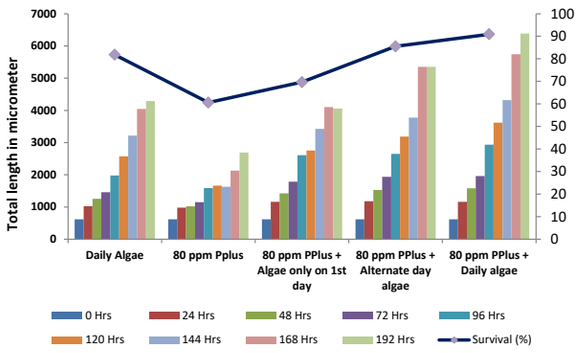
Thraustochytrids are osmoheterotrophic, oleaginous, eukaryotic, unicellular monocentric fungi-like protists. Thraustochytrids are one of the potential and richest sources of PUFA. Thraustochytrid isolate (*Aurantiochytrium* sp) was (Isolate from CUSAT, Cochin) developed in mass scale and evaluated its potential to culture and enrich artemia and rotifers (Lipid: 43.7 %, Protein 37.7% and DHA 40% of total fatty acids). Significant differences were observed in survival and growth of artemia fed with live and lyophilized *Aurantiochytrium* sp. Average growth (total length 11 mm) and survival (97%) was maximum in artemia fed with microalgae *Nannochloropsis* along with 250 mg lyophilized *Aurantiochytrium* sp.. Study revealed the prospective use of new isolates of Thraustochytrids in aquaculture nutrition.



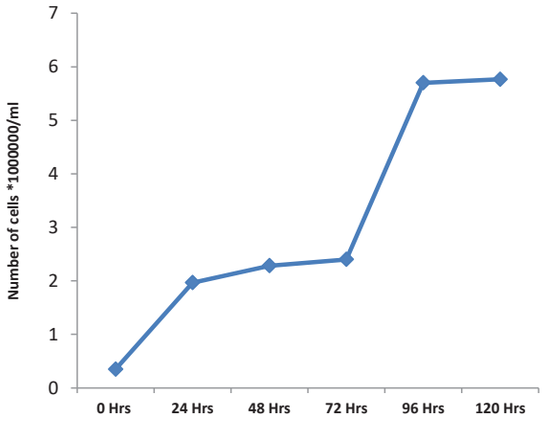
Thraustochytrids under microscope

Plankton ^{Plus} promotes growth of artemia

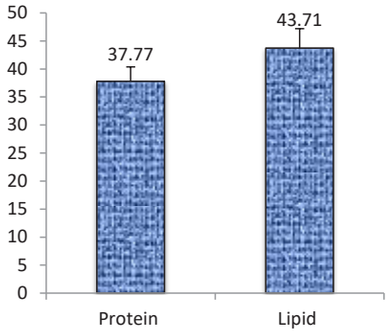
Potential of Plankton ^{Plus} for culturing the zooplankton (Artemia) was evaluated by feeding them with different concentrations of PPlus (20 ppm, 40ppm, 80ppm and 160 ppm) and 80 ppm was found to give better survival and growth compared to other doses. Study was conducted to reduce use of microalgae by supplementing PPlus for artemia culture. For this purpose, PPlus (80 ppm) was added along with microalgae (*Nannochloropsis occulata*) at different frequency of application, i.e., one-time (first day) application, alternate day application and daily application. The growth and survival of artemia were significantly ($p<0.05$) higher when PPlus was used with daily application of microalgae. Interestingly, the growth and survival of artemia were also higher when PPlus was supplemented with alternate day algae application compared to daily algae feeding without PPlus. The experiments clearly revealed that Plankton ^{Plus} supplementation @ 80 ppm with microalgae improved artemia biomass production and can reduce the usage of algae by 50 % for artemia culture.



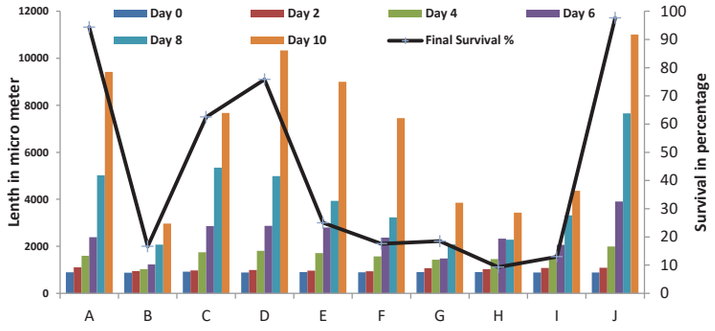
Growth and survival of artemia fed with Plankton ^{Plus}



Growth curve of Aurantiochytrium sp

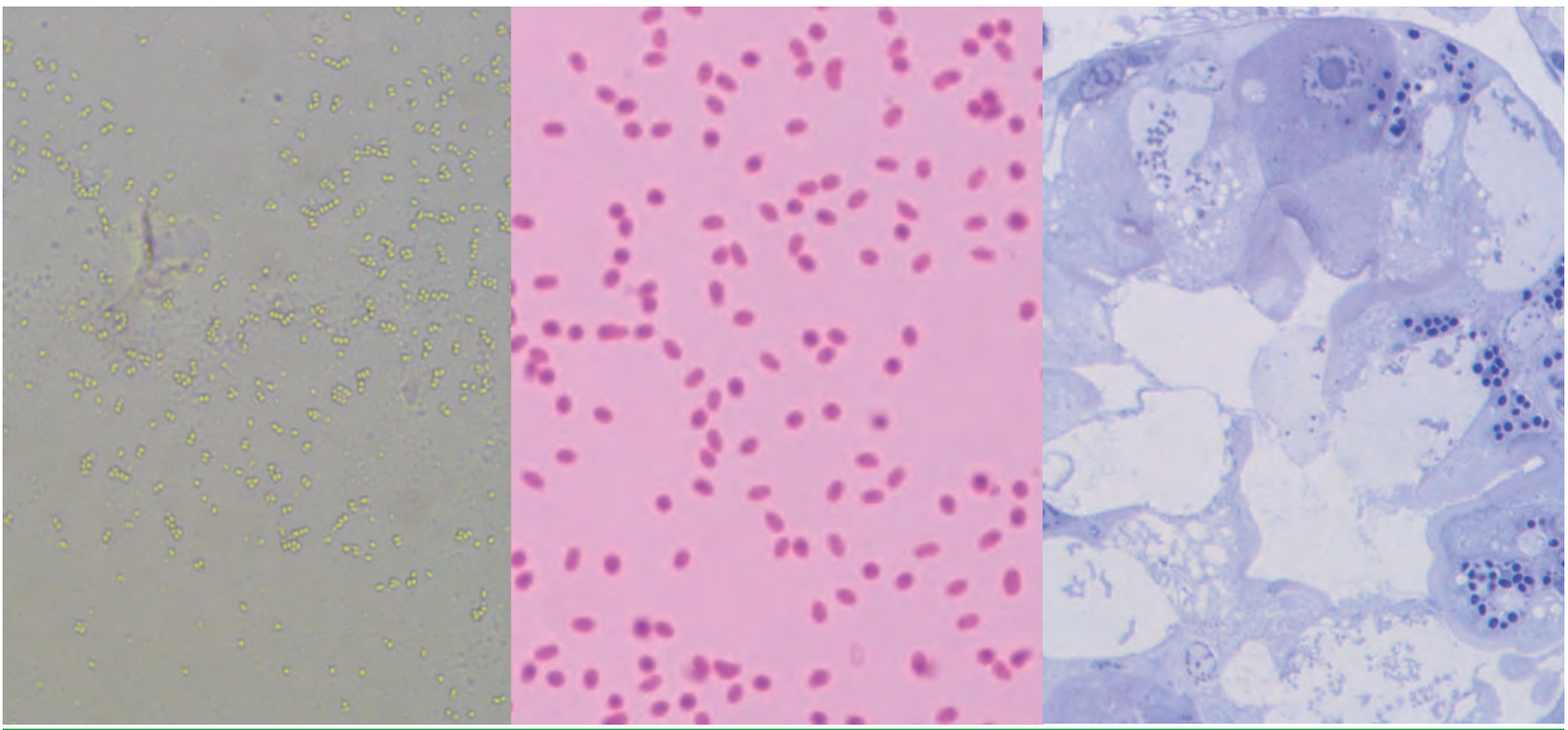


Protein and lipid content in Aurantiochytrium sp



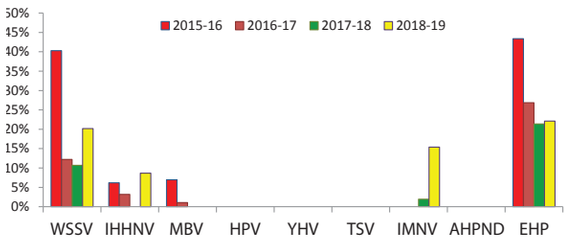
Survival and growth of artemia. A: Fed with Nannochloropsis occulata, B: Without any feed, C: Freeze Dried Aurantiochytrium (FDA) @ 125 mg/1500 Nos, D: FDA @ 250 mg/1500 Nos, E: FDA @ 375 mg/1500 Nos, F: FDA @ 500 mg/1500 Nos, G: Wet Biomass Aurantiochytrium (WBA) @ 0.5 g/1500 Nos, H: WBA @ 1 g/1500 Nos, I: WBA @ 1.5 g/1500 Nos, J: FDA @ 250 mg/1500 Nos + Nannochloropsis occulata

AQUATIC ANIMAL HEALTH

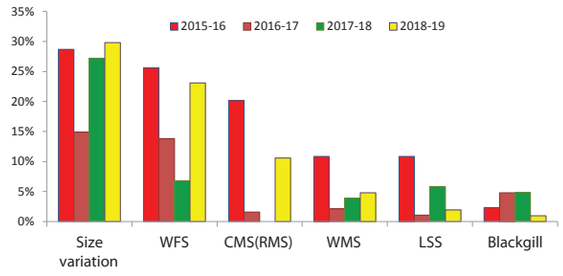


WSSV and EHP continue to be the major infectious agents limiting productions in Indian shrimp farming

Diseases are the biggest threat in shrimp aquaculture growth and sustainability. As part of the on-going active shrimp disease surveillance programme since the year 2014, a total of 523 shrimp farms have been screened for OIE listed pathogens in three maritime states viz., Tamil Nadu (TN), Andhra Pradesh (AP) and West Bengal (WB). During the last four years,the white spot syndrome virus (WSSV) and *Enterocytozoon hepatopenaei* (EHP) have been recognised as the predominant pathogens affecting shrimp farming in the two major shrimp farming states AP and TN. The hepatopancreatic microsporidiosis caused by *E. hepatopenaei* had the highest prevalence rate of 43% during 2015-16. However, the prevalence of EHP decreased over the years and during 2018-19, its prevalence was about 27%. The prevalence of the most dreaded white spot disease (WSD) was about 40% during 2015-16,which declined to 11%in 2017-18 and again increased to 20% during 2018-19. Infectious myonecrosis virus (IMNV) was first time observed during 2017-18 in India. Its prevalence was found to increase to about 15% during 2018-19. The prevalence of infectious hypodermal and haematopoietic necrosis (IHHN) disease ranged between 3-9%, over the last four years. The prevalence of other disease syndromes, attributable to poor farm management such as stunted growth, white faeces syndrome (WFS), loose shell syndrome (LSS), running mortality syndrome (RMS), white muscle syndrome (WMS)and black gill was about 15-30%, 7-26%, 1-11%, 0-20%, 2-11% and 1-5% respectively. White faeces syndrome (WFS) and stunted growth or size variation continue to be major issues due to poor farm management during the past four years.



Prevalence of viral, bacterial and fungal diseases in Andhra Pradesh, Tamil Nadu and West Bengal during 2015 – 19 (n= 523 farms)



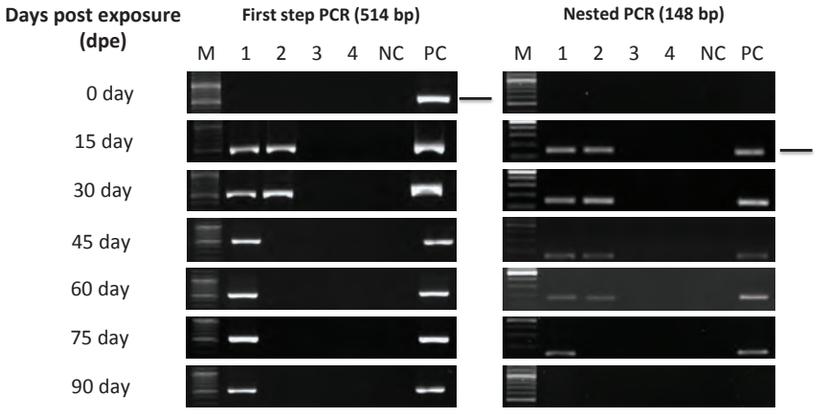
Prevalence of disease syndromes of shrimp in Andhra Pradesh, Tamil Nadu and West Bengal during 2015 – 19 (n= 523 farms)

The Indian brackishwater aquaculture was free from other OIE listed diseases such as taura syndrome (TS), yellow head disease (YHD), acute hepatopancreatic necrosis disease (AHPND) and necrotising hepatopancreatitis (NHP).

Polychaete worms can transmit *Enterocytozoon hepatopeanei* to shrimp

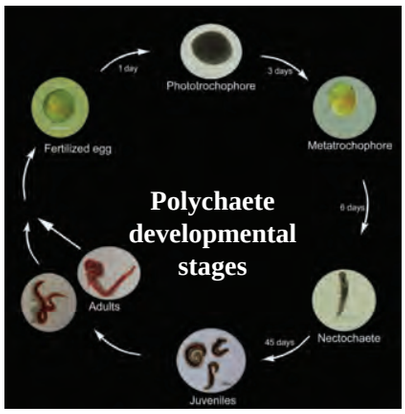
Earlier studies at CIBAhad revealedthat thepolychaete worms (*Marphysa* spp.) serve as carrier for shrimp pathogens such as WSSV (8.5% of the samples), EHP (7.6%of the samples) and multiple pathogens (WSSV and EHP in 3.6% of the samples). In an experimental study, EHP-infected shrimp faeces, when fed to polychaetes, the polychaetes attained the status of carriers and were capable of transmitting EHP to naïve SPF-*Penaeus vannamei* providing evidence that the polychaetes can be the source for EHP infection in shrimp hatcheries and *vice versa*. The study confirmed the horizontal transmission of EHP from infected shrimp to polychaetes & *vice versa*. However, no evidence of vertical transmission was recorded in different developmental stages of polychaetes.

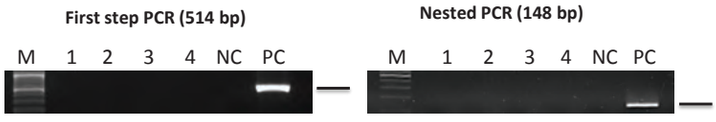
Polychaete group (n=20/tank)	PCR (SWP)	Days post exposure (dpe) of EHP						
		0	15	30	45	60	75	90
Tank A	1st step	-	+	+	+	+	+	-
	Nested	+	+	+	+	+	+	+
Tank B	1st step	-	+	+	-	-	-	-
	Nested	-	+	+	+	-	-	-
Tank C	1st step	-	-	-	-	-	-	-
	Nested	-	-	-	-	-	-	-
Tank D	1st step	-	-	-	-	-	-	-
	Nested	-	-	-	-	-	-	-



Horizontal transmission of EHP from shrimp to polychaete by oral feeding: PCR screening of polychaete worm for EHP at different days of post exposure (dpe) (0, 15 & 30)

Lanes: M- Marker (100 bp), 1- Tank A, 2-Tank B, 3- Tank C, 4- Tank D, NC- Negative control, PC- Positive control



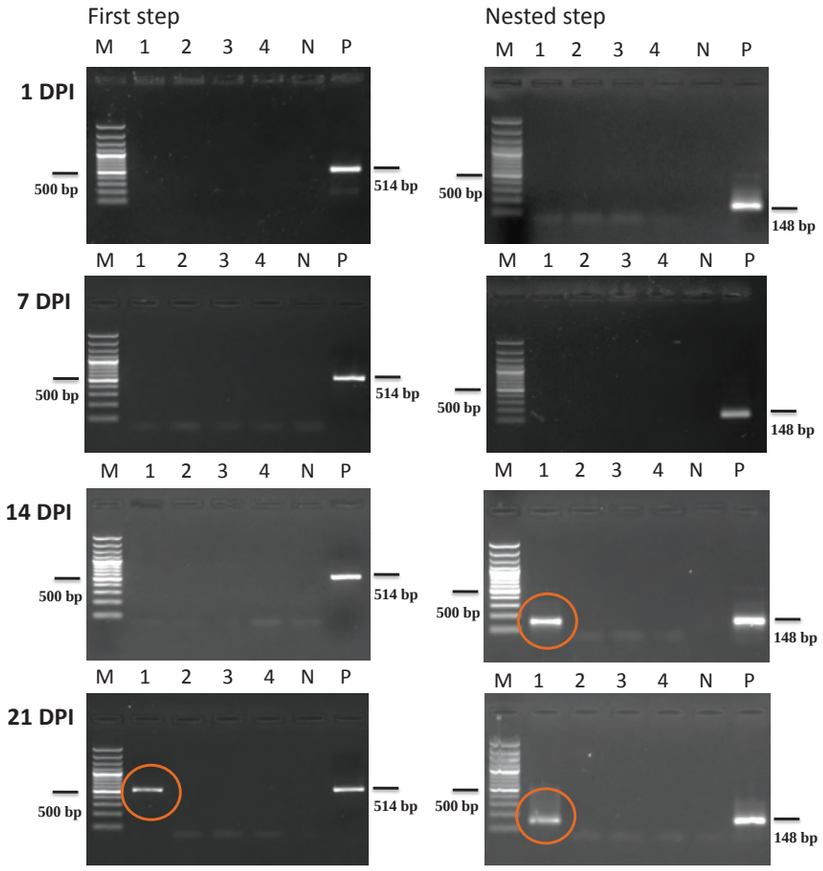


Lanes: M- Marker (100 bp), 1- Fertilised egg, 2- Metatrochophore, 3- Nectochaete, D- Juvenile, NC- Negative control, PC- Positive control

PCR screening suggests that EHP is not transmitted vertically among polychaetes

EHP spores remain infectious for more than a year in seawater at room temperature

Changes in the temperature strongly influence the viability of microsporidians such as EHP. Viability and infectivity of EHP spores stored in pond water with salinity 26‰at different temperatures was examined. Pondwater collected from shrimp farm with history of EHP infection was stored at different temperatures (room temperature (RT), 4°C, -20°C and -80°C) and the infectivity of EHP was studied by bioassay experiments in shrimp post larvae for a period of three months. The EHP spores stored at 4°C, -20°C and -80°C for one month were unable to induce EHP infection in shrimp post-larvae up to 30 days of observation period by PCR. However, the EHP spores stored at room temperature were found to produce infection in shrimp within 14 days post-exposure (dpe). First detection of EHP infection (by nested PCR) was possible at 14 dpe, while the same group of animals showed first step positive at 21 dpe onwards till the end of the experiment. The spores were found to retain infectivity even after three months of storage at room temperature in seawater. The spores preserved at room temperature in seawaterlost infectivity after 1 ½ years. The study concluded that spores stored at 4°C, -20°C and -80°C showed dramatic decrease in spore viability and infectivity to shrimp PLs, but spores stored in seawater



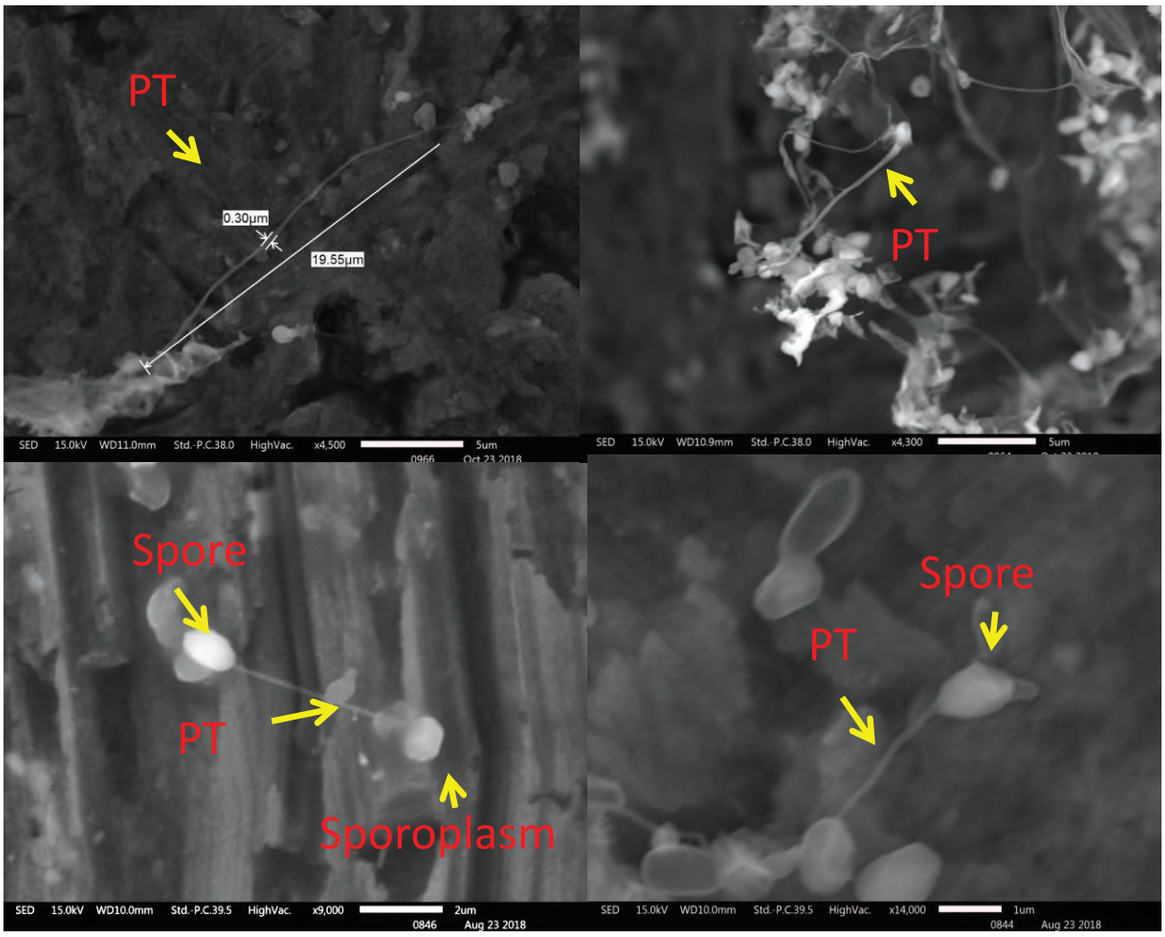
M- 100 bp marker, Lanes: 1 to 4 EHP- spiked water samples stored at different temperatures (1- at room temperature, 2- at 4°C, 3- at 20°C and 4- at 80°C), N Negative control, P- Positive control

Viability and infectivity of EHP spore in seawater stored at different temperatures

at room temperature were found to produce infection in shrimp within 14 days post-exposure and retained their activity up to1 ½ years.

Germination of EHP spores could be experimentally induced

Generally, spore germination begins with an environmental trigger, which varies for different species depending on their habitat. Germination of EHP spore starts with general swelling of the spore followed by specific swelling of the polaroplast. The internal pressure of the spore culminates the discharge of the polar filament by eversion. The discharged polar tube can range in length from 50– 500 µm in length. The entire event of germination takes place in fewer than two seconds. If a potential host cell lies nearby, the discharging tube can strike this cell and pierce its membrane. Once the polar tube is fully discharged, the continued pressure within the spore forces the sporoplasm through the polar tube. Germination of EHP spores was induced by using several dyes, hydroxides, chlorides and buffers at different pH levels. In our preliminary investigations, germination of EHP spores was successfully attained by using potassium hydroxide and phloxine.



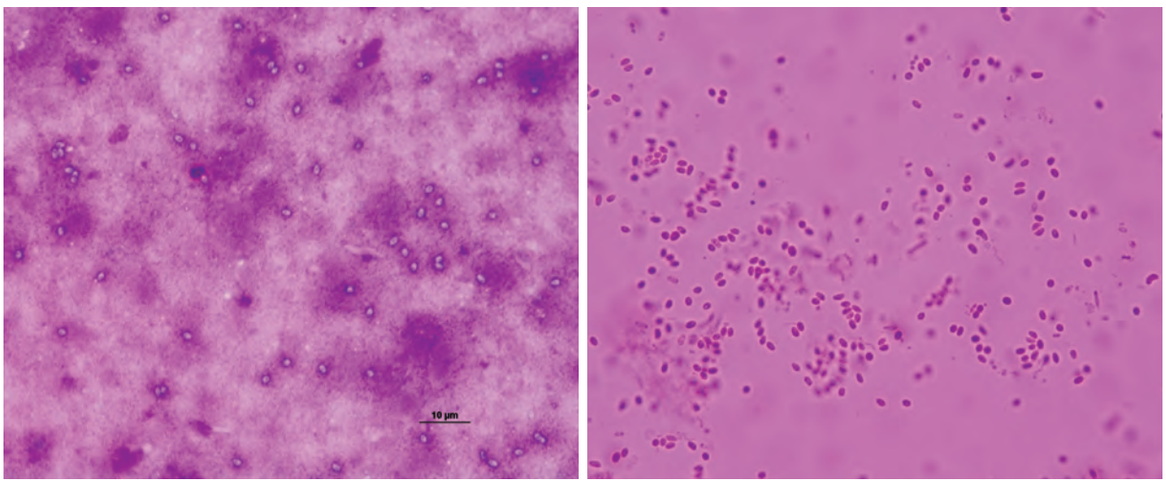
Scanning electron microscopic image of induced germination in EHP spores (PT- Polar tube)

EHP is the likely causative agent of white faeces syndrome (WFS)

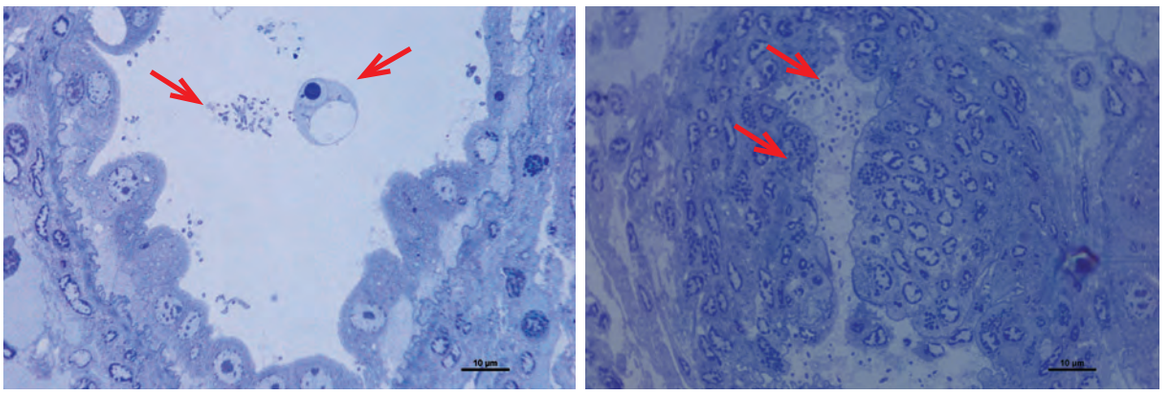
EHP infections in shrimp have been often reported to be associated with reduced feed consumption, growth retardation and white faeces syndrome (WFS). To study the association of EHP with WFS, a detailed investigation was carried out using affected animals collected from shrimp farms. The microscopic examination of squash preparation of hepatopancreas (HP) revealed aggregated transformed microvilli (ATM) like structures and dense EHP spores. Squash preparations of white faecal string collected from EHP affected shrimp farm also revealed presence of large numbers of mature EHP spores.Scanning electron microscopy (SEM) of white faecal threads also revealed dense mature EHP spores and rod-shaped bacteria. Transmission electron microscopy (TEM) showed immature and mature spores in epithelial cell cytoplasm and degenerated and germinated spores in tubule lumen.

In an experimental study, when the juvenile shrimps were fed with white faecal threads collected from WFS affected ponds, purified spores, EHP infected HP tissue,after 24-36 hrs, challenged animals produced only transparent and non-floating faecal threads. These faecal threads when tested were found to be positive for EHP by PCR. Further, dense mature EHP spores could be observed by scanning electron microscopy in the transparent and non-floating faecal threads.

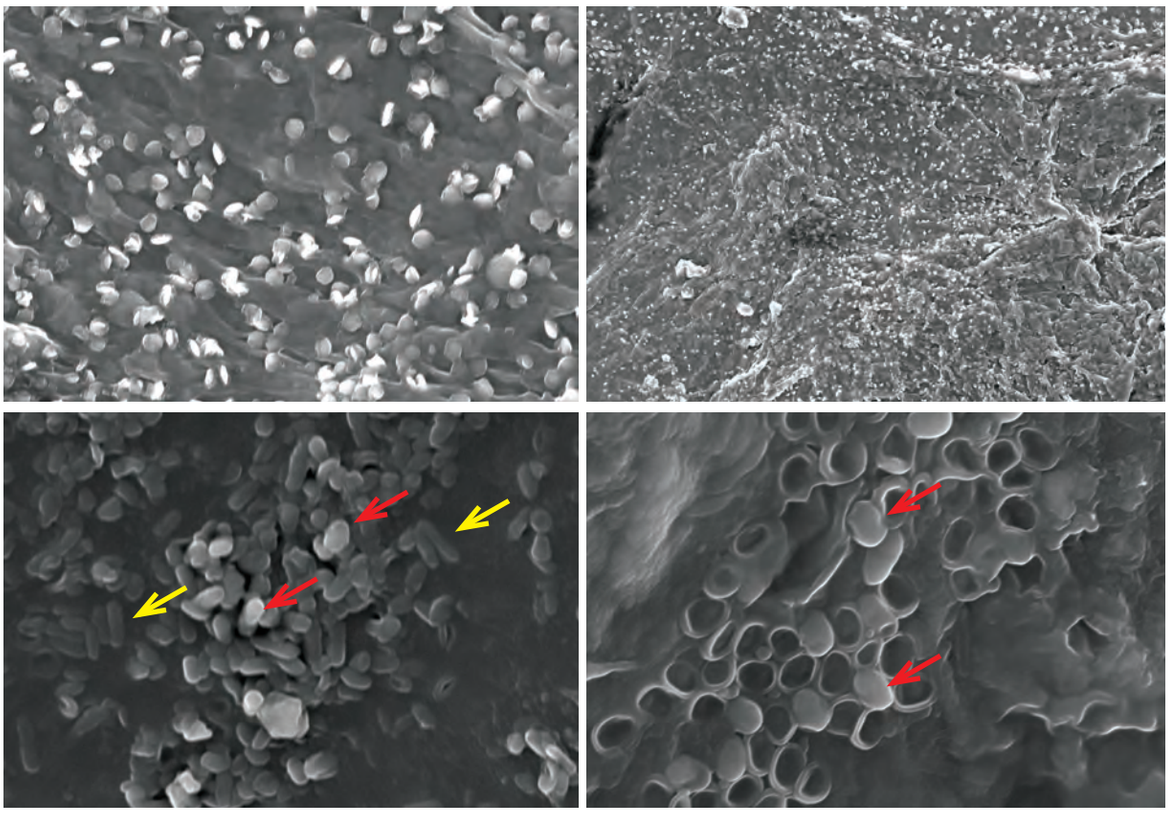
In our earlier studies EHP was detected by PCR in all the WFS affected and also in EHP-recovered animals. Further, epidemiological investigations in 322 farms also revealed a significant role of EHP with the increased frequency of WFS occurrences. However in EHP experimental infection studies, white faecal threads could not be produced under laboratory conditions. Thus it is evident that white faecal threads are one of the clinical sign of EHP and it also construed that white faeces syndrome probably caused by EHP.



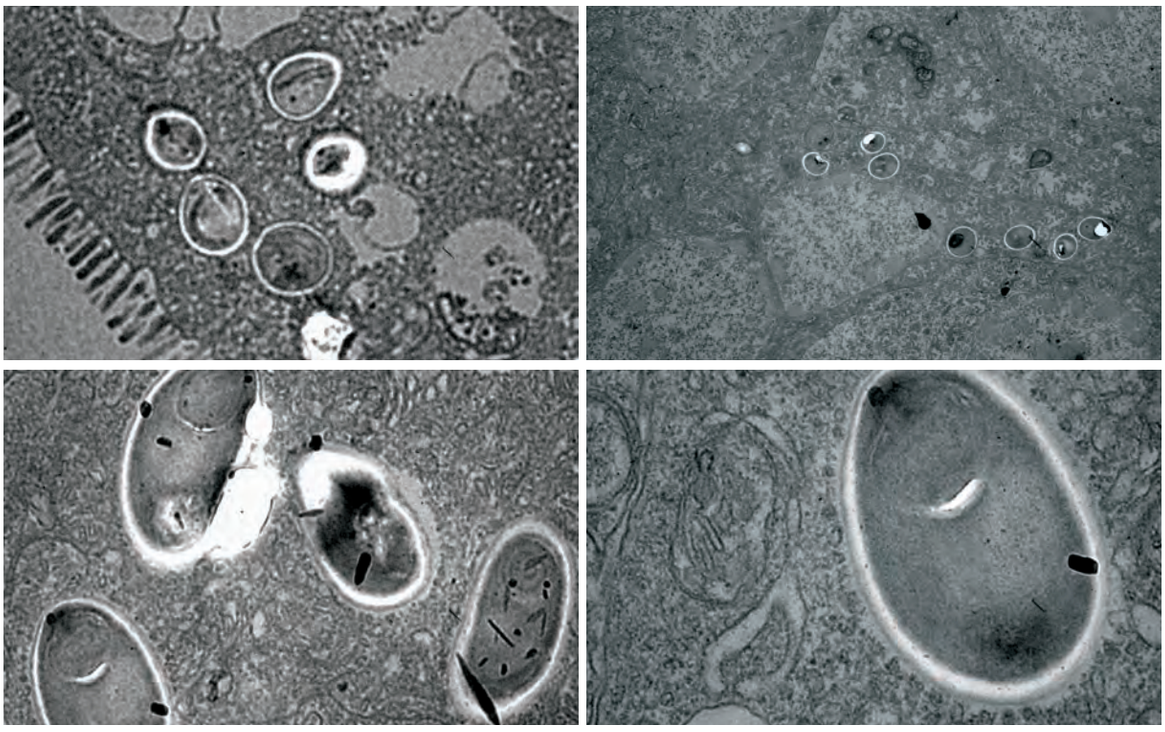
Squash preparations of WFS affected *hepatopancreas* (A) and WFS faecal strings showing dense EHP spores (B)



Semi-thin sections of HP tubules revealed sloughing of B cells and EHP spores (arrow) in epithelial cell cytoplasm and lumen of WFS affected HP tubules (E & F).



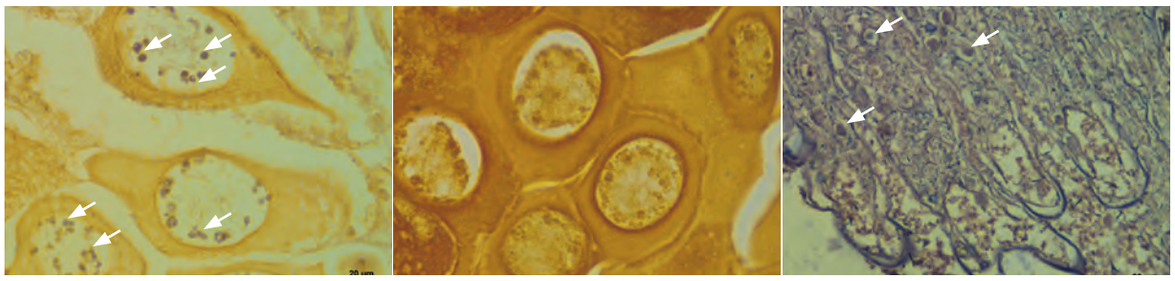
Scanning electron microscopy (SEM) unveiled dense mature EHP spore (red arrow) and also rod-shaped bacteria (yellow arrow) in white faecal threads.



Transmission electron microscopy (TEM) showing immature spores in ephithelial cell cytoplasm and degenerated spores in tubule lumen.

Vertical transmission of WSSV to larval shrimp is a possibility

To assess the vertical transmission of WSSV, a controlled laboratory trial was conducted in Indian white shrimp *Penaeus indicus*. The animals collected from the wild and tested negative for WSSV were divided into four groups and injected with 50 µlof WSSVsuspension having 10^1, 10^2, 10^3 and 10^4 copy numbers μl^{-1}. After 58 hours post-infection, the animals became moribund with clinical signs of WSSV infection. At this stage, shrimps were sacrificed and gill and ovary samples were collected in Davidson's fixative for histopathology and 90% alcohol for PCR (pleopod, gill and ovary). PCR analysis of samples from injected groups indicated all the samples to be positive for WSSV by 1st step PCR (Kimural et al.1996). Gill and ovary samples were processed for histopathology and subsequently by *in situ* hybridization. Intranuclear inclusion bodies reactive to the VP28 probe were observed in WSSV infectied ovarian cells. Control cells did not have any such cells. The study indicates



WSSV Infected Ovary 100 x | Ovary (Control) 100 x | WSSV infected Gill 100 x

WSSV VP28 probe reactive intranuclear inclusion bodies in ovary cells and gills of WSSV infected shrimps (Arrow)

that even a lower dose of infection by WSSV have the possibility of vertical transmission. Mass mortality of farmed mud crab, *Scylla serrata* in Andhra Pradesh

Mass mortality of farmed mud crab, *Scylla serrata* in Andhra Pradesh

Commercial scale mud crab culture is fast developing in the coastal areas of Andhra Pradesh. The total area under mud crab culture was about 7360 hectares during 2017-18 as per the information from the Department of Fisheries, Andhra Pradesh. Occasional disease and mortality is not uncommon in mud crab culture. Apart from availability of seeds, in the current year, disease outbreak and mass mortality of farmed crabs was found to be the major stumbling blockin profitable mud crab culture. Mass mortality of mud crab *Scylla serrata* culture was reported during September to November 2018 in Nagayalanka, Krishna district, Andhra Pradesh. For investigation of the problem, a total eight farms were selected, four affected with disease and four healthy ponds. All earthen ponds were stocked at 1000 per hectare using green local (GL) crabs (100-200g). Culture was done for 90 days to obtain a final average body weight (ABW) of 750g with survival between 50 and 55%, and FCR of 2.3-4.3. Crab mass mortality was observed with clinical signs such as white spots on the carapace, lethargy, fungal growth over the exoskeleton, chitinolytic spots on the abdominal flap, fouling, physical deformities of claw and chelate legs, light greenish to yellowish or pinkish discoloration followed by death. Mortality was observed during 65th day of culture (DOC) and progressed up to 75% in a period of 10 days. Water salinity, pH, dissolved oxygen and temperature were 16.84 ppt, 8.13, 3.8% and 26.7°C, respectively. Post mortem examination revealed that the gills were heavily infested with metazoan crustacean parasite, stalked barnacle, *Octolasmis* spp. Abdominal cavity contained about 30-40mL serosanguinous fluid. Microbial load estimation in pond sediment, water and haemolymph of infected crab showed that there was significant increase in total plate count (TPC) and total *Vibrio* count (TVC) compared to that of healthy ponds. Polymerase chain reaction (PCR) screening revealed that the diseased samples were positive for white spot syndrome virus (WSSV). Histological studies showed that there was degeneration of gill tissue and were

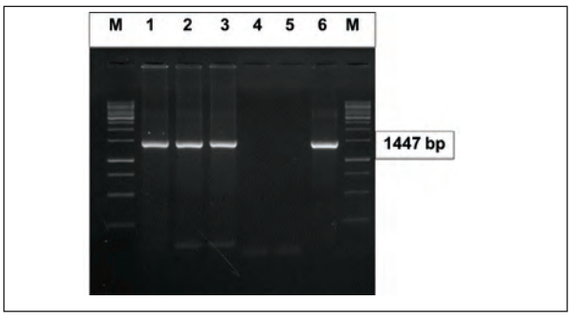
characterized by hypertrophied nuclei with marginated chromatin and eosinophilic to basophilic intranuclear inclusions. Haematological investigation revealed that total haemocyte count (THC) was lower in diseased crabs (6.90±0.48 x 10^6 cells mL^{-1})compared to healthy *Scylla serrata* (17.28±0.46 x 10^6 cells mL^{-1}). In healthy crabs, small non-granular haemocytes (SNGH) constituted 14.13±0.83% of the circulating haemocytes (2.43±0.10 x 106 cells mL-1) while large non-granular haemocytes (LNGH) constituted 45.25±2.32% (7.81±0.41 x 10^6 cells mL^{-1}). Semi-granular haemocytes or small-granular haemocytes (SGH) constituted 9.88±1.64% (1.70±0.27 x 10^6 cells mL^{-1}) while large granular haemocyte (LGH), constituting 30.75±1.55% (5.33±0.40 x 10^6 cells mL^{-1}). SNGH, LNGH, SGH and LGH (x 10^6 cells mL-1) among the diseased crabs were significantly low as 1.85±0.20 (26.63±1.68%), 3.85±0.32 (55.63±1.14%), 0.42±0.07 (6.25±1.13%) and 0.79±0.08 (11.50±1.37%), respectively.

Crab mortality with clinical signs such as white spots on the carapace, fungal growth over the exoskeleton and fouling.

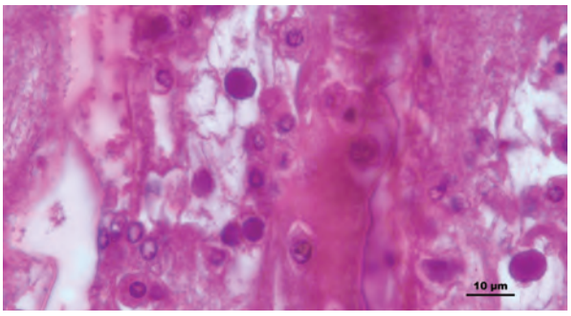
Crab with clinical signs such as fungal growth over the exoskeleton, chitinolytic spots on the abdominal flap and fouling.

Crab with heavy infestation of stalked barnacle, *Octolasmis* spp. in the gills.

Crab gills with heavy infestation of stalked barnacle, *Octolasmis* spp. Scale bar: 5000 µm.



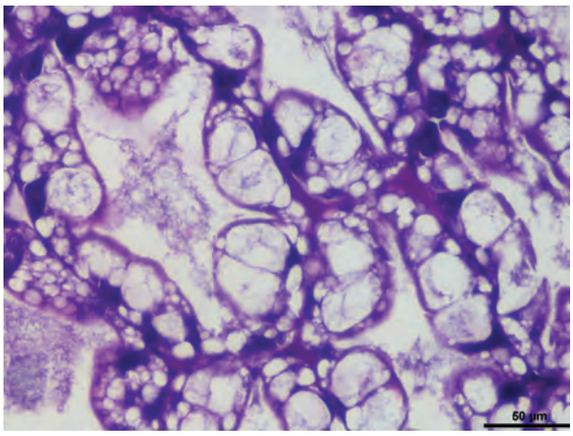
Lane M: Ladder; Lane 1-3: Crab sample positive for WSSV; Lane 4&5: negative control; Lane 6: positive control.



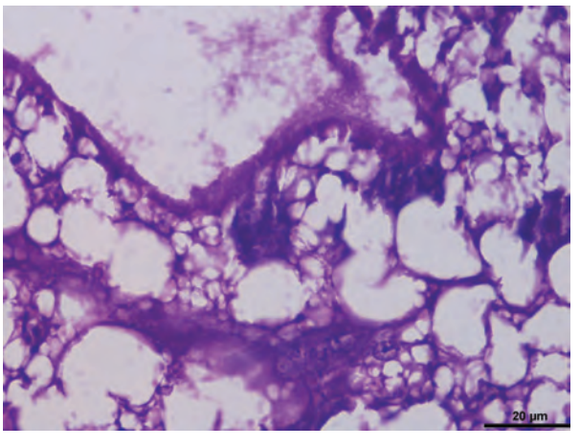
Histopathology of gill tissue showing degeneration and hypertrophied nuclei with marginated chromatin and eosinophilic to basophilic intranuclear inclusions. H&E. Scale bar: 10 µm.

Comparative pathological changes in shrimp hepatopancreas in response to viral and parasitic infection

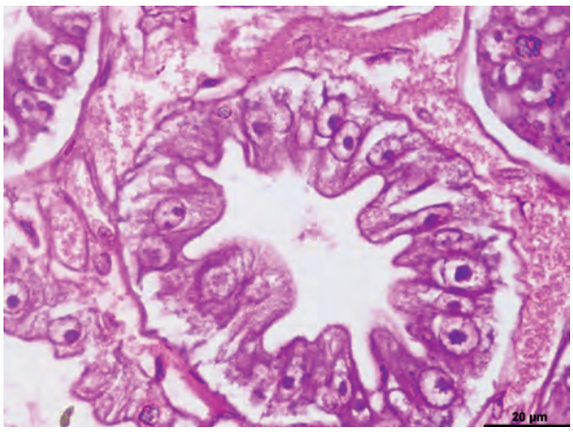
The hepatopancreas is a primary digestive organ of shrimp which plays the dual role of secreting digestive enzymes and absorbing nutrients. Due to its pivotal role in digestion and metabolism, it is considered as shrimp powerhouse, which also serves as primary target organ for many of the pathogens. Histopathological examination of hepatopancreas in response to infection often serves as first step in identifying any new pathogens. Shrimp samples confirmed positive by PCR for WSSV, IHHNV, WSSV & IHHNV and EHP were preserved in Davidson fixative were processed as per the method described by Lightner *et al*, (2004). The histological changes observed in hepatopancreas of WSSV infected shrimps were increased vacuolization of B cells, increased number of F and R cells, degeneration of hepatopancreatic tubular epithelial cells in few cases with presence of proteinaceous exudate in the tubule. The IHHNV infected shrimp hepatopancreas had normal hepatopancreatic cells like B, F, R & E cell with no changes. Few cases showed degenerated tubular epithelial cells. The combined WSSV and IHHNV infection had hepatopancreatic lesions similar to that of the WSSV infection. In comparison, EHP infected shrimp hepatopancreas had tubular cells like B, F, R cell necrosis and degeneration. Further haemolymph accumulation noticed between the tubules. The study suggests that these pathogens affect the hepatopancreatic architecture and thereby the functioning of the hepatopancreas.



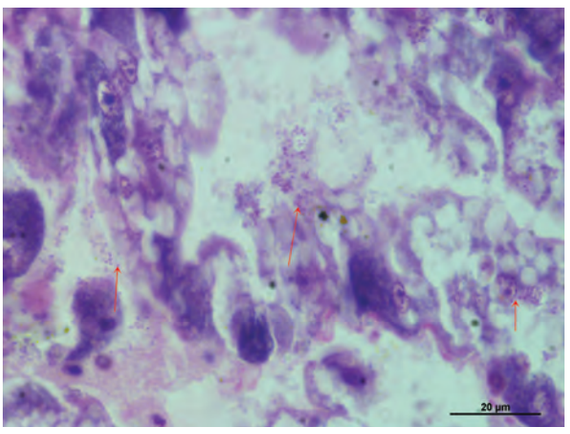
WSSV infected *hepatopancreas* showing increased vacuolization of B cells (H&E 100x)



WSSV & IHHNV infected *hepatopancreas* showing increased vacuolization of B cells (H&E 100x)



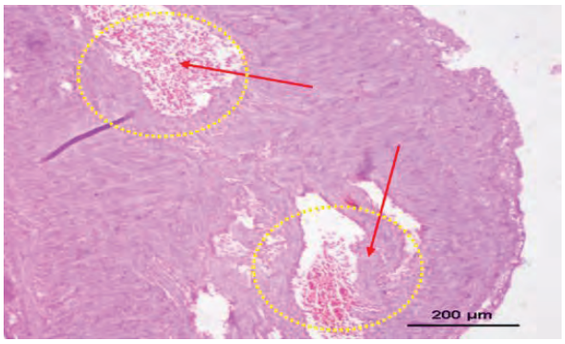
IHHNV infected *hepatopancreas* showing normal appearance



EHP infected *hepatopancreas* showing total necrosis and degeneration of hepatopancreatic cells (H&E 100x)

Tilapia lake virus (TiLV)can be cross-transmitted to seabass

With the availability of sea bass seed from CIBA and RGCA, pond farming of seabass has been increasing. In a finfish disease surveillance investigation, the *L.calcarifer* samples collected from nursery, monoculture, cage culture and co-culture with tilapiafrom Andhra Pradesh and TamilNadu, when screened for Viral Nervous Necrosis (VNN), Iridovirus and Tilapia Lake virus (TiLV),all were found negative for VNN and Iridovirus infection. However, two farm samples co-cultured with tilapia experienced chronic mortalities and suffering with haemorrhagic encephalitis had TiLV infection. Challenge experiment conducted to test the inter species transmission of TiLV from infected tilapia to seabass showed successful transmission of TiLV with cumulative mortalities in fish challenged by different routes with varied experimental duration in inducing the disease. TiLV induced pathognomonic lesions were observed in the liver and brain in experimentally infected fish. Such jumping viral pathogens from tilapia could be a serious threat to aquaculture diversification with sea bass.

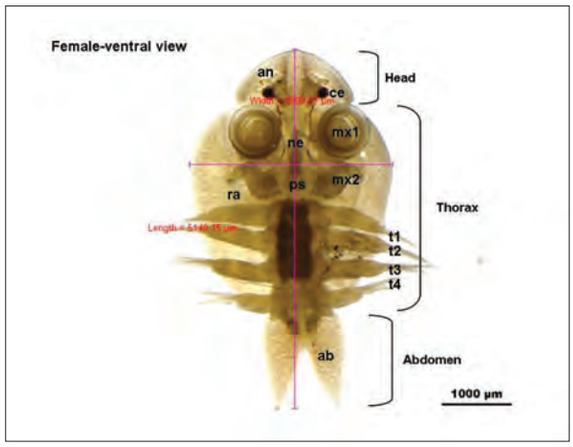


Haemorrhages observed in TiLV infected fish (H&E 40x)

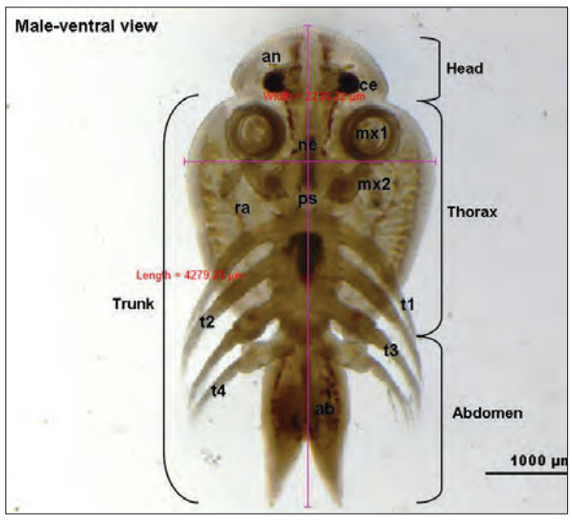
Prevalence of parasitic infections in brackishwater finfishes

Increasing intensification with lack of adequate health management strategies result in increased incidences of parasitic infestations. Parasites are the major concern for health, productivity and reproductionof aquaculture species. Surreptitiouslyharbouring the host, theyare considered economically more significant than acute diseases. Hence, cataloguing the prevalence of the parasitic infestation would help in formulating the control measures in aquaculture. So, parasitic profiling was done during 2016-19 in a total of 3145 fishes and crabs of different species with varying sizes such as *Lates calcarifer* – 2237 no., *Mugil cephalus* – 170 no., *Liza* spp. – 26 no., *Scatophagus argus* – 81 no., *Etroplus suratensis* – 156 no. *Chanos chanos* – 267 no., *Labeo rohita* – 200 no. and *Scylla serrata* – 8 no. collected from Tamil Nadu, Kerala, Andhra Pradesh and Maharashtra. Six major genuses such as *Argulus, Caligus, Lernanthropsis, Zeylanicobdella, Anisakis* and *Octolasmis* were found to infect finfishes and crabs as shown in the Graph 1 and Figure 1-10. No parasites were found in *Liza* spp. and *C. chanos.*

The tissue damages caused by these parasites were assessed by haematological and histopathological changes. Clinical signs such as lethargy, erratic swimming, reduced feeding, hanging at the surface, poor body condition, emaciated, anaemic, flashing and rubbing against surfaces with mortality of 80-100% was observed in fish affected with



Female crustacean ecto-parasite, *Argulus quadristriatus* collected from Asian seabass, *Lates calcarifer*. Scale bar: 1000 µm.

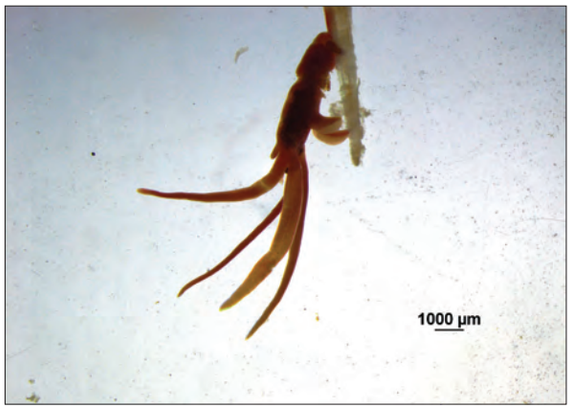


Male crustacean ecto-parasite, *Argulus quadristriatus* collected from Asian seabass, *Lates calcarifer*. Scale bar: 1000 µm.

parasitic infestations.Haematologically, there was significant (P<0.01, P<0.05) decrease in RBC, WBC, haemoglobin, PCV, thrombocytes and myelocytes population. But there was an increase in lymphocytes and monocytes, suggestive of chronic infestations.

Histologically, degenerative changes in gills, cloudy swelling, focal degeneration, fatty liver changes, diffuse tubular degenerative changes in kidney and increased white pulp with increased Melano-Macrophage Centres (MMC) was observed.

Female crustacean ecto-parasite, *Lernanthropsis mugilii* collected from mullet, *Mugil cephalus*. Scale bar : 5000 µm.



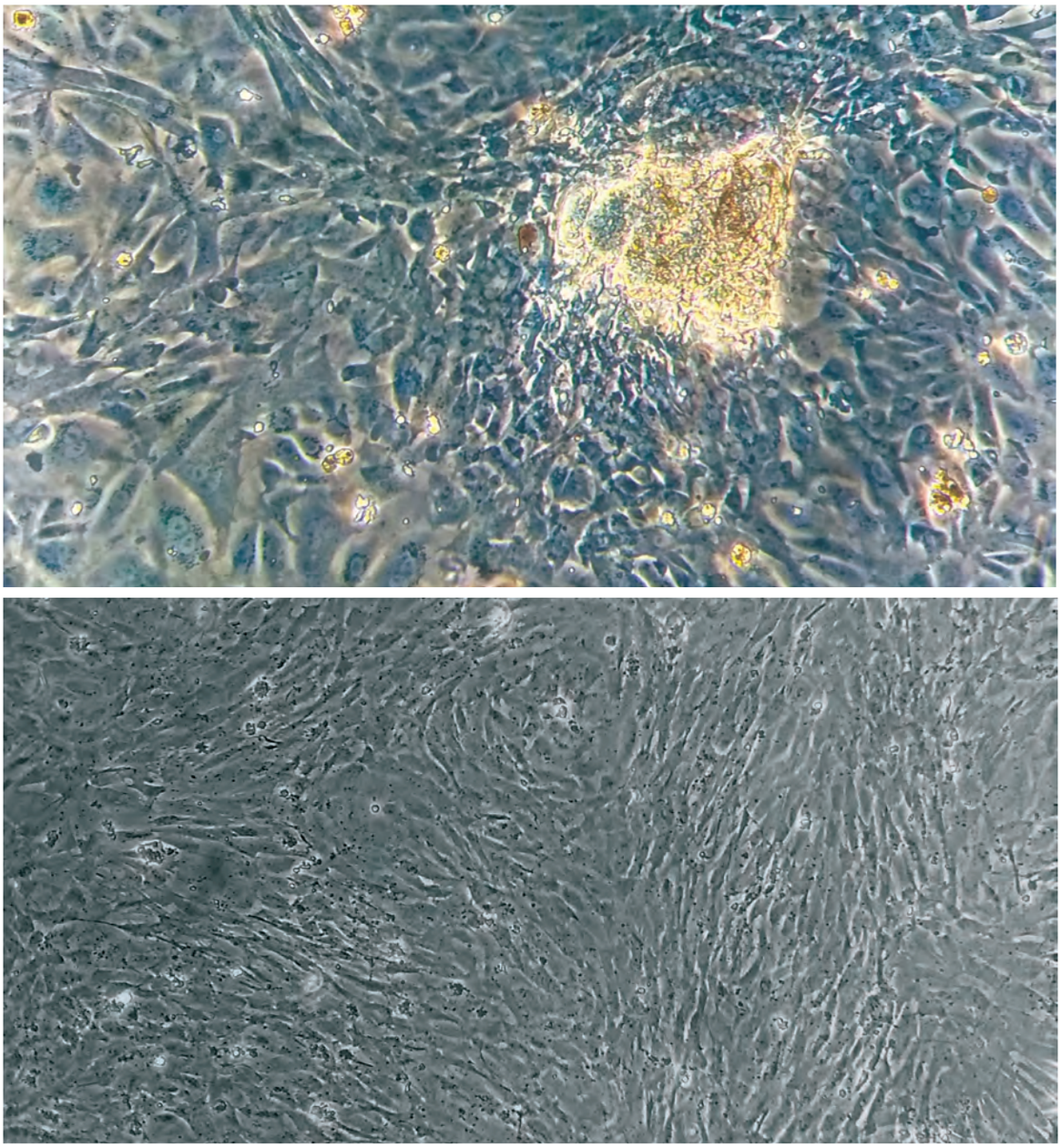
Male crustacean ecto-parasite, *Lernanthropsis mugilii* collected from mullet, *Mugil cephalus*. Scale bar : 1000 µm.

Male crustacean ecto-parasite, *Caligus minimus* collected from Asian seabass, *Lates calcarifer*. Scale bar : 500 µm.

Stalked barnacle, *Octolasmis* spp. collected from mud crab, *Scylla serrata*. Scale bar : 5000 µm.

Primary cell culture of milkfish

Milkfish (*Chanos chanos*) is a herbivorous euryhaline fish known for its relative resistance to disease and infections. Hence, it could serve as good model to study fish immune system, viral pathogenesis and preventive development such as vaccines. In the present work attempts were made to develop primary cell culture from fins, gills, spleen, kidney and brain tissues of milkfishusing L-15 medium and foetal bovine serum (FBS). The brain tissues developed a monolayer with 100% confluenceafter 12 days of incubation. On subsequent subculture of monolayer, the cell attachment and 100 % confluenceswas attained in 120 hours by five passages and 72-96 hrsby seven to ten passages. However, primary culture could not be developed with kidney, spleen, gill and fin tissue. EHP spores failed to be cultured in vertebrate cell lines



Development of primary cell cultures of milkfish brain in L-15 medium supplemented with foetal bovine serum

EHP has posed a serious threat to shrimp farming. To understand the pathogenesis and infectivity of EHP spores, its propagation was attempted in vertebrate (fish and mammal) cell lines. Striped snake head fish (SSN-1), and mammalian cell lines such as Vero and Madin-Darby canine kidney (MDCK) known to be susceptible for microsporidians were used to for EHP propagation. The two mammalian and fish cell lines inoculated with EHP-spores were intact without any cytopathology. Further, when second and third passages were tested, they were found negative for EHP by PCR, indicating that these cell lines were not suitable for propagation of EHP.

EHP spores failed to be cultured in vertebrate cell lines

EHP has posed a serious threat to shrimp farming. To understand the pathogenesis and infectivity of EHP spores, its propagation was attempted in vertebrate (fish and mammal) cell lines. Striped snake head fish (SSN-1), and mammalian cell lines such as Vero and Madin-Darby canine kidney (MDCK) known to be susceptible for microsporidians were used to for EHP propagation.The two mammalian and fish cell lines inoculated with EHP-spores were intact without any cytopathology. Further, when second and third passages were tested, they were found negativefor EHP by PCR,indicating that these cell lines were not suitable for propagation of EHP.

Development of primary cell culture in Edible Oyster, *Crassostrea madrasensis*

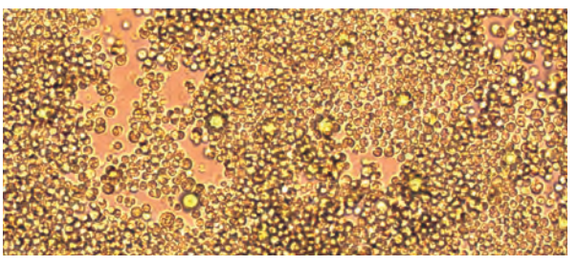
The explant culture from gill, mantle of Edible Oyster, *Crassostrea madrasensis* was carried out in L15 medium augmented with salt and incubated at 26 to 28°C. Explant culture from both the organs showed the migration of epithelial cells at 24 h. The gill and mantle epithelial cells measured 13.82±2.04 µm and 13.04±2.12µm, respectively at 24h. Total 25 passages for mantle were successfully carried out. These explant cultures could be used for environmental toxicants and shrimp virus propagation studies.

Development of primary cell culture in Green mussel, *Perna viridis*

The explant culture from mantle and gonads of Asian Green mussel, Perna viridis was carried out in L15 medium augmented with salt and incubated at 26 to 28°C. Explant culture from both the organs showed the migration of cells at 24 h. The mantle and gonad cells measured 11.45±1.13µm, 13.17±2.77µm, respectively at 24 h. These explant cultures could be used for environmental toxicants and shrimp virus propagation studies. Five passages of gonad cells were successfully carried out.

Stable commensal bacterial association favours healthy larval cycles in milkfish and Asian seabass

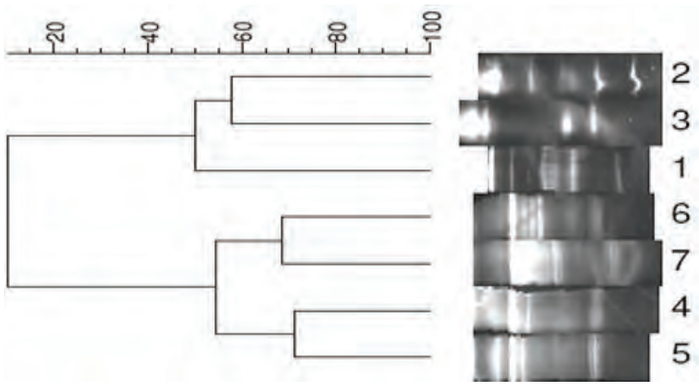
Commensal bacterial population protects fish larvae from the negative effects of pathogenic and opportunistic bacteria. Hence to understand the microbial dynamics, the larval production cycles of milkfish and seabass were investigated during 2017 and 2018 at fish hatchery facility at MES, CIBA. The bacterial quantification and characterisation were carried out in larvae and rearing water on 1, 4, 8, 12 and 18th day post hatching. The heterotrophic bacterial counts in the rearing water of milkfish were in the order of 103 cfu ml-1 and were stable throughout the cycle. However, in the seabass rearing systems the heterotrophic bacterial population were comparatively lower, unstable and of the order of 102 cfu ml-1 with a production loss at 14th day. The 16s PCR based DGGE profiles of milkfish and seabass larvae were also compared.The microbial characterisation in the seabass larval cycle revealed the presence of pathogenic and opportunistic vibrios such as *V. vulnificus, V.chagasi, V.splendius*. Non-opportunistic bacteria with high species diversity and stability were salient features of larval cycles of milkfish and productive cycles of seabass (Table). DGGE profiles of healthy and diseased cycles of seabass also revealed independent clustering of both cycles at 50% confidence interval in the neighbour joining tree (Fig). The study indicates that the non-opportunistic bacteria with high species diversity and stability in the early days of larval cycles inhibit the establishment of opportunistic and pathogenic bacteria.



Primary cell culture (5th passage) from gonad of Green Mussel

Bacterial isolates characterised biochemically from Milkfish and Asian seabass larval rearing system.

DOC	Milkfish larvae *(Chanos chanos)*	Asian seabass larvae *(Lates calcarifer)*
1(2017)	*V.littoralis, V.alginolyticus, V.calviensis, B. circulans*	*V.pectenicida, V.chagasii, V.littoralis, V.mimicus*
1(2018)	*V.alginolyticus, V.littoralis, V.metschnikovii, V.mimicus*	*V.littoralis, V.coralliilyticus*
4(2017)	*V.fisheri , B. circulans, V.littoralis, V.mimicus*	*V.vulnificus, V.mimicus, V.splendius, V.pectenicida, V.chagasii,V.rumoiensis*
4(2018)	*V.ponticus, V.alginolyticus, V.calviensis, V.littoralis*	*V. alginolyticus, V.proteolyticus, V. mimicus, V. pacinii,V.coralliilyticus*
8(2017)	*V.fisheri, V. hepatarius,V. superstes, B. circulans,B.polymyxa*	*V.vulnificus, V. calviensis, V.corallilyticus, V.chagasii*
8(2018)	*V.ponticus, V.alginolyticus, V.calviensis, V.littoralis,V.mimicus, V. proteolyticus*	*V.proteolyticus, V.coralliilyticus, V.littoralis, V.natriegenes, V. mytilli*
12(2017)	*V.alginolyticus, V.littoralis,*	*V.alginolyticus, V.chagasii, V.vulnificus*
12(2018)	*V.ruber, V.natriegenes, V.littoralis*	*V.coralliilyticus, V.littoralis, V.alginolyticus*
18(2017)	*V.alginolyticus, V.littoralis,V. hepatarius, V. superstes B.polymyxa, B. circulans, V. mytilli*	***Larval loss at 15th day***
18(2018)	*V.alginolyticus, V.ruber, V.natriegenes, V.parahemolyticus, V.littoralis, V.fisheri*	*V.cyclotrophius, V.littoralis, V.pacinii, V.coralliilyticus,V.proteolyticus, V.alginolyticus, V.pectenicida*



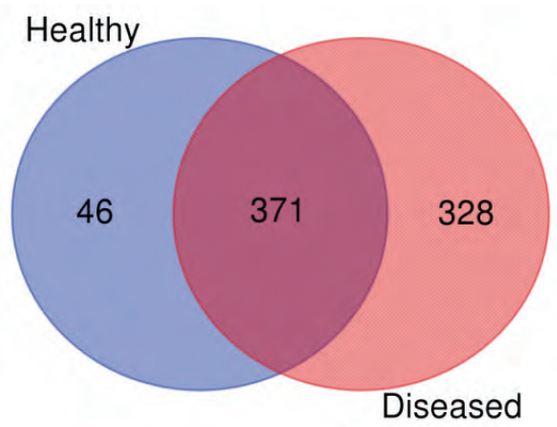
Microbial profiling of Milkfish and Asian seabass larvae using DGGE –PCR: 1,2,3 were DGGE profiles of 4,8,12 day old diseased seabass larvae, 4,5,6,7 were DGGE profiles of 4,8,12 and 18 day old milkfish larvae.

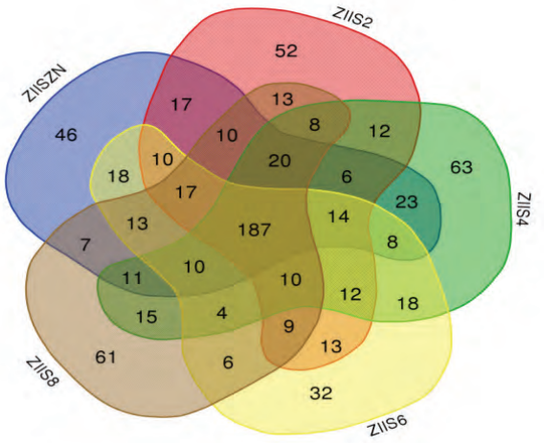
Microbial profiling of Zoea syndrome

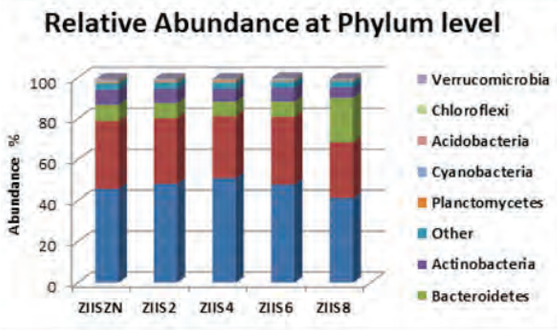
Zoea-2 syndrome has emerged as a serious threat to Indian shrimp hatcheries, especially after introduction of *P. vannamei*. It causes delayed molting or impairment of metamorphosis, followed by mass mortality at zoea II stage. Metagenomic study was conducted to figure out the etiology of the zoea-2 condition.Five samples namely, during the 2nd (ZIIS2), 4th (ZIIS4), 6th (ZIIS6) and the 8th (ZIIS8) day of syndrome and one healthy (ZIISZN) samplethat served as a control, were subjected to metagenomic analysis. Extracted DNA from these samples was sequenced on illumina platform and analysed using QIIME. The analyses revealed a significant microbial dysbiosis between healthy and diseased conditions. In total 49 phyla were identified, among which six were dominant, namely Proteobacteria, Firmicutes, Bacteroidetes, Actinobacteria, Planctomycetes, Cyanobacteria and which constitutes around 98.3% flora in all. In all the samples, Proteobacteria and Firmicuteswere found to constitute around 40% and 30%of the total microbial population respectively. Some of the phyla such as Proteobacteria, Firmicutes, Actinobacteria, Planctomycetes, Cyanobacteria, Chloroflexi, and Verrucomicrobia showed significantly lesser in abundance in diseased samples compared to healthy one. On the contrary, Bacteriodetes and Acidobacteria showed a considerable higher abundance in zoea syndrome affected samples.

Analysis of bacterial abundance at the genus level showed the presence of 745 genera out of which 187 were present in all the samples and 46, 52, 63, 32 and 61 were unique to ZIISZN, ZIIS2, ZIIS4, ZIIS6 and ZIIS8 samples respectively. Among core genera 16 were dominant and belonging to the phyla Proteobacteria, Firmicutes, Bacteroidetes, and Actinobacteria.

Some of the genera such Devosia, Unclassified Rhodobacteraceae, Nonlabens, Muricauda, Unclassified Flavobacteriaceae, Unclassified Flavobacteriales, and Pseudoalteromonas as were more abundant in zoea syndrome affected samples compared to the healthy larvae. There was no trend or pattern in the bacterial abundances with regard to dominant genera as the days of syndrome progressed. Overall, a total of 46 genera were seen specific to healthy, 328 specific to the syndrome and 371 genera common in both.



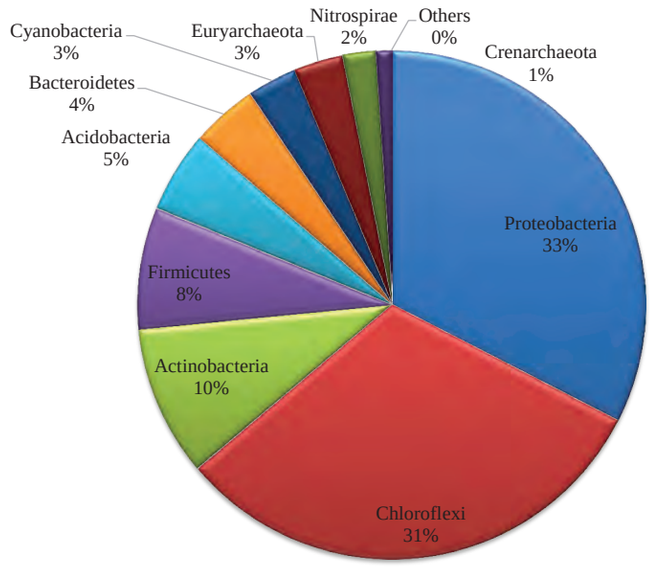




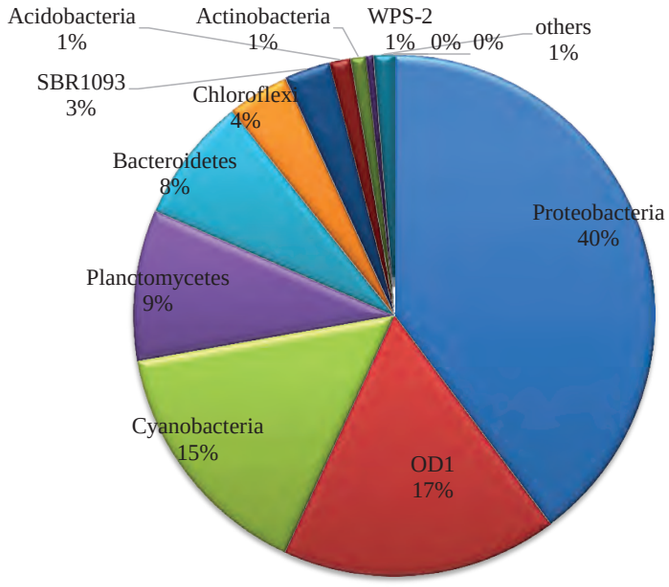
Bacterial abundance in zoea syndrome affected shrimp larvae at phylum level

Microbial profiling of CIBAMOX

CIBAMOX, a product of CIBA, developed for mitigation of nitrogenous wastes in aquaculture ponds was subjected to microbial profiling by 16s rDNA metagenomics. The analysis revealed several novel bacteria involved in nitrogen metabolism. From the sequence analysis it was observed that bacterial group belong to Caldilineaceae family were also dominant in ammonia oxidation besides Nitrosomonas and NitrobacterA large percentage of microbes identified in the AOB and NOB enrichments belonged to the phylum Proteobacteria, which are widely established in environments and play important roles in the process of nutrient cycling and mineralization of organic compounds.Nearly 62% of the sequences in these enrichments were found to be unclassified genera, which show that there might be novel microbial flora involved in ammonia oxidation or aiding ammonia oxidation process.



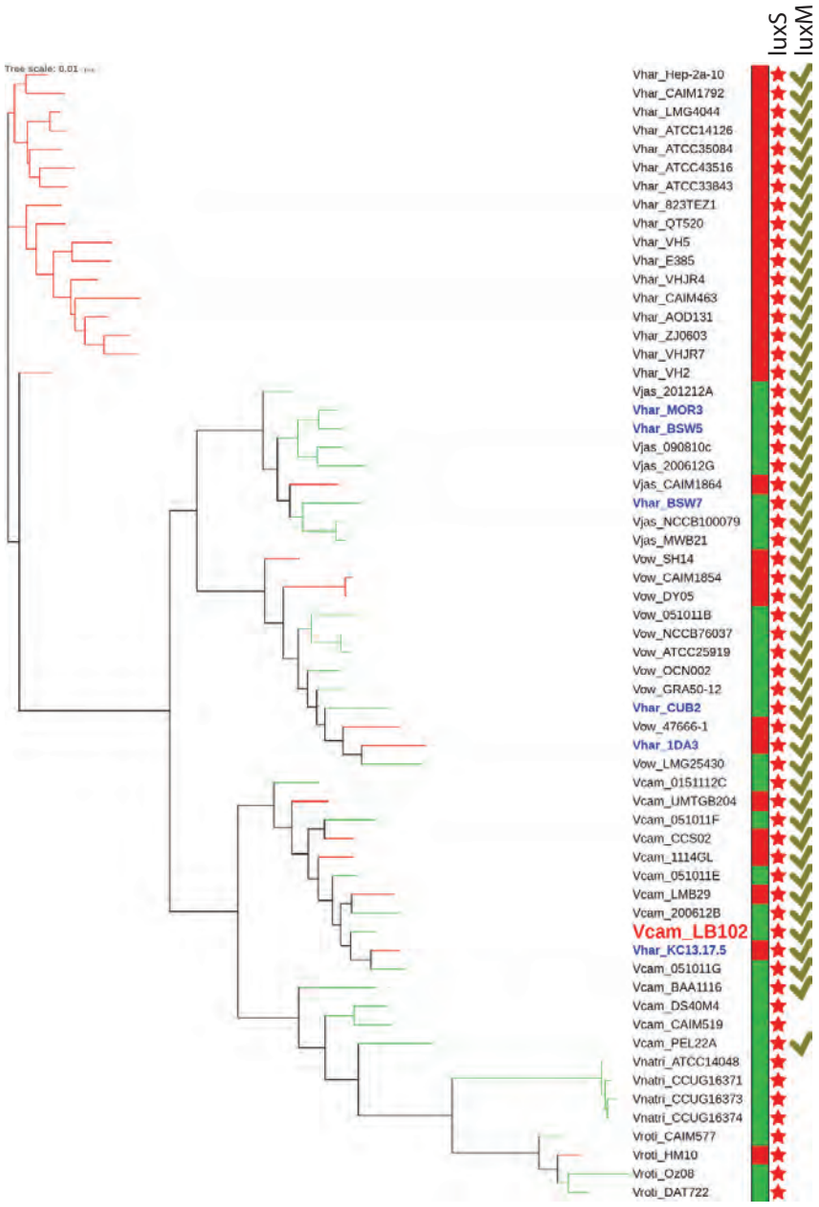
Microbial diversity in AOB consortia



Microbial diversity in NOB consortia

Characterization of quorum sensing system in *Vibrio harveyi* clade species

Vibriosis is the major challenge in shrimp hatchery often leading to 100% mortality in mysis and early postlarval stages. For long it was considered that *V. harveyi* is the primary causative agent for luminescent vibriosis. However, the recent reports suggest that it is also caused by several other related bacterial pathogens such as *V. campbellii, V. owensii, V. rotiferianus, V. jasicida* which together form the part of Harveyi clade. To understand the virulence, quorum sensing system was characterised in sixty genomes of *Vibrio harveyi* clade (Table). The autoinducer 2 synthesizing luxS gene was present in all the isolates of *V. harveyi* clade. However, autoinducer 1 synthesizing gene luxM was present in *V. harveyi, V. campbellii, V. jasicida* and *V. ovensiii* but absent in *V. natriegens* and *V. rotiferianus*. Seeing, the differential conserved nature the *luxM* gene can be used for diagnostic purpose.

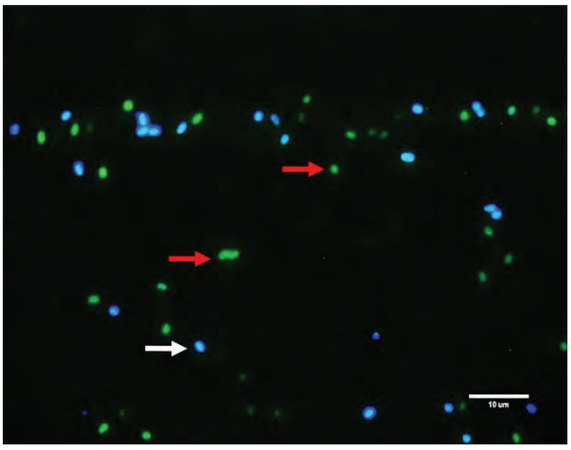


Distribution of quorum sensing genes in Vibrio species under Harveyi clade (red and green color show pathogenic and environmental origin of isolates)

Development of diagnostics

Rapid detection technique to differentiate viable and dead EHP spore

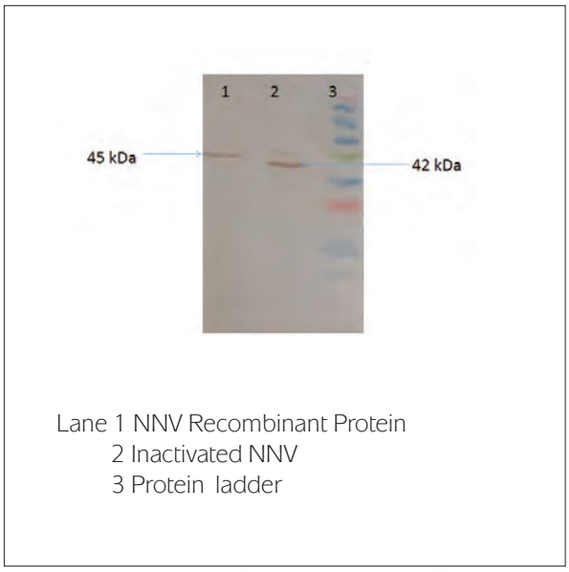
Purification of EHP spores are usually attempted by centrifugation step in different media using refrigerated centrifuge, which often render spore unsuitable for experimental infections. Hence, methods are required to ascertain the infectivity of the purified spores to assess the effect of treatments. The present study demonstrated a staining technique to assess the viability of EHP spores by combining the nucleic acid stain Sytox Green and the chitin binding stain Calcofluor White. These two stains were used to differentiate the live (freshly harvested) and dead (boiled) EHP spores. Dead spores were stained by Sytox Green and appeared yellow-green oval bodies through the blue (470-490 nm) excitation filter and white-yellow through violet filter (395-415 nm). The viable spores were stained by Calcofluor White which appeared as turquoise-blue through the violet filter (395-415 nm). This study demonstrated a staining technique to assess the viability of *Enterocytozoon hepatopenaeimi* crosporidian spores by combining the nucleic acid stain Sytox Green and the chitin binding stain Calcofluor White.



Fresh (live) and boiled (dead) spores of EHP stained with Sytox Green and Calcofluor White
[Note: When viewed through a blue filter (470-490 nm), live spores are not visible, while dead spores fluoresce yellow green; When the same area is viewed under a violet filter (395-415 nm), dual stained live spores as turquoise-blue ovals and dead spores appear as bright white-yellow ovals]

Development of indirect sandwich ELISA for detection of Betanodavirus

Viral nervous necrosis caused by betanodavirus results in 100% mortality in Asian seabass fry. The virus is transmitted both vertically and horizontally. Control of the disease is by using virus free broodstock and by stocking disease free seeds. Detection of the virus in the broodstock and the larval stages using a cost effective, high throughput test will help in controlling the disease. An indirect sandwich ELISA has been developed using rabbit polyclonal and mouse monoclonal antibodies against nervous necrosis virus. The monoclonal antibodies against the capsid protein of NNV was developed in collaboration with Centre for Bioseparation Technology, Vellore Institute of Technology, Vellore. The specificity of the antibodies to NNV was verified by western blot. An indirect sandwich ELISA was optimized by titrating the polyclonal capture antibody, monoclonal detection antibody and the conjugate by checker board titrations. The indirect sandwich ELISA had a sensitivity of 0.781 µg of antigen. The test can be employed to screen samples of brain from suspected fishes for the presence of NNV and to estimate the antigen content in the infected cell culture supernatants and vaccine preparations.

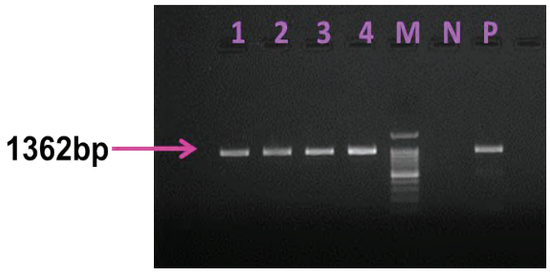


Lane 1 NNV Recombinant Protein
2 Inactivated NNV
3 Protein ladder

Western blot for NNV with MAb H5H2

Development of real time PCR assay for detection of iridovirus infection in fish

Iridovirus is an emerging finfish pathogen in India. SYBR Green based real time PCR assay has been developed for detection of iridovirus with custom designed primers. The PCR products were cloned and the copy numbers determined using online tools and standard curve analysis that generated a linear range of 10^1–10^6 DNA copies. Melting curve analysis showed the specific target gene amplification. The detection limit of the assay was found to be as low as 10 copies. Amembrane cofactor protein(MCP) gene based PCR was also standardised with custom designed primers for detection of iridovirus. The phylogenetic analysis of sequences from the Indian isolate formed clade distinct from the isolates from China and Taiwan.



MCP gene based PCR for detection of iridovirus

Farm inputs usage pattern in Indian shrimp culture

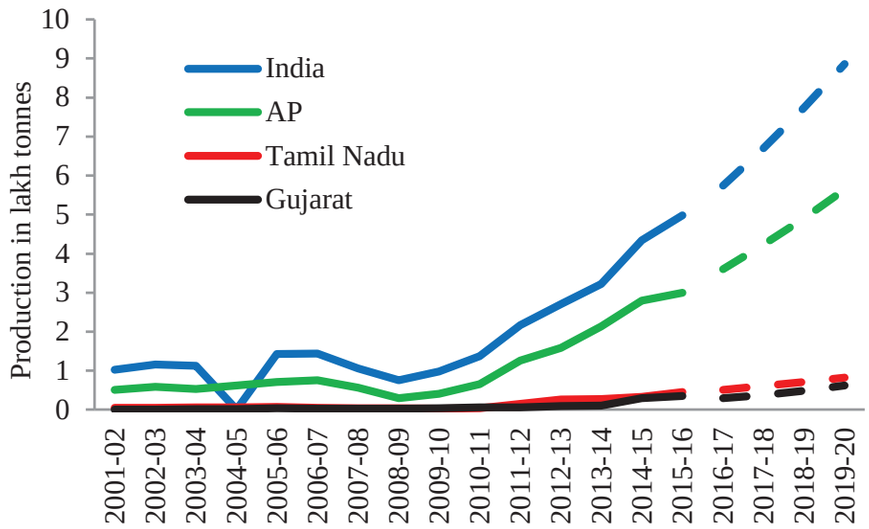
A number of inputs are used in shrimp farms presumably for enhancing productions and for various other purposes. A survey was conducted during 2017 to understand the input usage pattern inthe shrimp farms. The study was carried out in major shrimp producing states, Andhra Pradesh, Tamil Nadu, Gujarat and Maharashtra. The farm inputs were classified into five major groups based on application as disinfectants, probiotics, environmental modifiers, nutritional supplements, and anti-microbial. Quantity of the farm inputs used was determined per tonne of shrimp produced. The study showed use of environmental modifiers being used highest quantity to improve soil and water quality, followed by probiotics (water, soil and gut probiotics) and disinfectants. No record of use of anti-microbial product was observed during the study.

Classification of farm inputs used for shrimp aquaculture in 2017 (kg ton^{-1} of shrimp production)

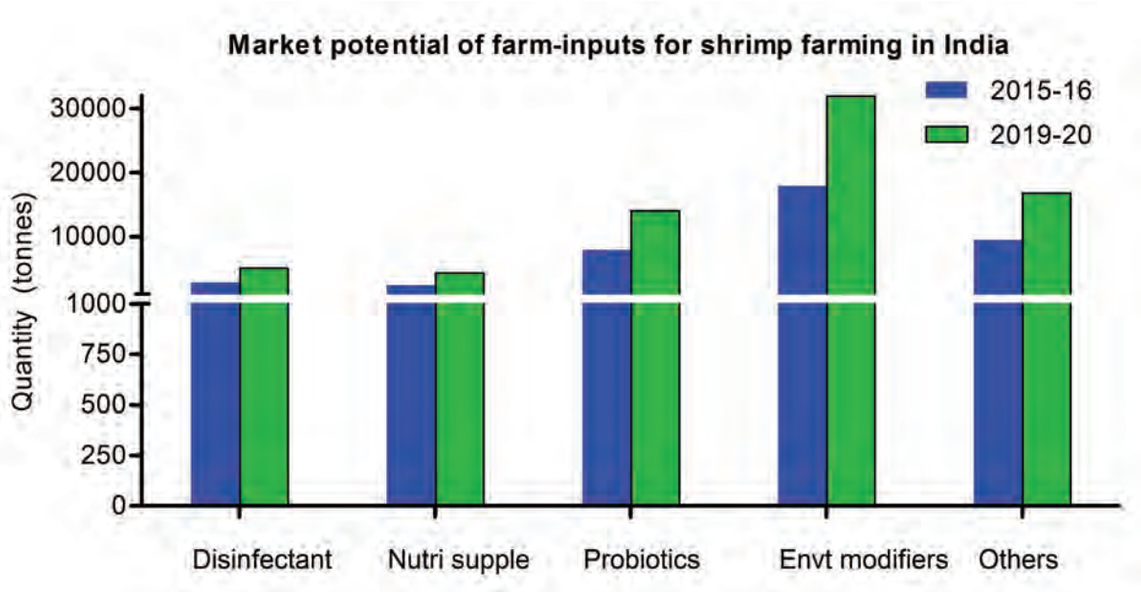
Farm inputs	TN	AP	Gujarat	Maharashtra
Disinfectants				
Oxidizing Agents	0.89	4.10	4.48	1.04
Detergents	3.13	1.88	4.20	6.76
Total	4.02	5.98	8.68	7.80
Probiotics				
Water Probiotics	7.75	2.95	7.25	8.35
soil Probiotics	6.13	17.06	5.18	4.99
Gut Probiotics	1.16	1.12	0.33	1.73
Total	15.04	21.13	12.75	15.07
Nutritional supplements				
Vitamins and Minerals	1.40	3.54	1.69	1.66
Binders	1.08	0.00	0.11	0.73
Total	2.49	3.53	1.80	2.39
Environmental modifiers				
Oxidising agents	5.74	0.00	2.85	0.00
Ammonia controlling agents	4.17	0.41	0.10	0.00
pH modifiers	0.43	3.00	3.20	0.00
Minerals	43.83	30.03	23.91	57.20
Total	54.17	33.44	30.07	57.20
Others				
Total	**11.36**	**24.97**	**0.12**	

Market potential of farm inputs in Indian shrimp culture

Market potential of various farm inputs for shrimp production of India was estimated. Various parameters such as production, area and risk of environmental parameters, disease outbreaks for the years 2015-16 and 2018-19 were taken into account. Demand for disinfectants, probiotics, nutritional supplements and environmental modifiers for the four years from 2015-16 to 2018-19 was 2831, 7882, 2423 and 17919 tonnes respectively, whereas, forecasted demand for the year 2019-20 will be 31915 tonnes.



Year wise production of farm inputs in India; state wise break up is given



Milkfish can reduce the bacterial load in *P. vannamei* culture pond

The mucus of some species of fish including milkfish (*Chanos chanos*) is known to be antibacterial. The levels of total heterotrophic aerobic bacteria (THAB) and total *Vibrio* (TV) in pond water were monitored periodically in milkfish - vannamei co-culture pond water. Control ponds were stocked with only *P. vannamei* (40 Nossqm^{-1}). Milkfish was stocked with two different stocking densities along with *P. vannamei* at 0.2 Nos sqm^{-1} and 0.4 Nossqm^{-1}. Water samples were collected between 10:00 and 11:00 AM from three different locations in the pond, pooled and THAB and TV were enumerated on tryptone soy agar (TSA) containing 1% NaCl (w/v) and thiosulfate citrate bile salt sucrose (TCBS) agar with 2% (w/v) NaCl, respectively. No significant difference in terms of level of THAB and TV was observed upto 80 DOC of culture period. However, at 100DOC, the level of THAB was found significantly higher ($p < 0.05$) in the control ponds (only vannamei) in comparison with milkfish vannamei co-culture. At DOC 100, the total *Vibrio* level was found higher in control group in comparison to two groups culturing milkfish, but significant difference was not observed ($p < 0.05$). No significant difference was observed while considering the average bacterial load throughout the culture period both in case of THAB and TV among different experiment group. The present study showed that the introduction of milkfish helps in reduction of bacterial load in the shrimp culture ponds.

Microbial counts during milk fish-vannamei co-culture

Duration of culture (Days)	THAB Log10 CFU ml-1 (Mean ± SE)			TV Log10 CFU ml-1 (Mean ± SE)		
	A	B	C	A	B	C
DOC 0	3.630 ± 0.182	3.460 ± 0.194	3.358 ± 0.174	2.649 ± 0.036	2.720 ± 0.399	2.820 ± 0.322
DOC 20	4.387 ± 0.093	4.347 ± 0.041	4.428 ± 0.522	3.255 ± 0.105	3.199 ± 0.175	3.173 ± 0.188
DOC 40	4.911 ± 0.790	4.721 ± 0.152	4.974 ± 0.396	3.563 ± 0.033	3.711 ± 0.068	3.568 ± 0.539
DOC 60	4.929 ± 0.394	4.594 ± 0.171	4.498 ± 0.027	3.170 ± 0.159	3.112 ± 0.104	3.176 ± 0.141
DOC 80	4.716 ± 0.422	4.636 ± 0.089	4.793 ± 0.382	3.277 ± 0.310	3.134 ± 0.155	3.245 ± 0.200
DOC 100	5.491 ± 0.036[a]	4.635 ± 0.216[b]	4.652 ± 0.183[b]	4.066 ± 0.394	3.680 ± 0.226	3.613 ± 0.113
Average during culture	4.677 ± 0.252	4.399 ± 0.024	4.450 ± 0.172	3.330 ± 0.102	3.259 ± 0.144	3.266 ± 0.173

$p < 0.05$

A = Control (Only *P. vannamei* 40 Nos./sq.m.)

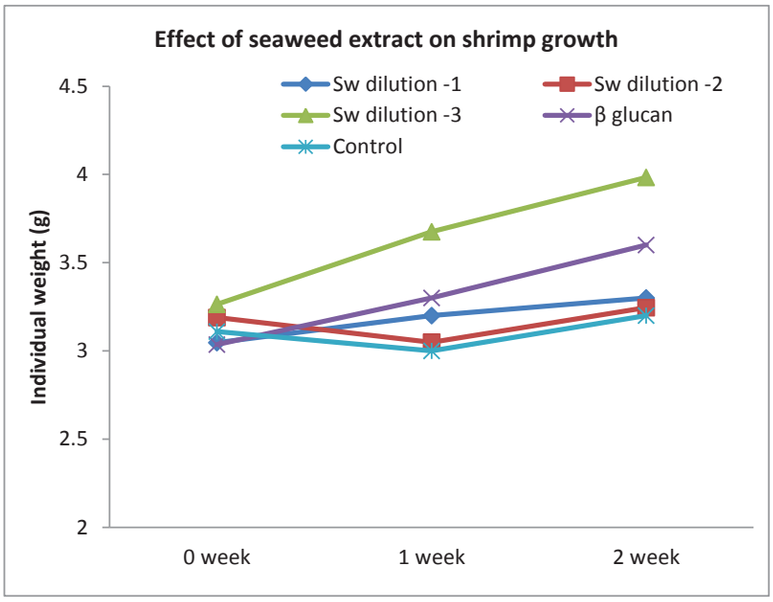
B = *P. vannamei* (40 Nos./sq.m.) and Milk fish (0.2 No./sq.m.)

C = *P. vannamei* (40 Nos./sq.m.) and Milk fish (0.4 No./sq.m.)

Application of brown seaweed extract as growth promotor for shrimp

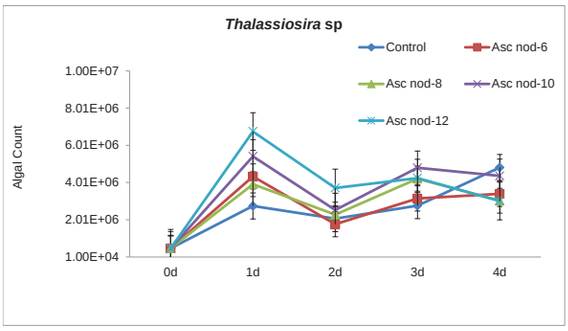
Brown seaweed (*Ascophyllumnodosum*)extract was used as immunostimulant and growth promoter for shrimp juvenile and growth enhancer for micro algae.

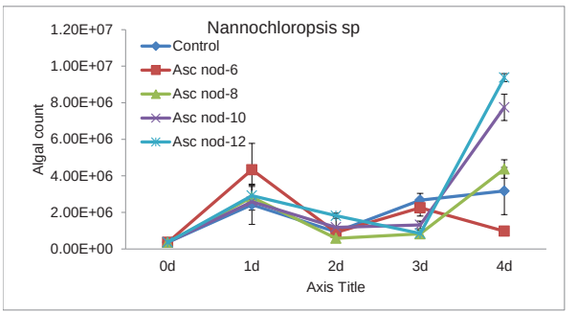
Crude extract of brown seaweed, was fed to shrimp (3.57±0.11) by feed-top dressing. The shrimp fed with the micro algal preparation registered improved growth by 20% in a span of two weeks at three-fold dilution. However, at higher concentration, the extract was having negative effect on growth and survival.



Application of brown seaweed extract as algal growth enhancer

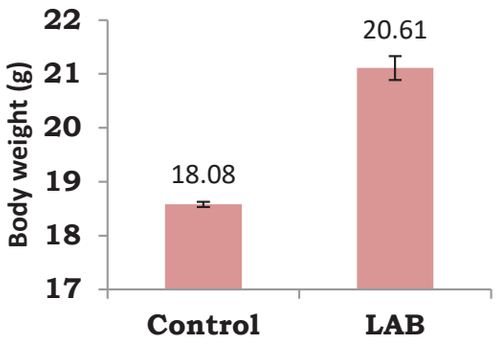
Thalassiosira sp and *Nanochloropsis* sp were used for studying the influence of seaweed extract on the growthof these algae.The brownseaweed extract was incorporatedin the microalgal culture media at different dilutions before inoculation. The study confirmed growth promotion activity of the seaweed extract in improving the algal cell density in short span of time. *Thalassiosira* sp recorded rapid increase in the cell density (100 fold in one day) however a rapid decline was observed in the cell density subsequently. The growth of *Nanochloropsis* sp recorded a gradual increase until four days except for highest concentration of the extract which caused reduction in cell density after one day. In both the cases, 10-12 concentration of the crude extract showed highest growth promotion activity.



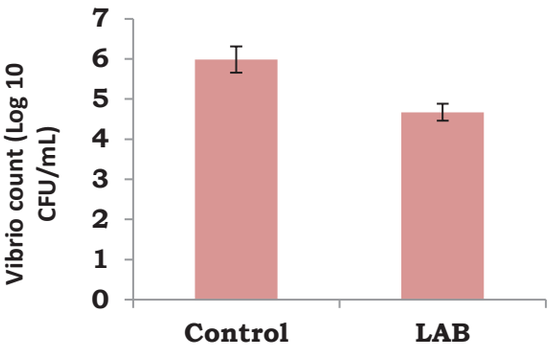


Improved growth performance and survival of *Penaeus vannamei* with feed supplemented with lactic acid bacteria (LAB)

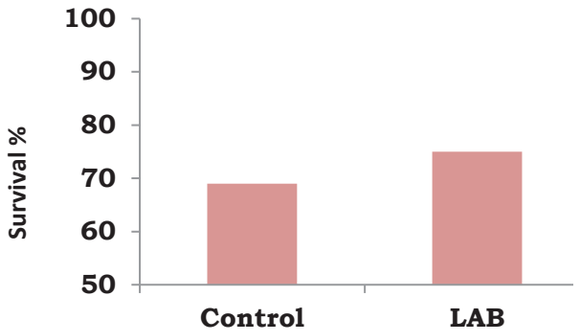
Different species of lactic acid bacteria (LAB) are known to have beneficial effect as gut probiotics and successfully used in shrimp culture in different countries. A feeding trial was conducted on *P. vannamei* (5.5 to 7 g) with feed supplemented with two isolates of lactic acid bacteria (LAB) viz., *Lactococcus lactis sub* sp. *lactis* SDKRC-5 (isolated from home-made curd)and *Lactobacillus* isolate (SDKRC-6) (isolated from gut of wild shrimp *P. indicus*) at the level of 107 CFU g-1 of feed. These two isolates were previously selected on the basis of maximum inhibitory potential against *V. parahaemolyticus*. After 63 days of feeding trial, the LAB supplemented feed yielded 14% higher growth over the control. The survival in the LAB supplemented and control group were 93.3 and 83.3 %, respectively.A challenge trial was conducted on juvenile *P. vannamei* with virulent *V.campbelli* strain (106 CFU I/M injection). After 8 days of challenge, the survival in treatment and control groups was 75 and 68.97 %, respectively. The *Vibrio* counts in the gut ofshrimp was significantly lower ($p<0.05$) in case of LAB treated group (4.671 ± 0.209 Log_{10} $CFUg^{-1}$) as compared to control (5.987 ± 0.327 Log_{10} $CFUg^{-1}$). The study showed that incorporation of two selected isolates of LAB aids in enhanced growth performance and survival of shrimp and also tolerant to challenge with virulent *Vibrios*.



Growth of P. vannamei fed with LAB incorporated feed after 63 days of culture



Vibrio count in gut of P. vannamei fed with LAB incorporated feed

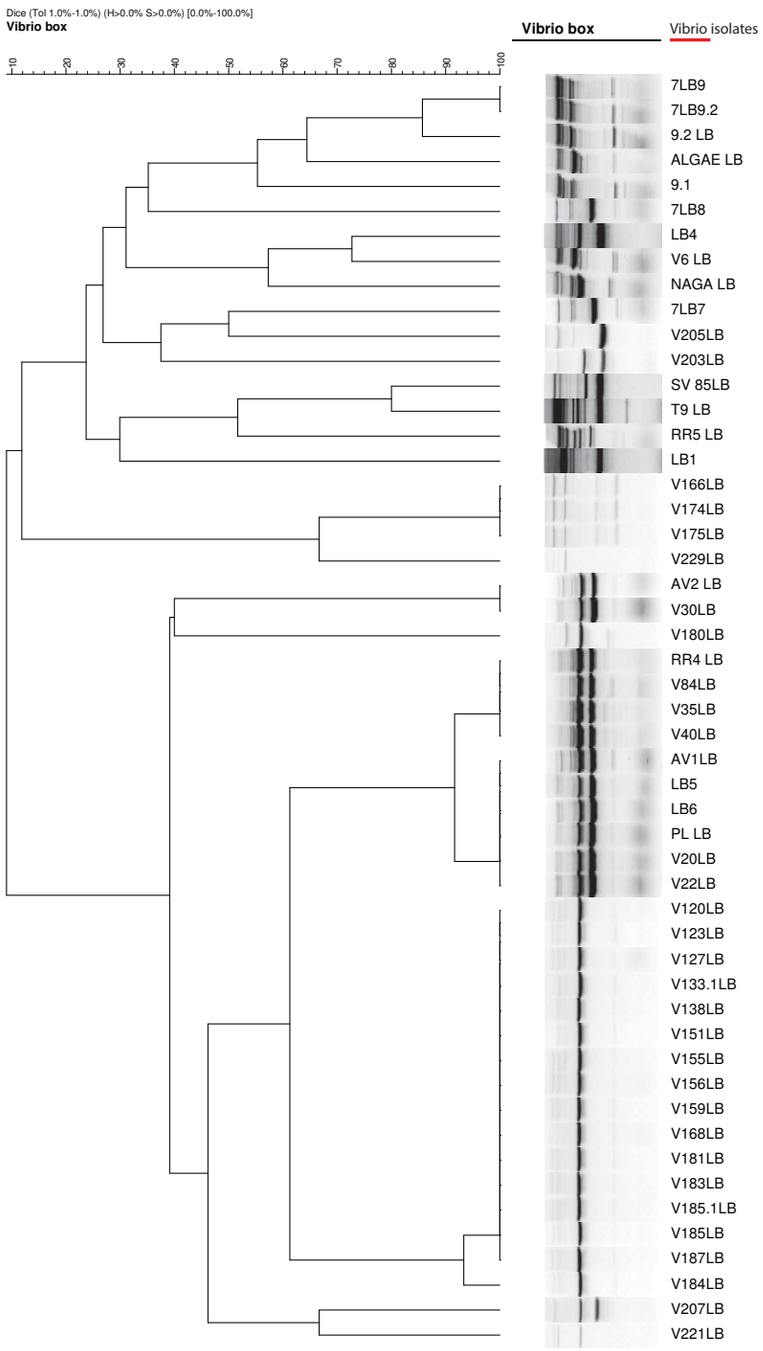


Survival in P. vannamei after challenge with V. campbellii

Prophylactics

Biocontrol of vibrios in shrimp hatcheries using bacteriophages

New luminescent bacteria and bacteriophages were isolated from shrimp hatcheries were studied for their susceptibility/host range. During the field trials, fresh luminescent *Vibrios* (47 isolates) and corresponding bacteriophages (36nos) were isolated. Using BOX PCR, these luminescent *Vibrios* segregated into 17 groups at 60% hierarchical level.

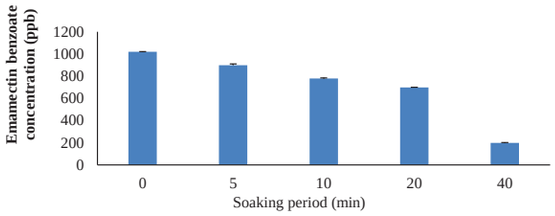


Diversity of luminscent Vibrios by BOX PCR

Therapeutics

Emamectin benzoate effective against crustacean parasitic infestation in Asian Seabass

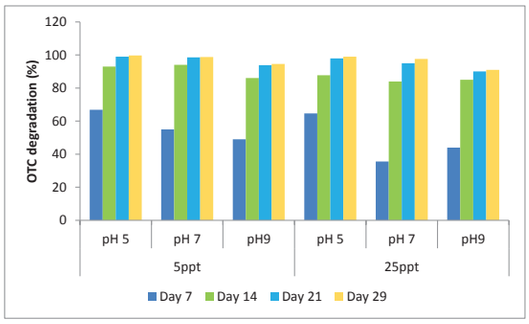
Finfish stocks often suffer parasitic infestation during captivity and culture. An experiment was conducted to assess the efficacy of emamectin benzoate (EB) against *Caligus minimus* infestation in Asian seabass. Proposed therapeutic treatment regimen of 50µg of EB kg^{-1} fish BW d^{-1} for 7 d was administered through feed. Significant improvement in survival (92%), reduction in parasitic load and improvement in haematological parameters were observed after fifth day of treatment. No parasite could be recovered on and after 7th day of treatment. In addition, leaching effect of EB was also determined at different time intervals by QTRAP 4000 LC-MS/MS analysis. It was found that there was 6.25 fold decreases in EB level after soaking the top-dressed feed in water for 40 minutes.



Withdrawal of emanectin benzoate (EB) from feed coated with 1250 ppb

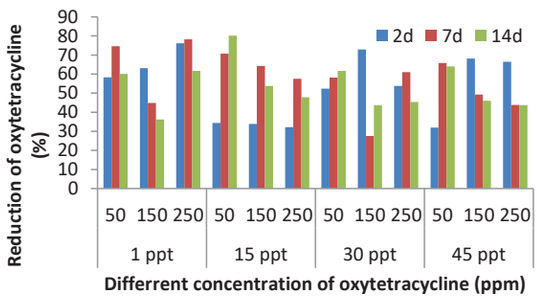
Influence of pH on OTC degradation under varying salinities

Oxytetracycline (OTC) is one of the few antimicrobials approved by the USFDA for use in aquaculture. Persistence of such antibiotics in the environment is an important issue and needs to be understood with regard to environmental characteristics. Influence of pH (5, 7 and 9) and salinity (5, 25 ppt) on OTC degradation at two different concentration of OTC (5 and 10 ppm) was studied. The yard experiment was conducted in 6 L plastic containers with 500 gm of soil and 5 L water mixed with 5 or 10 ppm of OTC. Water samples were collected periodically and the concentration of OTC was determined using LCMS/MS. It was observed that the degradation of OTC was faster in lower pH compared to higher pH irrespective of the salinity. The observed variation in the rate of degradation could be attributed to the chemical nature of the drug under different pH conditions. These results of the study suggest the role of pH in the degradation of OTC in brackishwater farming conditions.



Evaluation of Pleurotus sp edible mushroom on degradation of oxytetracycline

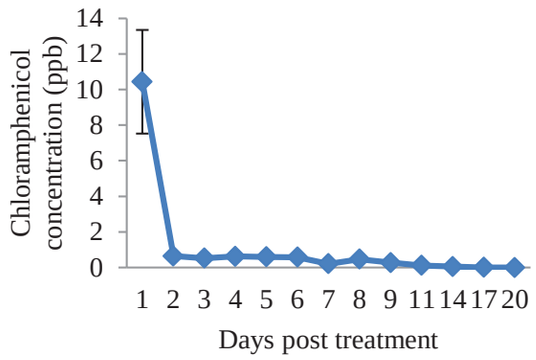
The *Pleurotus* sp an edible mushroom was evaluated for the degradation of OTC. The experiment was conducted *in vitro* in different salinities (1, 15, 30 and 45 ppt) with soil base at three different concentrations of OTC (50, 150 and 250ppm) and treated with *P. ostreatus* with fungal load of 10^{4} CFU ml^{-1} . The suspended water samples were collected at periodic intervals on 2, 7 and 14 days after treatment and estimated for antibiotic in treatment and control. It was found that the *Pleurotus* species degraded the OTC at all salinities.



Percentage reduction of oxytetracyclene in edible mushroom, *Pleurotus* sp at different salinities.

Withdrawal of chloramphenicol in shrimp muscle tissue

Withdrawal period of chloramphenicol in *Penaeus vannamei* (8 g) was studied by feeding commercially available feed coated with chloramphenicol at the dose of 500 mg kg^{-1} feed for 7 days. Concentration of the antibiotic in muscle tissue was determined by LCMS/MS. Concentration of chloramphenicol in the muscle tissues dropped drastically within two days (0.64±0.08 ppm)of stopping feeding shrimp with antibiotic fortified feed and complete elimination of the antibiotic was observed at 20 days post cessation of antibiotic treatment.



Withdrawl period of chloramphenicol in *Penaeus vannamei*

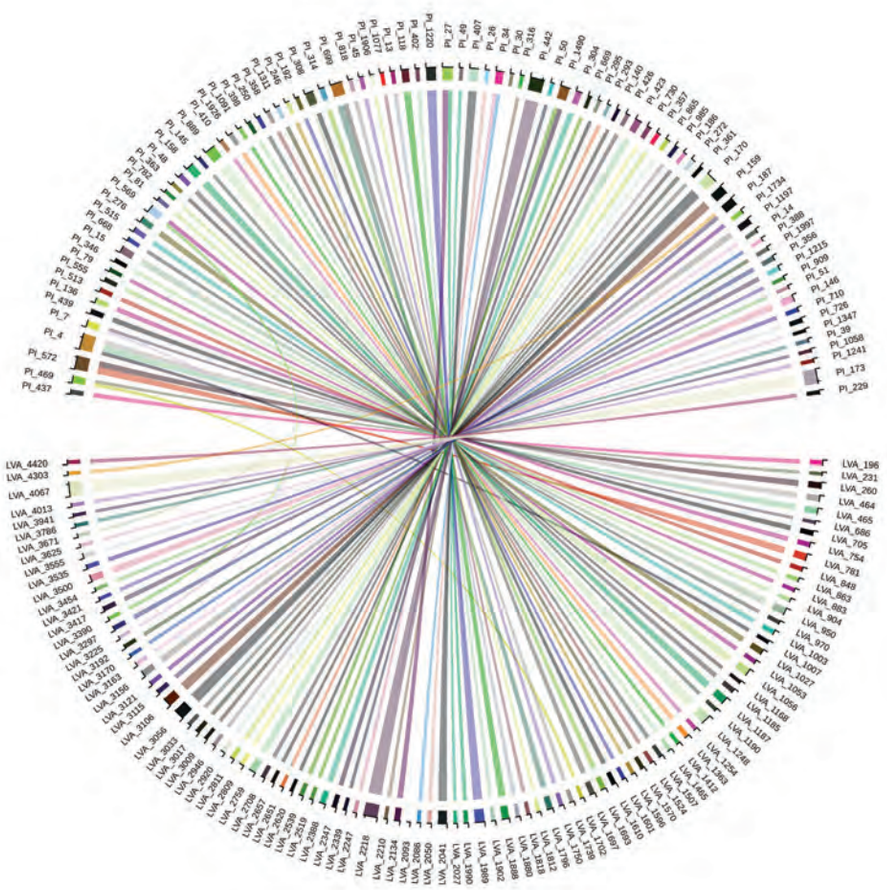
Services to the sector

National Referral Laboratory for Brackishwater Aquatic Animal Diseases

CIBA's Aquatic Animal Health and Environment Division is serving as National Referral Laboratory for brackishwater aquatic animal diseases (NRLD) and serving the stakeholders including Aquatic Quarantine and Certification Services (AQCS), Southern region, Aquatic Quarantine Facility (AQF), Chennai, shrimp hatcheries and shrimp farmers. During April 2018 to March 2019, a total of 63 samples including imported *Artemia* cyst, frozen tissue and feed samples were tested for OIE listed shrimp and fish pathogens for the AQCS, Chennai. All the samples were tested negative for OIE listed pathogens.

Screening of samples for OIE listed pathogens

Sl.No.	Sample	No Tested	DNA viruses		RNA viruses			Bacteria		Parasite
			WSSV	IHHNV	IMNV	TSV	YHV	AHPND	NHPB	EHP
1	Prawn frozen feed	2	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
2	Imported Artemia cyst	59	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
3	Sea fish (Gallons)	1	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
4	Semi-moist feed	1	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
5	Total samples Tested	63	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve



GENETICS AND BIOTECHNOLOGY

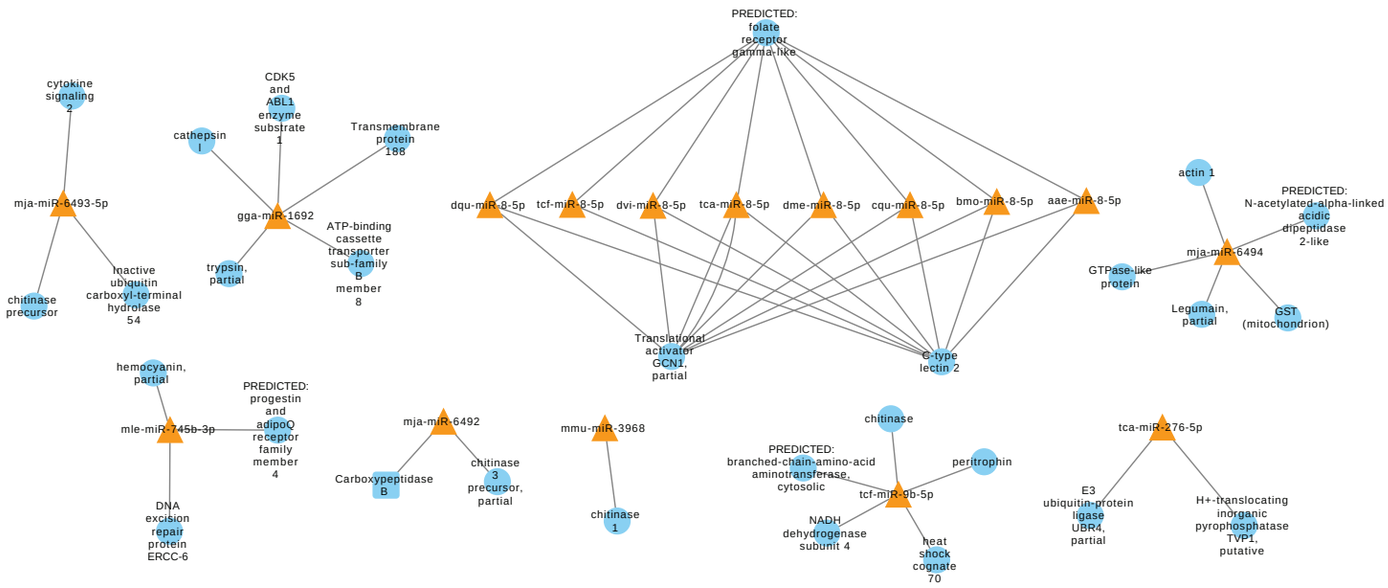
miRNA's expression profiling during WSSV infection

In recent years, the importance of viral and host microRNAs (miRNA) in mediating viral replication and control of host cellular machinery, has been realized and increasing efforts have been taken in order to understand the interactions of miRNAs from host and pathogen during infection. small RNA sequencing was performed to identify the miRNAs involved in shrimp (*Penaeus vannamei*) immune responses under WSSV infection condition. The expression profiles of miRNAs of shrimp infected with WSSV under two contrasting conditions of field outbreak and controlled experimental conditions were compared and as a result, 23365 known miRNAs and 481 novel miRNAs were identified. Amongst the most abundantly expressed miRNAs, the hypoxia related miR-210 and immune pathway related miR-29b were expressed only in infected shrimps of both conditions.

The other miRNAs included miR-8-5p, having a functional role in modulation of chitin biosynthesis and miRNAs targeting chitinase, an important enzyme involved in growth and moulting in shrimps, indicating an interaction between WSSV infection with moult cycle of shrimp. The miRNA target prediction revealed several immune-related gene targets such as cathepsin, c-type lectin, hamocyanin and ubiquitin protein ligase. The shrimp miRNA mja-miR-6489-3p, was also found to target early virus gene wsv001 of WSSV. Our study, therefore, provides the comparative analysis of miRNA expression from shrimp during WSSV infection in two different conditions.

Shrimp Contig-level assembly of *Penaeus indicus* genome with long-reads

PacBio sequence data was generated on pacific biosciences sequel platform using magnetic bead loading and 600-minute movies. The 20 Kb sequencing libraries were used for sequencing where



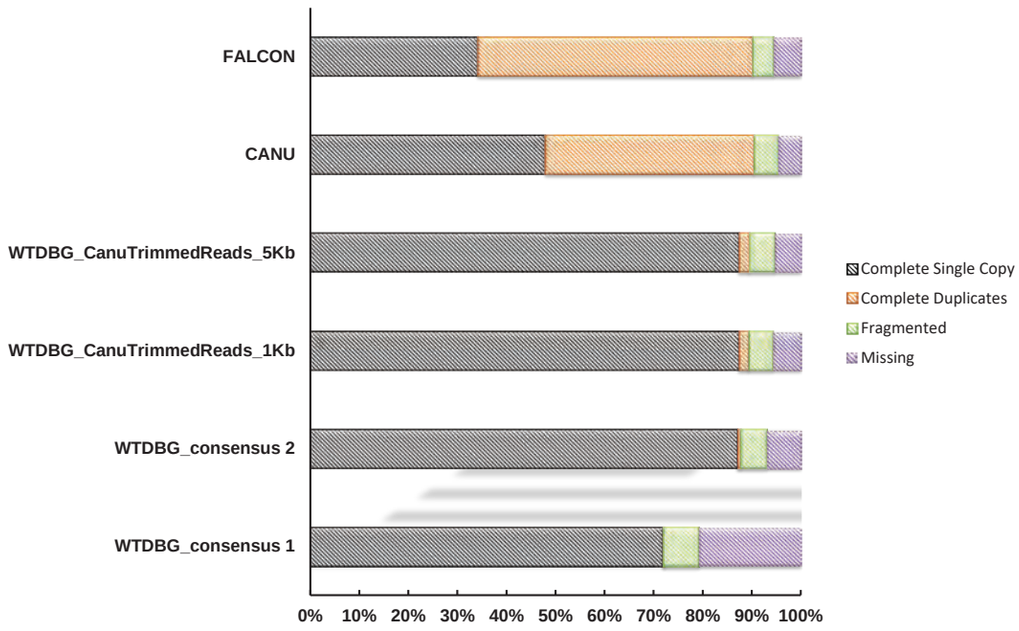
Interactions between miRNAs and target genes of WSSV infected *Penaeus vannamei*

inserts over 17 Kb size were retained based on BluePippin size selection. About 20,857,430 reads of 176,539,267,324 bases length of sequence data which is equivalent to 71X coverage of genome was used for building contig-level genome with assemblers Falcon, Canu and WTDBG2.

The comparative quality metrics of various assemblies are presented in Table. The assembly with Canu is almost close to the total length of genome. The BUSCO scores for the assemblies generated is shown in Figure. The assemblies generated with WTDBG2 have higher BUSCO scores for complete single copy genes. Especially the assembly made with raw reads using consensus 2 algorithm has about 73% genome represented in 12,278 contigs with a N50 of about 1 Mb. Generation of optical map and HiC data, scaffolding and chromosome linking are in progress.

Quality metrics of various assemblies generated with Falcon, Canu and WTDBG2.

Statistics	CANU	FALCON	WTDBG			
			CANU reads, >1kb	CANU reads >5kb	consensus 1	consensus 2
Total Length, Gb	2.36	3.39	1.33	1.31	1.55	1.8
N50, bp	54 266	69 258	73 486	72 942	1 201 053	991 596
No of Contigs	83893	76547	37371	36715	2168	12278
BUSCO Score (%)	95.2	94.2	94.2	94.6	79.3	93



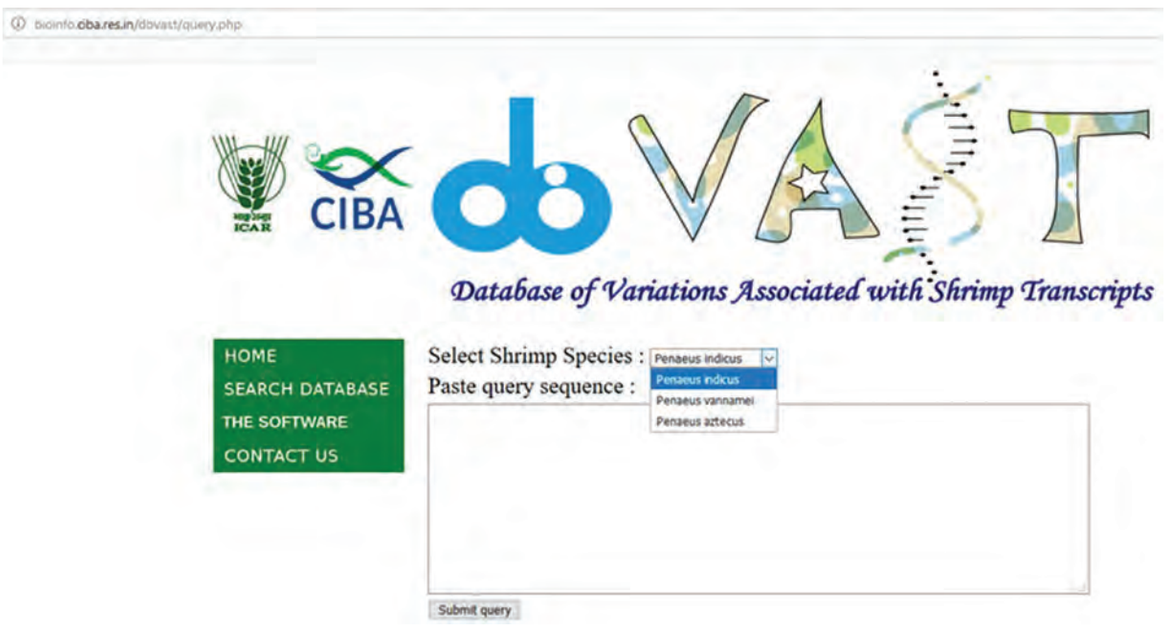
Busco statistics for six assemblies generated with Falcon, Canu and WTDBG2.

dbVAST: database of variations associated with shrimp transcripts

Farmed shrimp are an important export commodity for foreign exchange earnings in several coastal countries across the world. The shrimp constitutes one of the important aquaculture commodities which contribute significantly to human food consumption . Though genetic improvement programmes are in operation since two decades, the genomic resources that help in augmenting culture production are scanty. For example the Single Nucleotide Polymorphisms (SNPs) in coding sequences that could become potential selection criterion in selection programs are not yet documented. Therefore either by utilizing the datasets available at Genbank or the datasets generated at ICAR-CIBA, we have documented SNPs in annotated transcripts of three important shrimp species, *Penaeus vannamei, Penaeus indicus* and *Penaeus aztecus* and presented them for browsing as an on-line application in a friendly manner.

For *P. indicus*, the RNAseq reads SRX4808137, SRX4808138 and SRX4808143 were used for building reference transcripts. Whereas for *P. vannamei* and *P. aztecus*, the RNAseq data of *P. vannamei* obtained from GenBank, SRX3556257 and SRX3556279 was used to build reference transcripts. First, the good quality reads obtained after quality control with Trimmomatic V0.36 were assembled *de novo* in Trinity v2.3.2 to generate transcripts. Later, CD-HIT version 4.6 was used to cluster transcripts that were similar by more than 95% which were then annotated in Blast2GO v4.1.9.

Then pooled RNAseq datasets (SRX4808140, SRX4808141 and SRX4808142 for *P. indicus*; SRX1870278 for *P. vannamei*; SRX1871046 for P. aztecus) were utilized to document SNP variations against reference transcripts. The good quality reads of pooled-samples were aligned on to annotated transcripts using bowtie2 v2.3.2 to generate a sequence alignment map (SAM) file which is converted



Home page of dbVAST tool.

to binary alignment map (BAM) file and then sorted using samtools-1.2. Then a pileup was generated for sorted bam file using samtools-1.2 which is then piped to bcftools-1.3.1 to generate variant call format (VCF) file. The SNP variations that satisfy the following criteria were then extracted from VCF file, a) the raw read depth at SNP site is ≥ 10; b) both the reference and alternate alleles are supported by at least 5 reads; and c) the phred-scaled quality score for the assertion made in alternate allele is ≥ 20.

The data of blast and SNP statistics of the transcripts were loaded in to relational database as separate tables using MySQL ver. 5.5.24 database management system installed on debian server. A database retrieval system has been developed using PHP scripting language embedded into HTML pages as a web-tool, dbVAST. The database is presented as a user-friendly on-line tool, where users are required to select a shrimp species and submit a query sequence of interest. Input query would be searched against annotated transcripts of the database using blastn algorithm to find the most similar transcript. If the search gets a hit in the database, then the sequence of the most similar transcript along with its blast and SNP statistics would be retrieved from the corresponding data tables and displayed on the screen.

MRF: Missing Region Finder

The white spot syndrome virus (WSSV) continues to be the major pathogen that has potential to inflict mass mortalities of shrimp during culture. Though first reported in 1995 and genome fully deciphered in 2001 (Feng Yang et al 2001), the WSSV is a difficult pathogen to contain in culture environments. The genome sequence of this virus does not show similarity to any other pathogen and this has severely limited the annotation of WSSV genomes. Therefore WSSV alone was aptly placed in a new Genus *Whispovirus* under Family *Nimaviridae*. Unique sequence coupled with circular nature of genome lead to difficulty in annotating the genome features of this virus. Except for few features all the other coding sequences (CDS) were annotated serially with a common prefix like WSSV (AF440570), wsv (AF332093), ORF (MF768985) etc. in the order in which they were assembled and submitted as linear sequence at GenBank. As the annotation nomenclature varies across genomes, the results inferred on a WSSV genome could not be easily comparable to other genomes. This has remained a grey area in comparative genomics studies of WSSV isolates. For example a CDS is annotated as wsv162 in AF332093, WSSV218 in AF440570, hypothetical protein in KT995472, KT995470 and KU216744, ribonucleotide reductase large subunit in KT995471, wsv161 in KY827813, orf90 in AF369029 and orf215 in MF768985.

Another issue of concern is very high similarity in sequence of WSSV isolates where complete genome sequence is available. In this case, traditional similarity-based methods estimate about 99% identity among isolates of WSSV. Despite high similarity, WSSV exhibits considerable variation in genome size from 280591 bp (MG702567) to 314232 bp (MG264599). In addition to variations in common sequence features, the CDS missing in some isolates might be correlated to some property of the virus and needs to be documented.

The need to study the deleted regions and to sort the nomenclature issue has motivated us to develop a tool that could compare two genomes of interest, one as reference and another as query and find the deletions (complete and partial) in query genome with respect to the reference genome. The deletions could be miniscule or regions stretching up to several kb. Then mapping of the deleted regions to generic feature format version 3 (gff3) table of the reference genome missing CDS in query genome could be fetched. Such a tool has potential to sort the nomenclature issue concerning WSSV genomes, as users can compare several genomes against a single reference genome. In such case, findings of comparative genome analysis in the annotation nomenclature of a single reference would be easily comprehensible.

In this study, we developed a new tool, Missing Region Finder (MRF) and demonstrated its utility to gain insights about WSSV genomes. Main purpose of developing the MRF tool is to compare a query genome against a reference genome and find deleted genome regions in query and tabulate the CDS in these deleted regions as per the annotations of reference genome. This is achieved in two stages. First, the genomic regions that are missing in the query compared to reference are identified and their coordinates are mapped. Next, using gff3 table of the

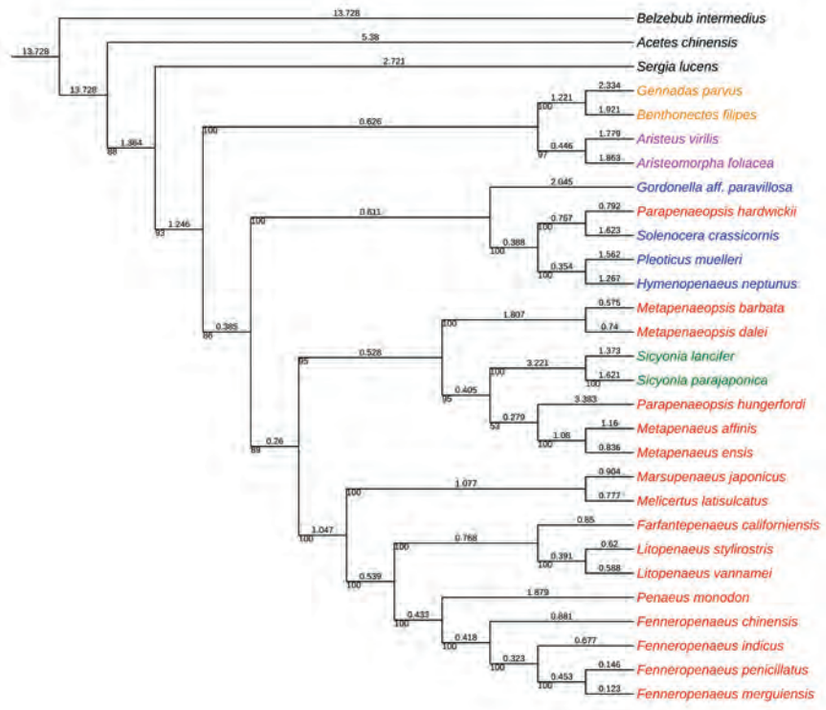
Home page of MRF tool.

reference genome, the CDS present in missing regions of query genome are tabulated. The tool is made available to all users in a web based online platform. The back end of the tool was implemented in a perl program, which reads the input files from the user and computes the missing regions in the query genome. The graphic user interface (GUI) was implemented using PHP and HTML, with stYles rendered by CSS.

Phylogenomics of shrimp in suborder, Dendrobranchiata

The controversy surrounding the taxonomy of penaeid shrimp is well known. Researchers across the globe were divided on the taxonomic revision in Genus *Penaeus* sensu lato where six new genera were created. The Food and Agriculture Organization (FAO) which is the repository for aquaculture statistics still uses old genus names. Many stakeholders related to trade, policy matters etc. are often confused as some researchers are using old genus names and others prefer to use new genus names. To address this issue, earlier we had conducted maximum likelihood and Bayesian phylogenetic inferences on complete mitochondrial genome sequences which indicated monophyly of *Penaeus* sensu lato. This year, average aminoacid identity (AAI) which indicates genome-wide similarity was estimated between all the species in each genus of order, Decapoda. The genera where complete mitochondrial genome sequence is available for at least 2 species were considered. The comparison of AAI estimates in order Decapoda with the estimates among species of *Penaeus* sensu lato would throw additional evidence for splitting or retaining the single genus *Penaeus*. Overall for 162 species belonging to 45 genera in order Decapoda, 405 AAI estimates were obtained in this study. The arithmetic mean and median of these estimates is 88.86 and 88.57 respectively. In *Penaeus* sensu lato, 45 AAI estimates were obtained among 10 species. The arithmetic mean and median of these 45 estimates is 93.92 and 93.37 respectively. Both these averages in Penaeus s.l. are higher than that obtained for species in Order, Decapoda. All the AAI estimates obtained among species of *Penaeus* s.l. are higher than the average estimate obtained among species in Order, Decapoda. Though there are no set standard values for AAI estimates to fix different species in a genus, it is expected that the species of same genus have high AAI estimates. When it comes to shrimps of Penaeus s.l., the AAI estimates are all above 90% .

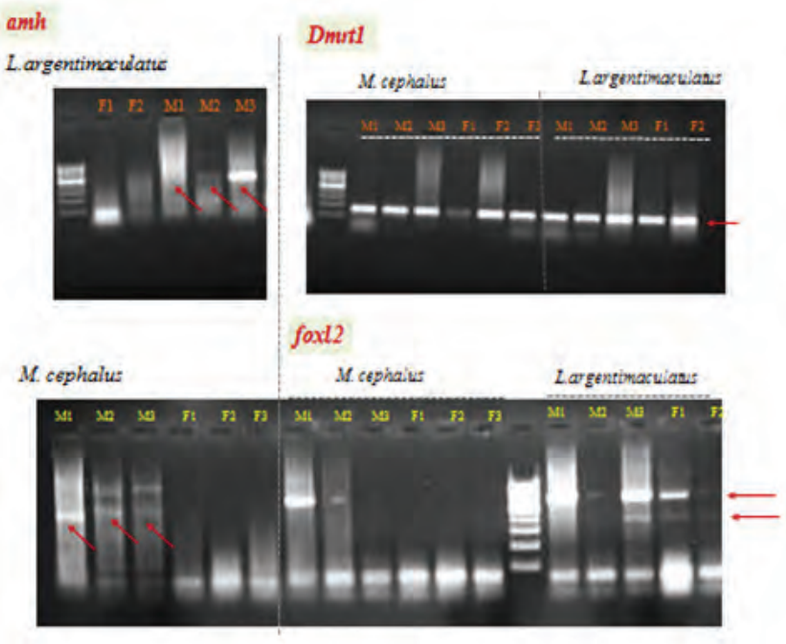
With such high estimates of AAI among them, these species qualify to be kept under one genus. The AAI estimates did not support polyphyletic status for *Penaeus sensu* lato and suggest restoration of old nomenclature.



The plot of AAI estimates obtained between species of *Penaeus sensu* lato and between species of all other genera in order *Decapoda*.

Sex discrimination in fish

Discriminating sex in most of the commercially important brackishwater finfishes are difficult as no easily identifiable morphological difference exits between the sexes. In the absence of sexual dimorphism, identifying the sex markers was attempted in grey mullet, *Mugil cephalus* and red snapper, *Lutjanus argentimaculatus*. The expression of sex specific markers reported in other fishes namely doublesex and mab-3 related transcription factor 1 (*dmrt1*), forkhead box L2 (*foxl2*) and anti-mullerian hormone (*amh*) were analysed using genomic DNA. The results indicated male specific expression for *amh*, while both *dmrt1* and *foxl2* exhibited strong expression in both males and female fish,



suggesting the possibility of using *amh* as markers for sex discrimination in fish.

Population structure of grey mullet, *Mugil cephalus*

The flathead grey mullet (*Mugil cephalus*), the most widespread mugilid species, inhabits estuarine, intertidal, freshwater and coastal marine habitats and forms commercial and subsistence fisheries in many parts of the world (FAO, 2000). Knowledge on the genetic structure of fish populations is important for the development of management and conservation strategies. The genetic diversity and population structure of *M. cephalus* along the Indian coast was examined with a 842bp segment of ATPase 6/8 gene of mitochondrial genome. Samples of M. cephalus were collected from 6 locations along the Indian coast namely Puri (12), Nagayalanka (16), Chennai (13), Fort Vypin (12), Goa (10) and Gujarat (10). The genetic identification of the species was confirmed using mitochondrial gene CO1. ATPase 6/8 gene was amplified by PCR using universal Primers. The pair-wise FST values indicated the presence of two distinct stocks along the Indian coast, one between Odisha and Kerala and the other between (Goa and Gujarat).

	Nagayalanka (Andhra Pradesh)	**Goa**	**Gujarat**	**Puri (Odisha)**	**Fort Vypin (Kerala)**	**Chennai (Tamil Nadu)**
Nagayalanka	---					
Goa	0.990*	---				
Gujarat	0.997*	0.068	---			
Puri	0.050*	0.984*	0.992*	---		
Fort Vypin	0.025	0.988*	0.996*	0.012	---	
Chennai	0.017	0.987*	0.995*	0.011	-0.002	---

FST estimates between stocks of *Mugil cephalus*

A total of 13 haplotypes were identified among the samples analysed. The highest nucleotide diversity was observed in Goa stocks.

Establishment of Pearlspot full-sib families and their growth performance

To fulfil the increasing demands for fish as food, progress must occur towards greater aquaculture productivity. The first step towards increasing the productivity would be to produce genetically improved fish varieties. Here we established two pealspot full-sib families on experimental basis to record the growth parameters which would be useful for selection.

Adult Pearlspot fish were grown in FRP tanks for breeding. Two pairs were identified and transferred to two different FRP tanks. After spawning, the larvae were cultured in the tanks to develop them into fries till 60th day. Meantime, hapas (1mX2m) were placed in the lagoon and it was surrounded by crab fencing net to avoid the entry of crabs and to protect the hapas from crab bite. The two full sib fries were then stocked in different hapas to culture them at Muttukadu lagoon. At the time of stocking the P^H and the salinity of the lagoon were 7.47 and 38PPT. The total body length and body weight of both the families were recorded and are presented in Table. Coefficient of variation (CV) was higher for body weight than

Growth parameters of pearlspot stocked in lagoon

	Growth parameters	Family1	Family2
Total body length	Mean on the day of stocking (cm)	2.1 to 3.3 (60th day post hatch)	1.2 to 2.0 (40th day of post hatch)
	Mean on 30th day of stocking (cm)	5.64±0.08	5.59±0.12
	Coefficient of variation (%)	6.5	8.4
Body weight	Mean on the day of stocking (cm)	0.9-2.1	0.7-1.8
	Mean on 30th day of stocking (cm)	4.7±0.2	4.3±0.25
	Coefficient of variation (%)	19.4	23.2

Full-sib families of pearlspot cultured in hapas

the total body length in both the families. Higher the CV indicates higher the variance exists among the individuals in the family which will facilitate to carry out selection among them efficiently.

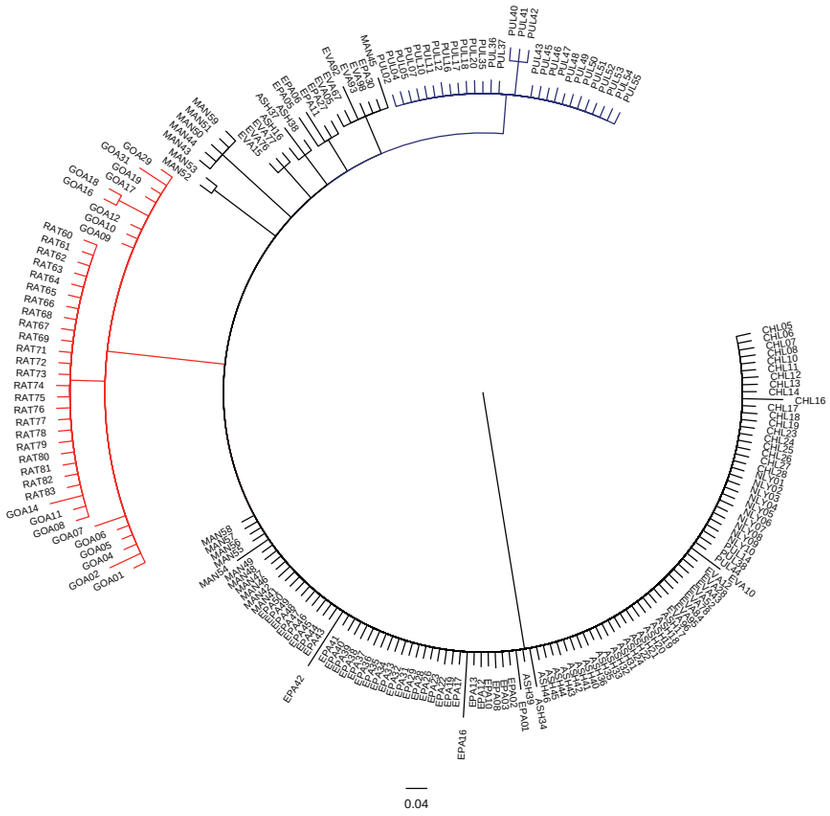
Population genetic structure and historical demography of pearlspot fish in Indian waters

Etroplus suratensis (Bloch 1790) commonly known as pearlspot is the largest among the Etroplus species and distributed in the lagoons, brackishwater and backwater environment of southern peninsular India and Sri Lanka. It fetches higher price not only as a food fish but an ornamental fish too due to its delicacy and attractive coloration. Study on population genetic structure of the fish would be useful on conservation of intra-species diversity.

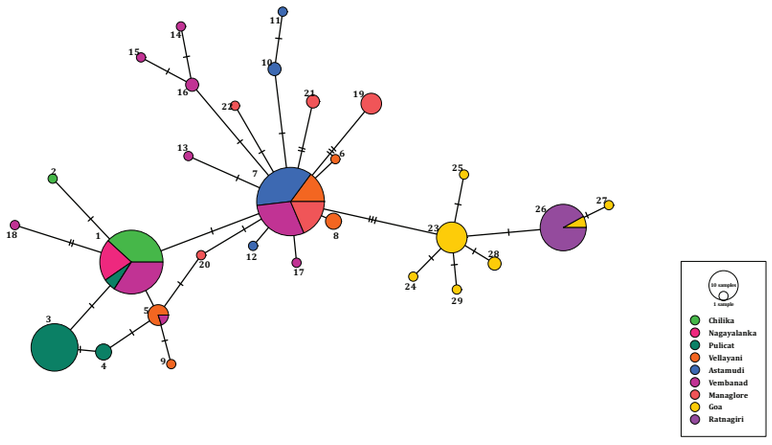
Sixteen tissue samples of *Etroplus suratensis* were collected from Ashtamudi Lake. ATPase 6/8 gene was PCR amplified, sequenced and included with the previously available data and reanalysed. The data includes Chilika (19), Nagayalanka(10), Pulicat (32), Vellayani (17), Ashtamudi (24), Vembanad (40), Mangalore (19), Goa (19) and Ratnagiri (23). AMOVA and FST based genetic differentiation were estimated using Arlequin3.5.2.2. Mantel test for isolation by distance was carried out using ade library of R 3.5.1. Phylogenetic tree was reconstructed by UPGMA method using Mega7.0 and by Mrbayes 3.2.2 The best evolutionary model for the sequences was selected

Using Bayesian information criterion implemented in Partition finder. Haplotype network was generated using PopART1.7.

The samples exhibited 31 polymorphic sites which include 16 singleton and 15 parsimony informative sites. The total haplotypes were 29 with the diversity of 0.85. Significant genetic differentiation (FST=0.75; P<0.01) was observed among all the stocks. Non-significant genetic differentiation was observed only between Chilika and Nagayalanka stocks. ATPase 6/8 gene revealed monomorphic pattern in Nagayalanka stocks. Mantel test (r = 0.46 P=0.025) suggests that the isolation by distance is non-significant. However, the positive correlation suggests smaller the differences between the nearer stocks than the farther one. The UPGMA tree established two haplo-groups;



Phylogenetic tree reconstructed by Mrbayes for *E.suratensis* stocks



Minimum spanning Haplotype network for the haplotypes of *E.suratensis* stocks

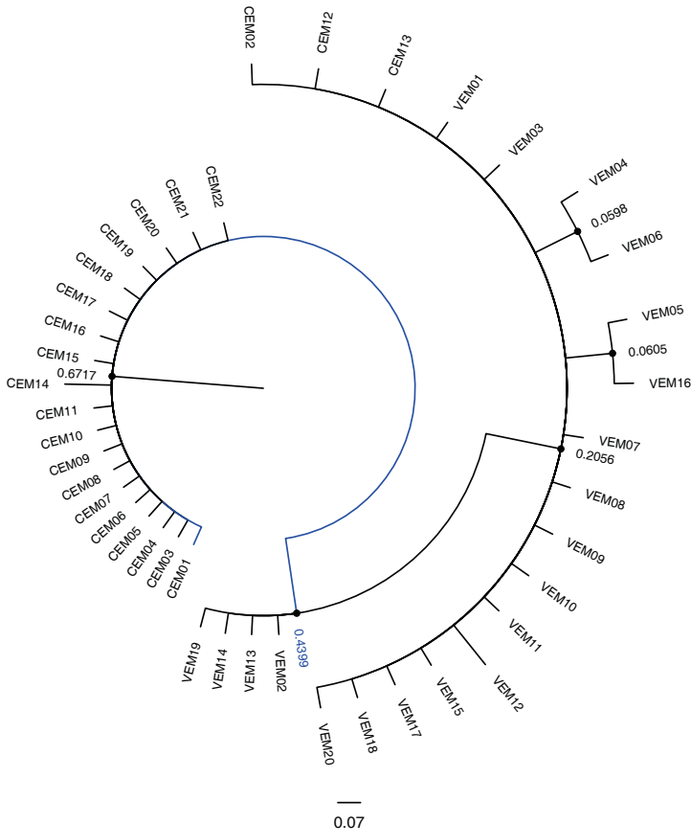
one of them includes Ratnagiri and Goa stocks and the second one consists of all the others. Non-significant Tajima's D (-1.47) and Fu's F statistic (-14.89) revealed there is no change in population size in the recent past..

Vempanad and Pulicat stocks of Orange chromide (*Etroplus maculatus*)fish are genetically divergent

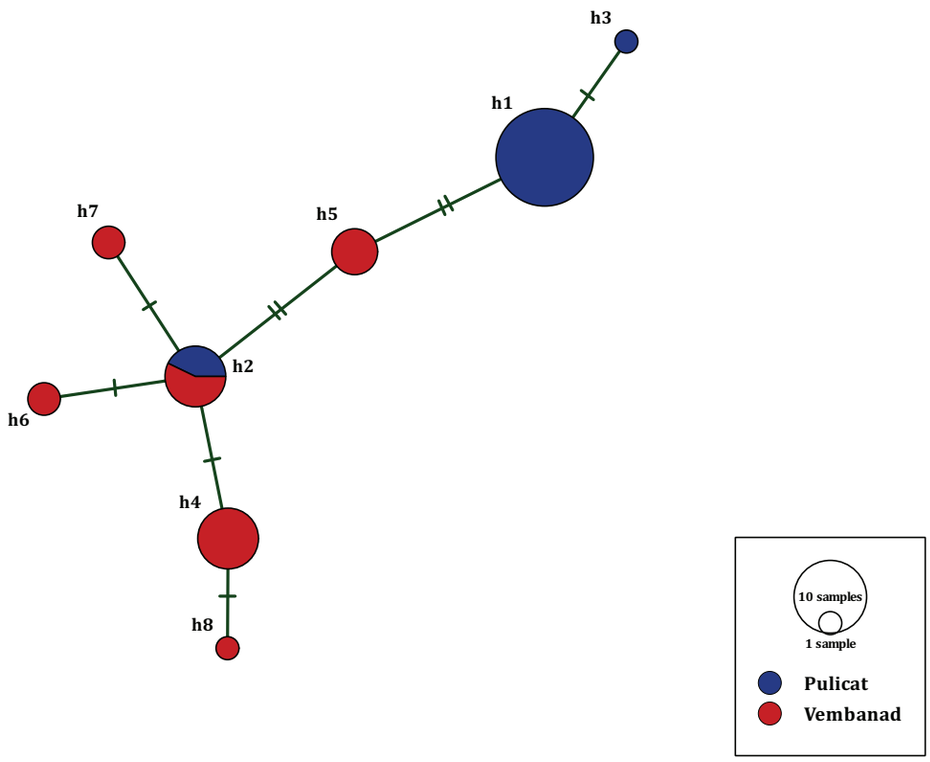
Genetic diversity is the outcome of the evolutionary processes adapted by the species to the spatial and temporal environmental changes since its origin. Hence the studies on species diversity are of paramount important to the conservation programs. *Etroplus maculatus*, commonly known as Orange chromide is a euryhaline fish endemic to brackishwater streams, lagoons, estuaries and the lower reaches of rivers in peninsular India and SriLanka. It is mainly utilized as freshwater and brackishwater ornamental fish due to its attractive coloring pattern. The population genetic diversity of *Etroplus maculatus,* in southern Indian waters was studied.

Twenty samples each were collected from Pulicat (South-East) and Vempanad lake (South-West) coastal regions were utilised to study the genetic structure using an mtDNA gene ATPase 6/8. Haplotype and nucleotide diversity were generated by Dnasp6.0. Haplotype network was generated using PopART1.7. AMOVA and FST based genetic differentiation were estimated using Arlequin3.5.2.2. Phylogenetic tree was re constructed by UPGMA method using Mega7.0 and by Mrbayes 3.2.2. The best evolutionary model for the sequences was selected Using Bayesian information criterion implemented in Partition finder.

The sequences exhibited eight variable polymorphic sites which include one singleton and seven parsimony informative sites. The total haplotypes were eight with a diversity of 0.76. More and diversified haplotypes were found in Vempanad (six with the diversity of 0.82) compared to Pulicat stock (three with the diversity of 0.33). The phylogenetic tree constructed by both Bayesian and UPGMA methods revealed two separate clades. Non-significant Tajima's D (Pulicat:-0.63, Vembanad:-0.063), Fu's F statsitics (0.231) and bimodal mismatch distribution indicating



Phylogenetic tree reconstructed by Mrbayes for *E.maculatus* stocks



Minimum spanning Haplotype network for the haplotypes of *E.maculatus stocks*

stable population size historically. The genetic differentiation study (FST=0.42) imparted significant (P<0.001) difference between the stocks. The AMOVA revealed a variation of 42% between the populations and 58% within the populations.

Population genetic structure of Indian white shrimp across Indian coast using microsatellite markers

Indian white shrimp (*Peaneus indicus*) is one of the important commercial penaeid species. Studying the diversity pattern of the species is considered important. 155 individuals of *P.indicus* collected across Indian coast i.e. Chennai (49), Kanyakumari (09), Puri (37), Quilon (47) and Mangalore (13). Ten microsatellite loci were genotyped by fragment analysis method. The alleles and genotypes were generated using the Fragman package of R statistical tool. The genotypes were tested for null alleles using micro-checker. Due to the presence of null alleles and monomorphic pattern three loci data were not included and the study comprises of seven loci data only. The average number of alleles among the populations was 8.5 with a range from 5.4 (Kanyakumari) to 11.4 (Quilon). The mean observed heterozygosity ranged at sampled loci were high, ranging from 0.67 (Kanyakumari) to 0.76 (Puri). The analysis of molecular variance (AMOVA) revealed that 97% of the genetic variation was maintained within individual component, rather than shaped according to geographical regions. Pairwise FST (Table) (ranged from 0.01 to 0.053) estimates revealed Chennai and Quilon stocks differed significantly (P<0.01) with other stocks. However, Quilon did not differ from Mangalore stock. Bottleneck tests revealed all populations displayed a normal L shaped distribution in the mode-shift curve and the populations had no significant excess of heterozygosity for Wilcoxon's signed-rank test under the TPM model, which suggests the population did not undergo any reduction in the recent past. Mantel test indicated there was no significant correlation between

Pairwise FST between the stocks

	Chennai (49)	Kanyakum (09)	Mangalore (13)	Puri (37)	Quilon (47)
Chennai	--------				
Kanyakumari	0.026**	----------			
Mangalore	0.050**	0.053*	--------		
Puri	0.347**	0.010ns	0.011ns	----------	
Quilon	0.011**	0.019*	0.010ns	0.013**	----------

genetic dissimilarity and geographic distance among populations (R= 0.0491; P =0.49). The above stock structure findings would be helpful in conservation and stock specific selective breeding.

First record of the Javanese ricefish, *Oryzias javanicus* (Bleeker, 1854) (Beloniformes: Adrianichthyidae) in the natural waters of India

The distribution of *O. javanicus* in the natural waters of the Indian peninsula was confirmed for the first time from Muttukadu lagoon, Tamil Nadu, bringing the number of *Oryzias* species recorded from India to five (the others being, *O. dancena* (Hamilton, 1822), *O. melastigma* (McClelland, 1839) (currently in the synonymy of *O. dancena*), *O. carnaticus* (Jerdon, 1849), and the endemic *O. setnai* (Kulkarni, 1940). The species shows population-level variations in their meristic counts. *Oryzias javanicus* is very similar to *O. dancena* and *O. carnaticus,* species that are native to the Indian subcontinent; *O. javanicus* can be easily distinguished from the Indian species, by the presence of yellowish sub-marginal bands on the dorsal and ventral sides of the caudal fin.

Table adapted from Yusof et. al., (2012) with observations of the present study: [a] Rays of dorsal and ventral lobes are indicated separated by slash. Number of unbranched and branched rays is indicated by Roman and Arabic numerals, respectively.

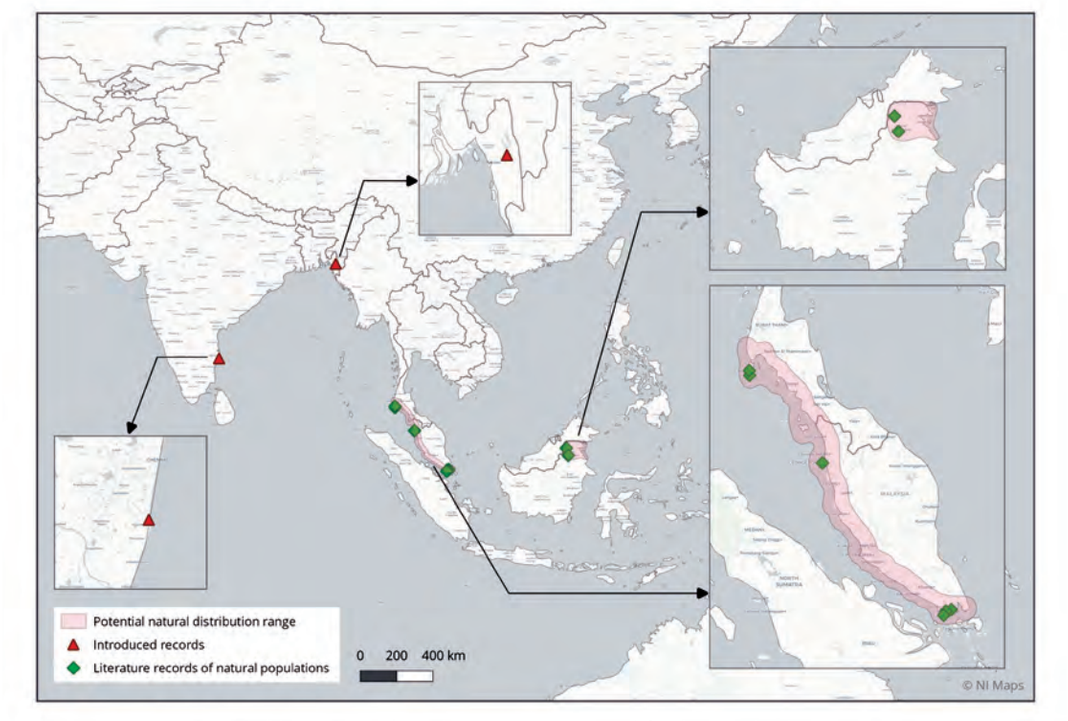
The nucleotide genetic distance between the populations occurring in India and Indonesia was found to be indistinguishable, which showed the same evolutionary relatedness in neighbour-joining and maximum-likelihood analysis.

The water bodies around Muttukadu currently comprise the westernmost distribution range of

Male (a) and female (b) *Oryzias javanicus* collected from the Muttukadu lagoon, India

Comparison of meristic counts of *Oryziasjavanicus*

Meristic counts	Roberts (1998)	Parenti (2008)	Magtoon & Termvidchakorn (2009)	Yusof et. al., (2012)	Present study
Dorsal-fin rays	6-7	6-8	6-8	6	6
Anal-fin rays	21-25	18-25	22-26	21	20-21
Pelvic-fin rays	6	5-6	NA	6	6
Pectoral-fin rays	11	10-13	11-12	10-11	10-12
Principal caudal-fin raysa	5/6	i, 4/5, i	i, 4/5, i	i, 5/6, i	i, 4/5, i

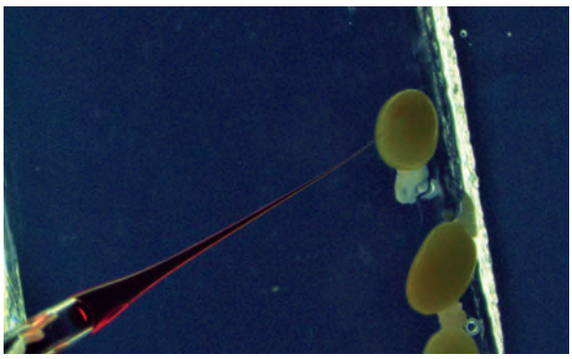


Map showing the native distribution range of *Oryzias javanicus* in South East Asia, and the new record from India

this species. The presence of considerable number of this species in the Muttukadu lagoon of ICAR-Central Institute of Brackishwater Aquaculture (CIBA), suggests that *O. javanicus* is well established in the present locality.

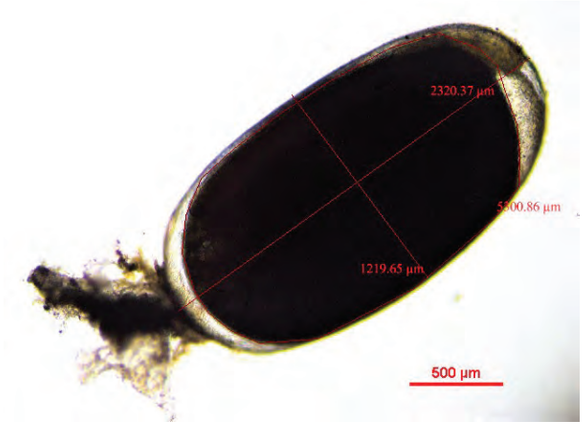
CRISPR-Cas9 mediated genome engineering for growth improvement of *Etroplus suratensis*

Currently, CRISPR/Cas9 is the most desirable tool for genome engineering. It efficiently introduces double-strand breaks (DSBs) in genomic DNA using cas9 and an appropriate guide RNA. For genome engineering, the myostatin gene of *Etroplus suratensis* has been characterized, and three different 20bp nucleotide sequences (target sequence) near to protospacer adjacent motif has been identified and synthesized. A standard PCR have done along with gene-specific oligos & constant oligonucleotide, to transcribe the target sequences into sgRNA using sp6 RNA polymerase enzyme. Three different stop codon cassette specific to each sgRNA were also designed and synthesized to include in CRISPR complex. 200ng/microliter sgRNA; 3 µM specific stop codon cassette, 600ng/microliter Cas9 Protein

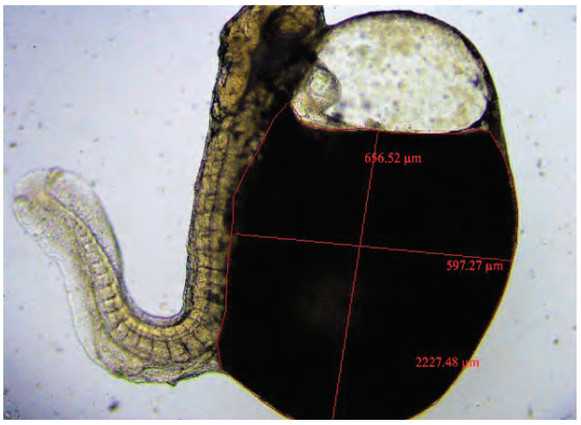


Microinjection

7hpf



24hpf



3dpf

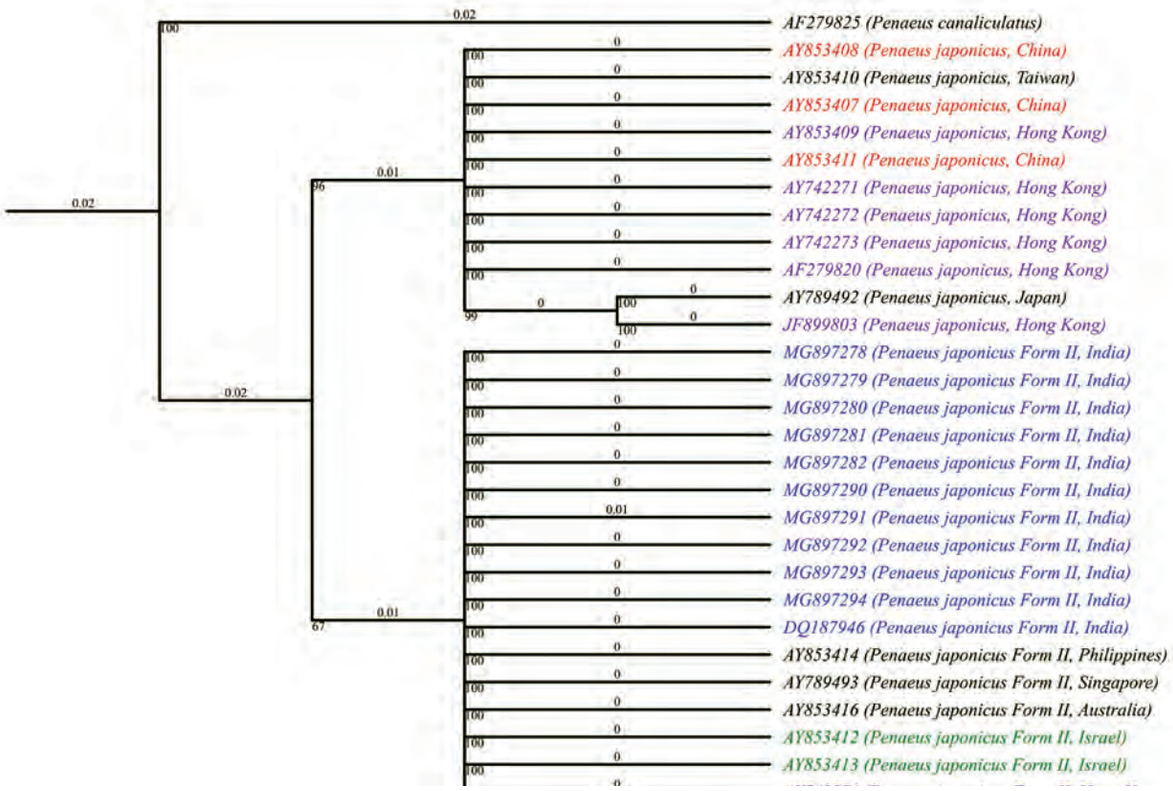
Microinjection of pearlspot egg with myostatin based CRISPR complex - Embryonic develpomental stages post injection

incubated at room temperature along with phenol red dye for 5 minutes to make CRISPR complex. About ten eggs of Etroplus suratensis were stacked one by one in an agarose gel, and each egg was injected with the injection mix @ 0.25µl using micromanipulator. Embryonic developmental stages and mortality of the eggs and larvae were documented.

Confirming the identity of *Penaeus japonicus* form-II in Indian waters using molecular markers

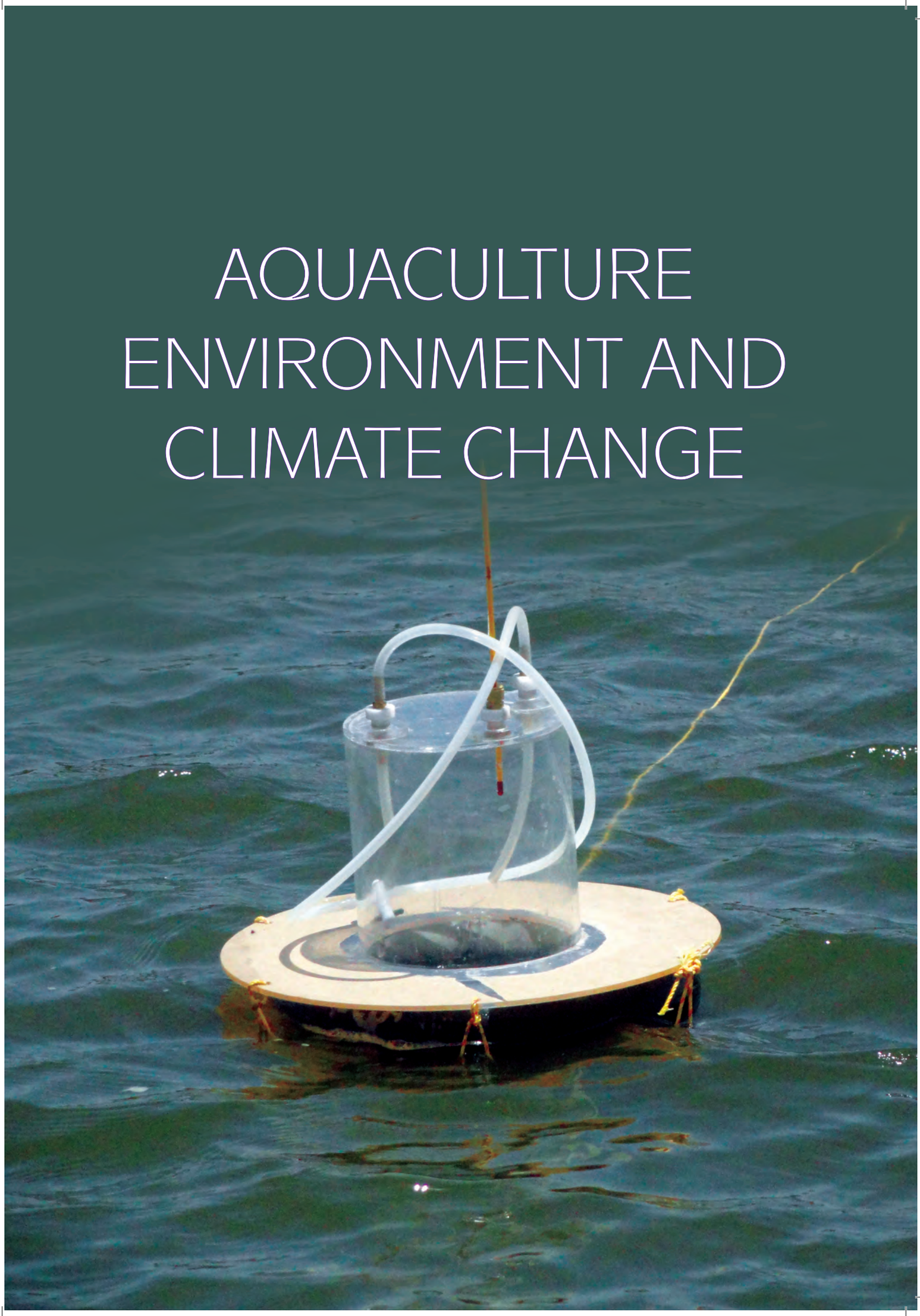
Penaeus japonicus was considered as a single species spread across Indo-West Pacific. However, recent studieshave shown the existence of cryptic species within kuruma shrimp, with a slight variation in banding pattern on carapace with no other noticeable morphological differences. Form-I exhibits two characteristic bands extending from the dorsal to the ventral carapace and in form-II, these bands do not extend to the lower half of carapace. Further it is confirmed through the genetic analysis that these morphologically similar varieties are genetically diverse and is reproductively isolated, forming different species. The form-I, due to the type locality of Japan retains the name *P. japonicus* and is confined to Japan. The form-II is verified by Tsoi et al. 2014 and fixed the name as *Penaeus pulchricaudatus* (Stebbing 1914)and it is widely distributed in South-East Asia, Australia, the western Indian Ocean, the Red Sea and the Mediterranean with type locality being South Africa (Great fish point). The presence of kuruma shrimp (*P. japonicus*) in both East and West coast of India is widely documented and has been reported in many reports. However, there is no genetic data available to conclude whether the species available in India is *P. japonicus* form-I or form-II.The morphological observations of Indian species matches with the form-II.Hence it is very important to identify and confirm the species in Indian waters. The phylogenetic analysis from partial mitochondrial DNA sequences from specimens obtained from both East and West coast of Indiawith the reference sequences of *P. japonicus* form-I and form-II revealed that the species is phylogenetically more closely allied to *P. japonicus* form-II/*P. pulchricaudatus*.

Cryptic species *P. japonicus* form-II/ *P. pulchricaudatus*, lateral view of female from Coromandel Coast.



Bayesian Inference phylogenetic tree of the 16S rRNA dataset. Numbers above branch indicates branch length and below indicates bootstrap values.

AQUACULTURE ENVIRONMENT AND CLIMATE CHANGE



Implications of trends in surface weather parameters for brackishwater aquaculture

Trends in surface weather parameters with base line data obtained from IMD for the years starting from 1969 to 2009 for vulnerable coastal districts identified by ICAR-CRIDA have been analyzed. Coastal districts identified include Surat in Gujarat, Alappuzha in Kerala, Nagapattinam in Tamil Nadu, West Godavari in Andhra Pradesh and 24 Paraganas in West Bengal. Annual and seasonal trends for maximum temperature, minimum temperature, amount of rainfall and number of rainy days have been projected. Analysis has been carried out using 'esd' library under R Stats environment.

Summary of surface weather parameters for five coastal districts of India

Coastal district Weather parameter	West Godavari	Nagapattinam	Surat	Alapuzha	24 Paraganas
Annual					
MaxT					
MinT					
Precip					
Seasonal – MaxT					
Winter					
Summer					
Monsoon					
Post-Monsoon					
Seasonal – MinT					
Winter					
Summer					
Monsoon					
Post-Monsoon					
Seasonal – Precip					
Winter					
Summer					
Monsoon					
Post-Monsoon					
Rainy days					
➢ 1 mm					
➢ 3 mm					

Increase No trend Decrease

Increased trends were observed for maximum and minimum temperature for almost all the districts except for 24 Paraganas. The increased trends in maximum temperature will impact pond water salinity and DO levels, whereas increase in minimum temperatures would be beneficial to brackishwater aquaculture to certain extent during winter crop. There is a decline in total rainfall over the years which will impact water availability for the aquaculture. There have been negative trends observed for number of rainy days beyond 1mm and 3mm rainfall per day, indicating that the number of rainy days coming down over the years and maximum rainfall occurs in fewer days. This trend will cause sudden drop in salinity, DO, and temperature which in turn cause stress to animals and make them susceptible to diseases.

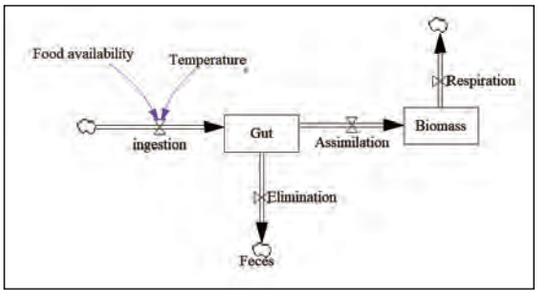
The annual average temperatures and total rainfall of base period were compared with multimodal climate change scenarios data obtained from IARI for RCP 4.5 of 2020s, 2050s and 2080s to project future values. Overall there has been around 2°C increase in the temperatures in 2080s compared to base period for all the districts under the study. There is a need to evaluate how these changes in surface weather parameters will actually impact brackishwater aquaculture through pond simulation models.

Change in climatic variables compared to base period.

Coastal district	Weather parameter	Base period	2020s	2050s	2080s	Increase
West Godavari	tmax	32.63	33.29	33.94	34.35	1.72
	timin	23.26	24.06	24.75	25.17	1.91
	Rainfall	1126.7	1121.36	1161.97	1198.57	71.84
Nagapattinam	tmax	33.36	34.8	34.8	35.2	1.84
	timin	24.29	25.84	25.84	26.26	1.97
	Rainfall	1455.2	1555.25	1555.25	1613.65	158.4
Surat	tmax	33.09	33.89	34.68	35.15	2.06
	timin	20.99	22	22.89	23.38	2.39
	Rainfall	585.81	572.9	592.7	602.67	16.86
Alappuzha	tmax	29.6	30.42	31.06	31.46	1.86
	timin	20.53	21.44	22.12	22.53	2
	Rainfall	2927.8	2827.36	2915.96	2995.7	67.93
24 Paraganas	tmax	31.16	31.88	32.65	33.13	1.97
	timin	22.09	22.99	23.76	24.24	2.15
	Rainfall	1803.7	1806.77	1871.33	1919.26	115.6

System dynamic climate models for shrimp aquaculture

System dynamics models are simulation models to abstract individual processes involved in aquaculture through mathematical functions. The processes such as feed conversion, growth dynamics, biomass production, nitrogen dynamics, carbon dynamics and changes that affect growth of the animal due to several biotic and abiotic factors during shrimp culture period need to be captured in the model. Relational diagram was developed by considering all the processes involved in shrimp aquaculture. Different stock variables in the model include body weight, biomass, total N, plankton, microbial load, DO levels, salinity etc. In order to check the impact of temperature on gut content, a model involving feed ingestion, assimilation and elimination processes was constructed. Python module PySD and XMILE scripts are being used for building the models.



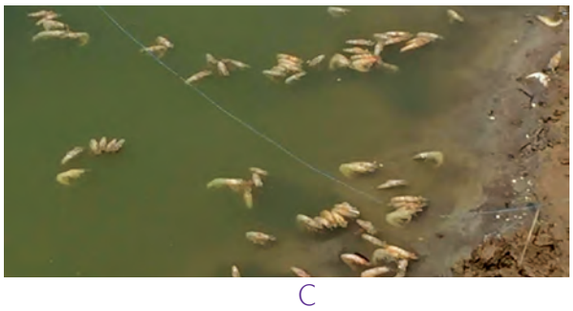
Sub process to estimate impact of temperature on gut content.

Damage to Shrimp farms due to Cyclonic storm Gaja

The Cyclonic storm Gaja which had a land fall during the early hours of 17th November, 2018 and its associated floods have made substantial damage to shrimp farming area of approximately 1926 ha in Nagapattinam, Thanjavur, and Pattukottai districts of Tamil Nadu. About 50-60% of the farming area had a standing stock in the four districts and the crops were in the duration of 70-90 days. The average size of shrimps in the pond during the extreme event was 10-12 g. About 90% of the shrimp farms in the affected area were small and marginal to the tune of 2-3 ha. The wind speed of 120-140 kmph damaged the infrastructure (breach of farm bunds, store sheds, electrical lines, aerators, motors, pumps. etc) in the shrimp farms. In about 20% of the affected areas, the shrimp farms were in the low lying area and were totally inundated, shrimps escaped from the ponds and loss of production and infrastructure was 100% for those shrimp farmers. Many farmers were forced to go for distress harvests due to lack of electricity for providing aeration and disease outbreaks in the standing crop due to poor weather conditions and water quality deteriorations. The loss assessed by the State Fisheries Department was Rs. 711 lakhs, much less than the actual assessed damage. Farmers are demanding for separate relief package for shrimp farming to rebuild the farms and take up the farming in the coming season, a comprehensive insurance scheme to be developed and implemented for shrimp farming and support with an institutional credit scheme with a low interest rate to redevelop the infrastructure.

A

B

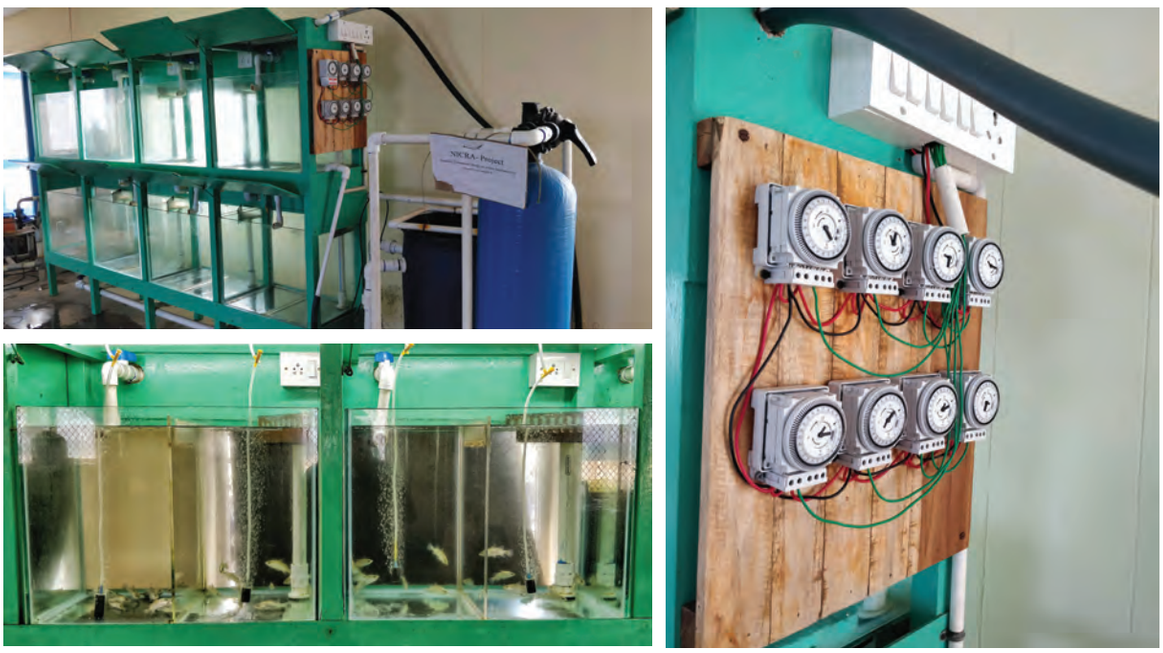


C

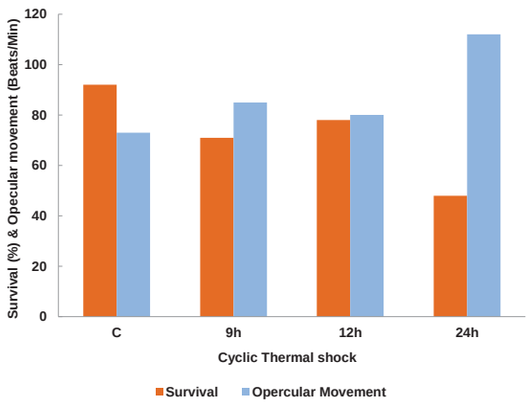
Gaja cyclonic storm damage to A. Farm shed and aerators
B. Pond dykes and C. Loss of stock due to power failure and water quality deterioration

Effect of diurnal thermal shock on seabass juveniles

In the aim to mimic effect of heat waves shock *in vivo*, heaters were assembled in the fabricated environmental manipulation unit with automatic electronic timers. A 15 days experiment was conducted where diurnal heat shock (34 °C) of different durations i.e. Control (RT), 9h, 12h and 24h (chronic) generated to assess the sea bass (TL - 7.5 cm; average body weight - 5.5 g) response towards cyclic heat shock versus chronic heat shock. It was found that seabass is more sensitive towards daily 9h heat wave, as survival (71%) was significantly less than 12h group. As a sign of heat sensitivity, seabass fry performed more opercular beating (85 beats/min) in 9h group compared to 12h group (80 beats/min), may be due to increased physiological need for oxygen under thermal stress. It is evident that sea bass is more stressed when 9h shock is given as it has less time to adapt physiologically. Minimum survival (48 %) and maximum opercular movement (112 beats/min) were found in 24h (chronic) heat shock. This study confirms elimination of agro-climatic zones having average water temperature of 34 °C for more than 9 hours daily during summer months, as a nursery rearing area for seabass.



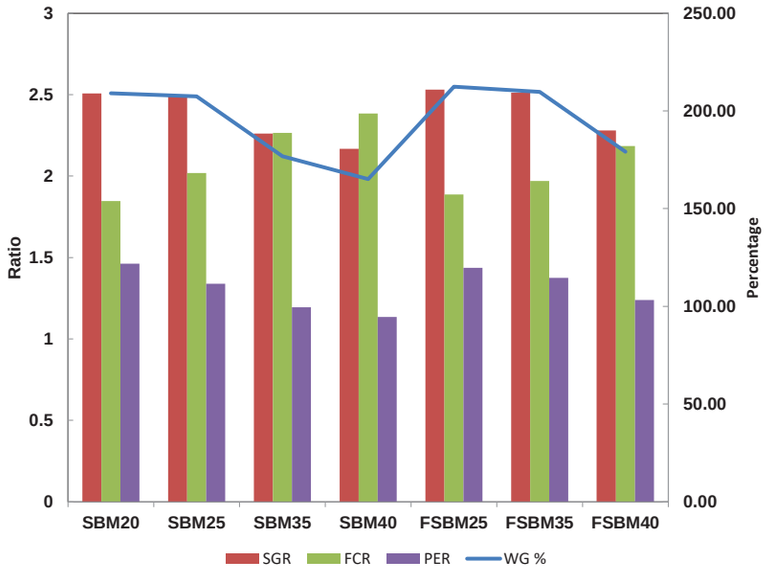
Automation in insitu environmental manipulation unit with electronic timers



Survival and opercular movement of Seabass exposed to heat wave shock

Effect of supplementation of phospholipid, soylecithin for amelioration of temperature stress in *P. vannamei*

In our earlier studies on the effect of temperature on growth and nutrient utilization at 29, 31, 33 and 35 ^{0}C in *P. vannamei,* better survival and growth was observed between 31 and 33 ^{0}C. Yard experiments were carried out to study the effect of supplementation of higher level of phospholipid, soylecithin at 31 and 35 oC. Three experimental diets were prepared with varying levels of lecithin viz., 1, 1.25 and 1.50% and tested in the juveniles (2.62±0.12 g) of *P. vannamei* in a 45 day feeding trial. The supplementation of 25% higher lecithin has improved the weight gain (%) from 134.2 in control to 144.03 at 31 °C. At 35 °C, the weight gain values were 109.0 and 134.9 at 1 and 1.25% lecithin inclusion, indicating better improvement at 35 °C. The increase of lecithin level beyond 1.25% has shown negative effect at both 31 and 35 °C.

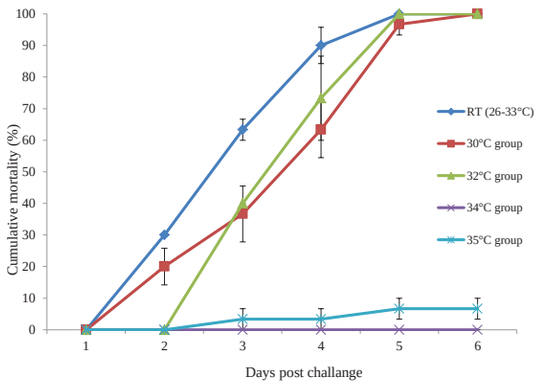


Effect of soylecithin supplementation for amelioration of temperature stress in *P. vannamei*

Effect of rearing temperature on WSSV outbreak in shrimp

Regular monitoring for environmental parameters and pathogenic agents was carried out in two *P. vannamei* cultured shrimp farms in Pazhaverkadu area, Thiruvallur District. During the study period of 98 days of culture, the farm management kept environmental parameters ideal for farming and no pathogens were detected. In the month of November 2018, the region experienced heavy rain fall due to the cyclonic effect causing drop in water temperature (from 28-31°C to 21-22°C) and salinity. As a result, the shrimp farms in the region experienced WSSV outbreak resulting high mortality of the farmed shrimp. Customised environmental parameter controlled fish/shrimp rearing system was fabricated for studying the fluctuations in temperature and salinity on disease occurrence. *P. vannamei* were maintained in five groups, room temperature (26-33°C), 30, 32, 34 and 35°C for seven days and were challenged with WSSV (107 copies/L) for two hours by immersion and maintained at the respective temperature group to assess the infectivity and mortality rate. Shrimp in room temperature (RT), 30, and 32°C experienced 100% mortality within 6 days post challenge and the dead/moribund shrimps tested 1st step positive by PCR. The shrimps reared in 34 and 35°C experienced 0% and 7% mortality respectively and both were 2nd step positive. The study confirms the role of temperature on WSSV infectivity and mass mortality. Further study on the effect of diurnal variation in temperature and heat

In situ temperature manipulation unit

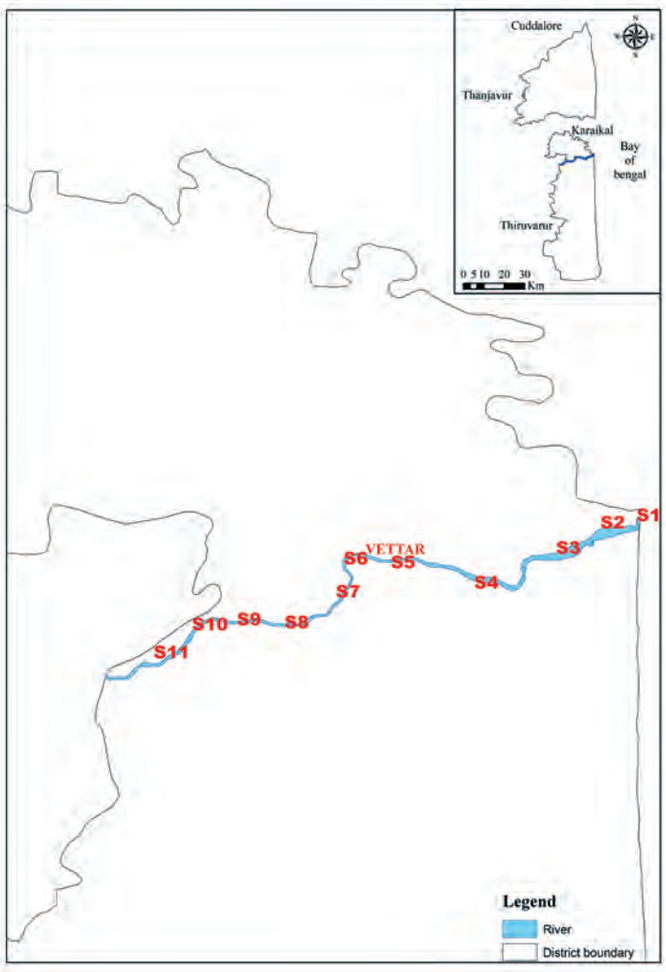


Influence of water temperature on shrimp mortality

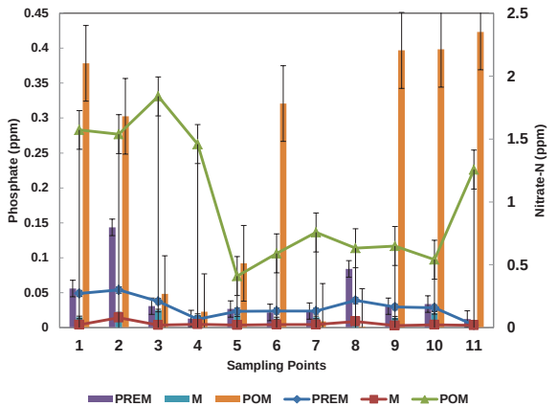
wave shock on disease outbreak will provide detailed insight into the role of weather parameters and climate change in induction of WSSV outbreak in shrimp farms.

Effect of seasonal changes on water quality parameters and carrying capacity of Vettar Estuary

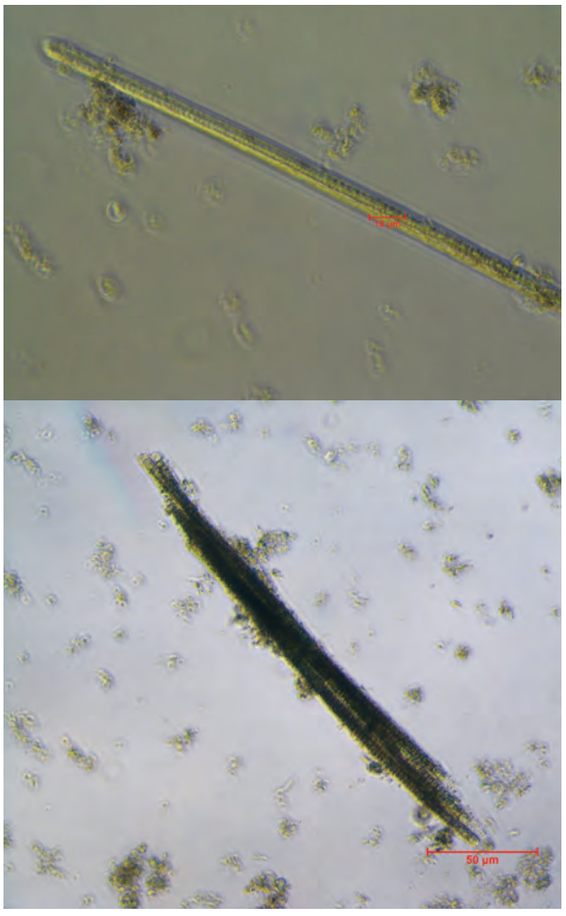
Water samples were collected from 11 different sites in Vettar Estuary, Nagapattinam District, Tamil Nadu during pre-monsoon, monsoon and post-monsoon to assess the seasonal changes on water quality and its carrying capacity. The salinity and pH ranged from 30-44, 8-30 and 32-54 ppt and 7.3-8.3, 6.9-7.5 and 7.5 – 8.1 during pre-monsoon, monsoon and post-monsoon, respectively. The eutrophic nutrients such as nitrate and phosphate were found to be highest during post-monsoon (0.955 and 0.218 ppm) followed by pre-monsoon (0.164 and 0.039 ppm) and monsoon season (0.0.029 and 0.016 ppm). Phytoplankton dominance also varied with the season. *Oscillatoria* sp was dominant during post monsoon and *Trichodesmium* sp was found to be dominant during pre-monsoon. The carrying capacity based on nutrients loading was found to be highest during



Sampling sites in vettar estuary to assess carrying capacity



Seasonal influence on nutrient concentration at different sampling sites in Vettar estuary



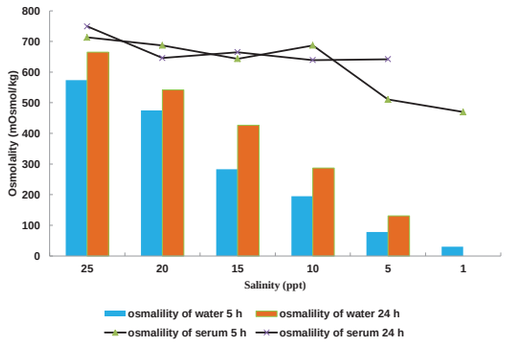
Dominant plankton species in Vettar estuary A. *Oscillatoria* sp. during post-monsoon and B. *Trichodesmium* sp. during pre-monsoon

the monsoon season with 133 kg/day followed by pre-monsoon (83 kg/day) and least during post-monsoon (64 kg/day). Nitrogen concentration was high during monsoon and pre-monsoon and during post monsoon season phosphate was the limiting nutrient which reduced the carrying capacity due to inflow of phosphate form the watershed area after the monsoon runoff.

Adaptation of *P. vannamei* to climate change induced salinity variation

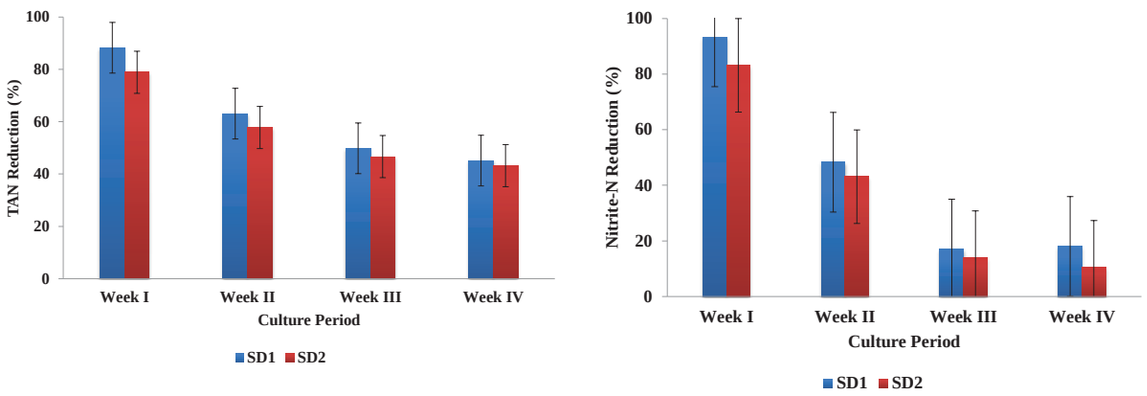
During extreme climatic events like flood, the salinity of shrimp pond water decreases sharply. To study the adaptation of *P. vannamei* under such sudden changes, the salinity of the water was reduced from 25 ppt to 20, 15, 10, 5 and 1 ppt in the yard experiment and the water and hemolymph were collected at 5 and 24 hours. Under the salinity variation of 25 to 5 ppt, water osmolality varied from 78-475 and 130-542 mOsmol/kg at 5 and 24 h respectively, whereas serum osmolality varied within a short range of 510-687 mOsmol/kg at 5 h and further narrowed and stabilized (639-665 mOsmol/kg) at 24 h. Shrimp survival was 95 % upto 5 ppt, only 20% in 1 ppt at 5 h and 0% at 24 h. Although *P. vannamei* is able to adapt quickly to changes in salinity due to its osmoregulatory capacity, it is unable to withstand the drastic change in salinity from 25 to 1 ppt. However, *P. vannamei* survived well even in < 1 ppt stable salinity in field and yard studies.

Effect of clay polymer adsorbent on nitrogen metabolites concentration in *P. vannamei* culture



Influence of drastic water salinity on osmolality of serum and water at 5hrs and 24hrs

In shrimp farming to overcome the problem of nitrogen metabolites viz., total ammonia nitrogen (TAN), and nitrite nitrogen (NO_2-N), application of adsorbents like zeolites, probiotics and water exchange, is the common practice. Clay-polymer based adsorbent was synthesized and evaluated for its effectiveness in the management of these metabolites. *P. vannamei* were stocked at two stocking

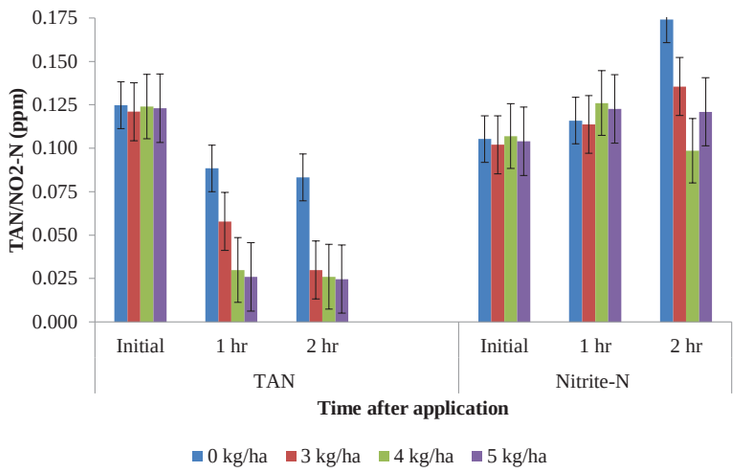


Effect of clay polymer based adsorbent on percent reduction in TAN and Nitrite-N in *P. vannamei* rearing tanks at different stocking density

densities (60 and 90 no/m^2) in100 L FRP tanks at 28 ppt salinity. The adsorbent was added at weekly interval @ 2.5g/ 100 l. The percent reduction of TAN was 88.3 and 78.9 during the first week and it reduced to 45.1 and 43.2 in the fourth week at lower and higher stocking density, respectively. Similarly, the NO_2-N level was reduced by 88.2 and 78.1, 18 and 10.5 percent during the first and fourth week at lower and higher stocking density, respectively. The efficiency of the adsorbent can be enhanced by raising the dose and frequency of application. The result indicates the use of synthesized adsorbent as an amendment for nitrogen metabolites management in shrimp culture.

Effect of oxygen releasing compound on water quality during shrimp culture

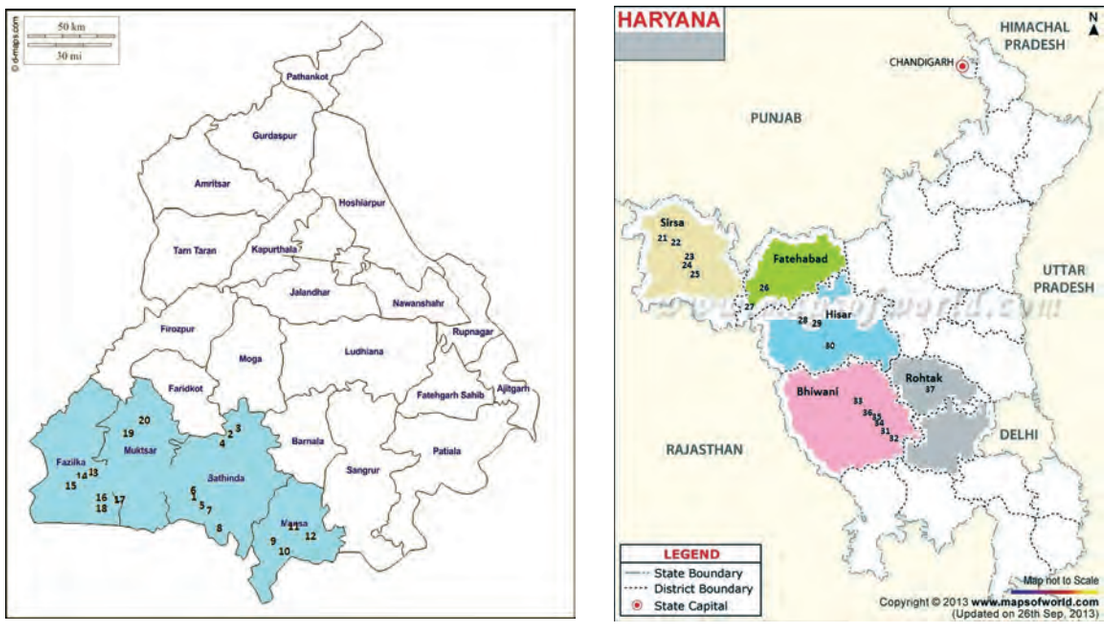
To study the effect of developed oxygen releasing compound (ORC) on water quality, 3, 4 and 5 kg ORC was applied per ha and water quality parameters were monitored at different time intervals. ORC enhanced the dissolved oxygen level to 7.5, 9.2 and 12.1 ppm from initial value of 4.8 ppm at 3, 4 and 5 kg/ha, respectively. Apart from enhancing the dissolved oxygen levels, total ammonia nitrogen reduced to 0.025 ppm after 2 h of ORC application from the initial value of 0.125 ppm. Higher dose (5 kg/ha) of ORC resulted in the plankton crash. Based on the DO levels and other water quality parameters, the optimum dose was found to be 3 kg/ha.



Effect of oxygen releasing compound on nitrogen metabolites concentration

Assessment of suitable sites for inland saline aquaculture in Punjab and Haryana

In India, salt-affected soils are spread over 6.74 m ha and likely to increase to 16.2 m ha by 2050 (ICAR-CSSRI, 2019). Salt-affected soils concentrated in North western parts of India comprising Punjab, Haryana, Rajasthan and Gujarat. To assess the degraded land for inland saline aquaculture, soil (34) and water (33) samples were collected from selected districts of Punjab and Haryana. The salinity, pH, hardness and alkalinity ranged from 2-20 ppt, 7.2 to 8.3, 540-6570 ppm and 126-601 ppm respectively. The no. of samples with in the optimum range for critical water parameters indicated that 95, 52 and 37 per cent inland saline waters were deficient in potassium, magnesium and calcium that warranted for mineral supplementation.



Sampling locations in Punjab and Haryana

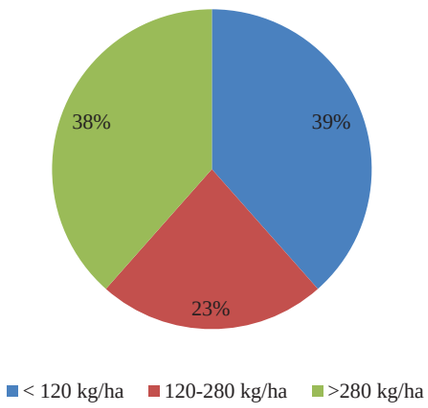
Mineral profile and chemical properties of inland saline waters

Sl.No	Water Parameter	Range	Samples in optimum value (%)
1	pH	7.16-8.27	100
2	Salinity (ppt)	2-20	70
3	Total Alkalinity (ppm CaCO3)	126-601	88
4	Total Hardness (ppm CaCO3)	540-6570	79
5	Calcium (ppm)	72-1080	63
6	Magnesium (ppm)	88-1181	48
7	Potassium (ppm)	2.1-46.3	5

Potassium supplying capacity of inland saline soils

Inland saline waters are deficient in potassium and rich in calcium, and results in imbalanced ionic ratios. To rectify the skewed ratio, minerals should be applied externally. As soils could also be a source of potassium, potassium supplying capacity of inland saline soils of Rajasthan was evaluated by quantification of potassium fractions viz., water-soluble, exchangeable, non-exchangeable and total. The water-soluble, exchangeable, non-exchangeable

and total potassium varied between 15 to 223, 27 to 814, 78-911 and 305 to 2275 kg/ha. Among the studied soils, 39% are low, 23% are medium and 38% are high in potassium fertility status based on labile K content. The soils from Jaitpura, Ajitpura, Jogni and Kishangarh were rich in labile potassium and could contribute to balance the skewed ionic ratio.



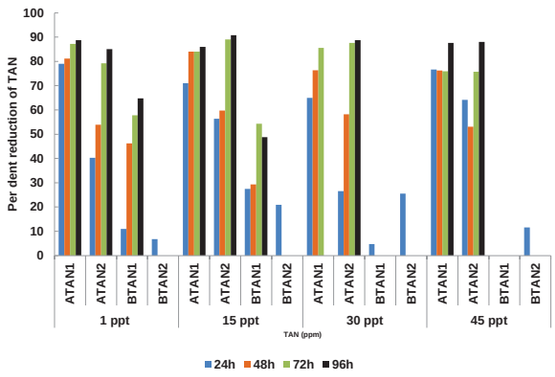
Potassium fertility status of inland saline soils of Rajasthan

Mycotic bioremediation of total ammonia nitrogen in varying water salinity

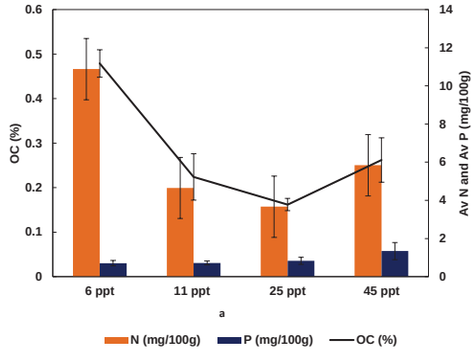
In vitro studies were conducted using the *Pleurotus erygnii* [A] and *Pleurotus ostreatus* [B] for remediating the nitrogenous metabolites. Both the species were applied @ fungal load of 10^4 CFU ml^{-1} in different salinity waters (1, 15, 30 and 45 ppt) spiked with total ammonia nitrogen concentration of 1 and 2 mg l^{-1}. Water samples were analyzed for TAN at periodic intervals 0, 24, 48, 72 and 96 h. TAN showed a reduction of more than 80% in 1, 15 and 30 ppt and less than 80% in 45 ppt within 72 h with *P. erygnii*. It was found that the *P. erygnii* has more potential to remediate total ammonia nitrogen in varying water salinities.

Carbon dynamics in relation to other nutrients in shrimp culture ponds

The variations in carbon concentration along with other nutrients like nitrogen and phosphorus in pond sediment of *P. vannamei* culture ponds varying in water salinity were studied. The shrimp culture ponds of varying salinity (6, 11, 25 and 45 ppt) were chosen in Elavur Village, Tiruvallur Distrct, Tamil Nadu within a perimeter of 5-10 km and carbon, nitrogen and phosphorus concentrations in the sediment during the culture period were determined. The average organic carbon content (0.48 %) in the sediments of low saline areas was found to be higher than that of high saline areas and decreases with increasing salinity, except at 45 ppt (0.26 %). Available nitrogen content varied from 3.6 to 10.8 mg/ 100 g and observed to follow the same trend as that of organic carbon. The available phosphorus content (0.7 to 1.3 mg/100 g) was observed to follow a reverse trend, an increase in concentration with increasing salinity. To further comprehend the changes in soil organic matter, water-soluble carbon (WSC) pool was studied. The WSC (mg/kg) was found to increase with salinity: WSC_{45} (2.5)> WSC_{25} (2.2)> WSC_{11} (2.1)> WSC_{6} (1.4).



Effect of *Pleurotus* sps.on TAN in different salinities



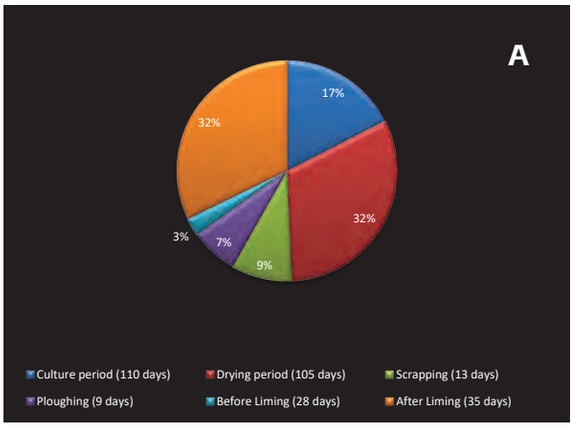
Carbon, nitrogen and phosphorus content in pond sediment (average of 3 samples) under varying salinities

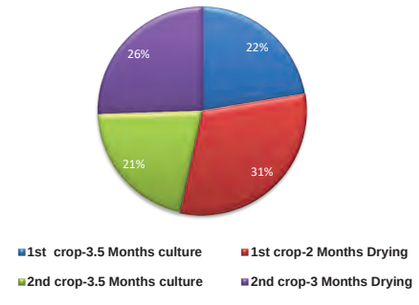
Contribution of culture practices for Greenhouse gases emission in shrimp farms

Studies were conducted in shrimp farms with single crop and two crops per year to assess the contribution of culture, fallow period and drying practices on GHGs emission. In the shrimp farms with single crop culture period of 110 days, the CO2 equivalent emission varied from 110-134 kg/ha. After harvest during the drying period, emission rate increased seven times (755 kg/ha) on the 3rd day of harvest compared to culture period and decreased gradually during fallow period. After scrapping and ploughing, GHGs emission increased thrice (360 kg/ha) and twice (282 kg/ha) compared to culture period. The highest CO_2 equivalent emission was recorded after liming, 13 times more (1304 kg/ha) compared to culture period. Single crop culture period of 110 days, drying period of 105 days, scrapping period of 13 days, and ploughing period of 9 days contributes 17%, 32%, 9 and 7% of total GHGs emission. In two crops per year, during the 1st crop, the CO_2 equivalent was 90 kg/ha on DOC 5 and increased gradually to 520 kg/ha on 90 DOC. After harvest emission increased 1.7 times (900 kg/ha) compared to culture period and decreased gradually to 216 kg/ha after 55 days of drying. During the second crop, CO_2 emission was 493 kg/ha on 90 DOC. During drying period, after one week of harvest, emission was 2.25 times more (1111 kg/ha) and decreased gradually to 113 kg/ha on the 80th day after harvest. The first crop culture period of 3.5 months, drying period of 2 months after 1st crop, second crop culture period of 3.5 months and drying period of 3 months after second crop in a year contribute to 22, 31 21 and 26 per cent of total CO_2 emission equivalent.

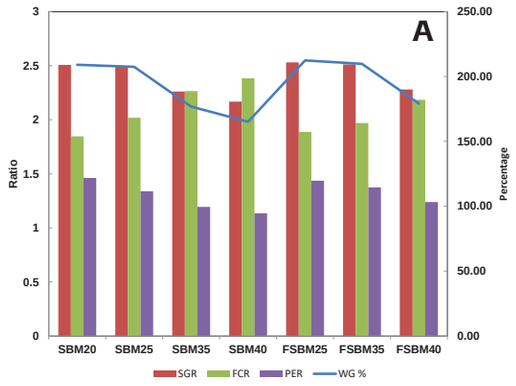
Effect of solid state fermentation of soybean meal on greenhouse gases emission in *P. vannamei*

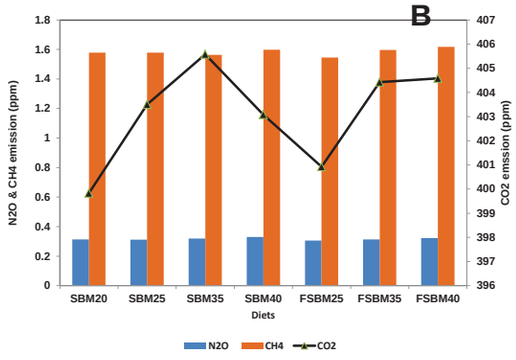
The development of alternatives to fish meal should not compromise the production performance and also should not increase the emission of greenhouse





Contribution of culture practices on GHGs emission from shrimp farms A. Single crop per year B. Two crops per year





Effect of varying levels of unfermented and fermented soybean meal in the diets of *P. vannamei* on A. Growth and nutrient utilization and B. Greenhouse gases emission

gasses (GHGs) into the environment. In the present study, soybean meal was subjected to solid state fermentation using *Aspergillus niger*. Seven experimental practical shrimp diets were prepared by incorporating various levels of raw and fermented soybean meal viz., 20% raw soybean as control, and six treatments 25, 35 and 40% of raw and fermented soybean meal. These diets were fed to the juveniles of *P. vannamei* (3.88 ±0.062 g) for evaluation of growth and nutrient utilization in 500 L FRP tanks with three replications for each diet. After 45 days of growth trail, six shrimp from each replicate tank were transferred to 100 LFRP tank specifically designed for measuring the GHGs emission. The GHGs were measured once in three days for 12 days. Increase of raw soybean meal beyond 25% and fermented soybean meal beyond 35% has reduced the growth performance and nutrient utilization efficiencies. Among the three greenhouse gasses, nitrous oxide (N_2O) emission was significantly ($P<0.05$) different with dietary treatments. The fermented soybean meal inclusion has significantly ($P<0.05$) reduced the emission of N_2O at 40% soybean meal inclusion level. This may be due to the lower apparent dry matter and crude protein digestibility values of raw soybean meal (78.46 and 89.46%) compared to fermented soybean meal (91.71 and 95.49%), respectively. CO_2 and CH_4 emissions were not influenced by the dietary treatments.

SOCIAL SCIENCE AND DEVELOPMENT

Database management on Indian Brackishwater Aquaculture : Aquastat India 2018

ICAR-CIBA created a statistical compilation, the first comprehensive database on the world and Indian brackishwater aquaculture scenario. Aquastat consists of an updated database on aquaculture resources, production, trade, and consumption from 1991 to 2017. It also attempted to include economic loss due to important diseases, doubling of farmers income, and review for World, India, and States. This work is significant as ICAR-CIBA has been mandated to act as a repository of the database on brackish water aquaculture. The technical information provided in "Aquastat India 2018" would be useful for all fishermen, researchers, and other stakeholders.

This compilation is unique in nature, and technical information provided in "Aquastat India 2018" would be useful for all fishermen, researchers, and other stakeholders.

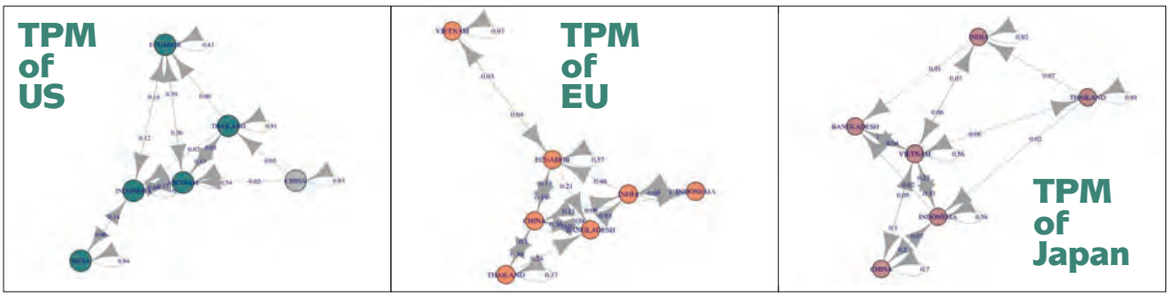
Aquastat India 2018

Indian Shrimp export performance from 2002-18

Methodology on Transition Probability Matrix using LINGO (Version 10) Package for shrimp exports was created to convert the data into a Linear Programming (LP), and Transitional probability matrix (TPM) values were estimated. The TPM indicated that India retained its share of 94%, and lost 6% to Indonesia in the US shrimp market. However, India gained 14 percentage of Indonesian share in the US shrimp market during the same period. China, and Thail, and retained their share of 93%, and 91% respectively, from 2002 to 17. Indonesia, Ecuador, and Vietnam lost their share of 30, 58, and 66 % to the other countries.

The direction of shrimp trade from the US, EU, and Japan: Methodology on Markov chain analysis: Transitional Probability Matrix (TPM) by R software

Over the period, India in US shrimp market gained an almost complete share of Indonesia, and Bangladesh shrimp market in the EU, and managed to retain half



Transitional probability matrix (TPM) values of shrimp imports

The trend of shrimp exports, and rejections from 2002-18

Country	Compound Growth Rate of exports/rejection						RCA		Instability index	
	2002-2010		2011-18		2002-18				2002-18	
	Exports	Rejections	Exports	Rejections	Exports	Rejections	2002-2010	2011-18	Exports	Rejections
US	-10.26	-23	25.59	2.71	13.84*	-1.1*	2.7	3.2	4.3	10.8
EU	6.52	-3.61	5.73	14.9	5.16*	-4.03*		4.74	6.6	11.6
Japan	-1.47	1.06$	2.71	-9.27	2.57*	23.8**	4.1	4.7	1.8	31.1

Note: Data for rejection: Japan (2006-17)*, Indicate significance at 1% , and 5% respectively**

of its exports over the period (2012 to 17). Ecuador gained maximum Indian share (47%) of the EU market. Vietnam was able to maintain 97% of its quota, whereas Ecuador, Thail, and China retained 57, 37, and 6% of their shares, respectively. India kept 92% of its share of the Japanese shrimp market, losing marginally to Vietnam (7%), and Bangladesh (1%) throughout 2002-17. Thail, and China retained their share of 91 and 70% respectively, while Indonesia and Vietnam retained half of their share in the Japanese shrimp market during the same period.

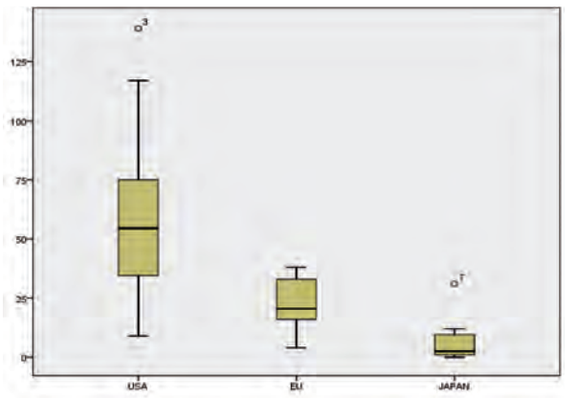
Compound Growth Rate of rejections of Indian shrimp exports to the US declined sharply by 23% in 2002-10, while it became -0.27 in 2011-17, overall period, the rejection rate remained at -2.42%. It may be seen along with the growth rate of exports by -10.26%, 26.40%, and 12.57% for the periods respectively. Similarly, Indian shrimp exports to EU grew from 4.55% (2007-10) to 18.36% (2011-17) while the rate of rejections increased from -3.61% to 3.34% in terms of CAGR during the same period. Indian exports to Japan grew marginally by 2.46% with higher rejections CAGR of 28.10%. However, during the first half of the study period, Indian shrimp exports to Japan declined by 1.47%, and rejections grew by 1.06% while in the second half of the period of study, exports grew by 2.56%, and rejections declined by 9.27%.

Analysis of instability in Indian shrimp exports, and rejections during the study period revealed higher variations in rejection by Japan while exports stayed relatively stable (2.48%). Exports to the US, and EU, and their denials remained steady at 6.90%, and 7.48% for exports, and 11.89%, and 12.14% for rejections respectively.

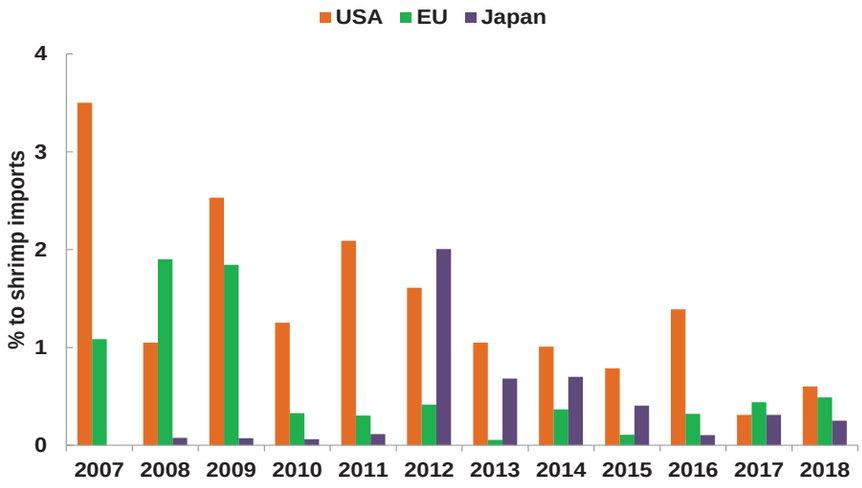
Shrimp export rejection by the US, EU, and Japan from 2002 to 2018

The export rejection database collated from trade portals of India, USA, EU, and Japan on shrimp products for the year 2002-2018, revealed Indian shrimp export rejections by the US, EU, and Japan were 83, 20, and five respectively. Box plot analysis of Indian shrimp export rejections to US, EU, and Japan showed that higher quantum of rejections was from upper quartile for the US while rejection distribution for EU and Japan situated at lower quartile.

In the USA, the rejection percent was 3.5 in 2007 and consistently reduced to 0.6 in 2018, which showed affirmative compliance of Indian shrimp exports. The share was very high during 2004 (6.1%). In EU, the rejection share was 1.08% in 2007 and significantly reduced to 0.49 during 2018 whereas, in Japan, the percentage was very high in 2012 (2%), and afterward it had decreased to 0.25 during 2018.



Country wise rejection of shrimp exported from India

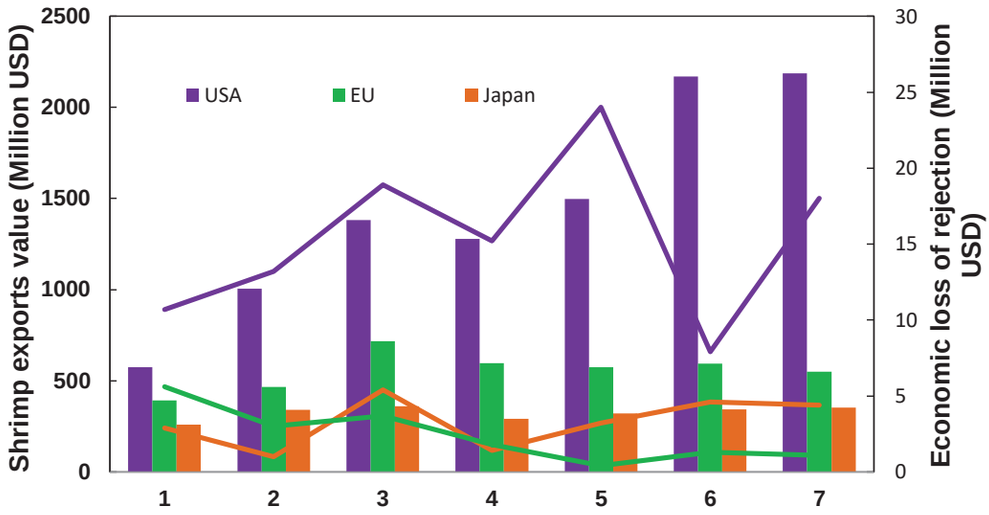


Indian shsrimp experot rejections

The economic loss of Indian shrimp export rejection by US, EU, and Japan

Estimated financial loss due to shrimp export rejection by the US was between Rs.7.5 crores to Rs.158 crores. Value of shrimp exports to the USA was 363 million $ US in 2002, and significantly increased to 2186 million USD during 2018 whereas the economic loss was 11 million $ US in 2012 and rose to 24 million USD in 2016, and during 2018, which had significantly decreased to 18 million USD, and showed an improvement in compliance performance and adoption of Better Management Practices (BMP) by the shrimp processors.

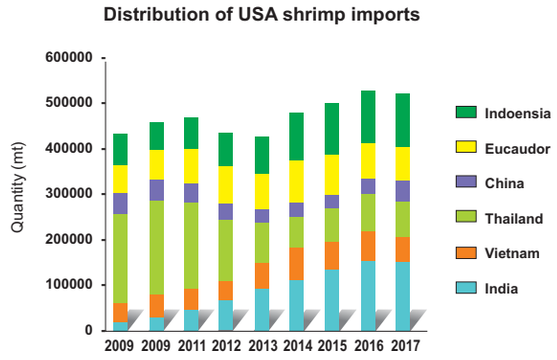
The European Union has more stringent food safety standards. In the EU, the value of Indian shrimp exports was 305 million $ the US and increased to 550 million $ US, and economic loss also significantly rose from 2.9 in 2012 to 4.4 million $ US in 2018. In Japan, the value of shrimp exports has been increased sharply from 258 million USD to 353 million USD from 2012 to 2018 whereas the economic loss had decreased from 5.61 million USD to 1.1 million $ US except during 2012 when the loss was 3.7 million USD. Japan has been traditionally importing Jumbo tiger shrimps for making ethnic dishes like tempura, and shush. There were incidents of rejections of shrimp imports from India during 2012-2014 for the presence of anti-oxidants.



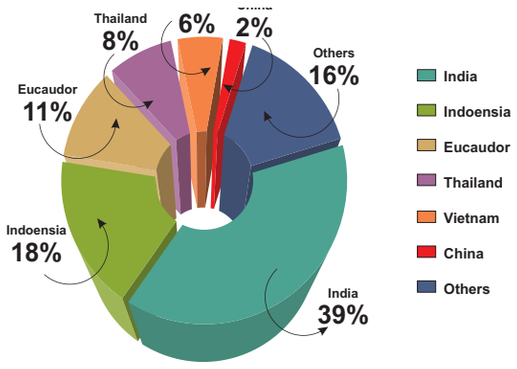
Economic loss due to the rejection in the export of shrimp from India

Panel Data Regression: Gravity model approach on US shrimp imports from India, and other exporters

Panel data methodology for US shrimp imports from India, and other major exporters used and based on the results of the Hausman test, and Breuch Pagan Lagrangian multiplier test, the random effects model, adopted. LM test clearly showed that there is a significant difference among various regions, and panel effect between different shrimp exporting countries to the US.



Import of shrimp in the United States from different Asian countries during t2009 -2017



Top shrimp exproters to USA by value in 2016

Economic analysis of brackishwater aquaculture technologies in India

An analysis of cage culture of pearlspot was carried out in a single cage of 4x4x3 m undertaken by KVK Alleppey, with the technological backstopping of CIBA Chennai, and KVK Ernakulam. The results indicated that the survival rate was 80% for 1000 fingerlings, the yield was 200 kg. Out of the total cost of Rs.37000, Rs. 10000 (25%) was incurred for feed, and Rs.8000 (21.6%) for the labor. Seed cost accounted for only 5.4 %. The gross return was Rs.80000, and the net profit was Rs.43000/crop, and the realized BCR was 2.16.

Pearlspot farming in brackishwater resources of Alleppey district in Kerala

Economics of Re-circulatory Aquaculture System

To study the economy of Recirculatory Aquaculture System (RAS) practiced at farmer's level, a survey sheet was prepared, and data were collected to do the economic analysis of existing RAS. Modification of RAS design could be done to reduce the cost of production, optimize the production volume for economic viability (Break-even analysis) of RAS.

RAS designed to study the reproductive performance of penaeid shrimps in comparison with flow-through the system. Preliminary trials of water quality analysis of shrimp maturation in flow-through system revealed that the Total Ammonia Nitrogen (TAN) was above the recommended limit (1 ppm) in all the tanks with 100% water exchange per day at a stocking density of 2 shrimps/m^2. To overcome the disadvantages of the flowthrough, a new RAS system is designed, and modified to improve water quality, subsidize water usage, preserve pheromones, and also ensure biosecurity in shrimp maturation. The shrimp broodstock RAS is designed based on the capacity, biomass, water flow rates, biofilter sizing, oxygen delivery, etc. The estimated capacity was to stock five shrimps/m^2. Broodstock RAS is modified as follows: Tank bottom is raised to 40 cm – to accelerate gravity flow, central drainage with slope- easy sludge removal, two-step swirl separation- removal of settleable solids (large, and fine solids), and bio ball filter aeration piping design- made adequate to provide fluidization of bio-balls. A further modification is possible to improve the capacity of RAS by replacing the media. The biomass and animal stocking density was calculated based on the carrying capacity of the RAS concerning the solids removal rate of mechanical filter, TAN removal rate of biofilter, Oxygen addition rate, etc. The flow rate required to maintain the optimum concentration of TAN, TSS (Total Suspended Solids), and DO (Dissolved Oxygen) in the RAS, and sizing of biofilter was calculated using the spreadsheet.

To summarize, RAS is designed to grow shrimp from its post-larvae stage to maturity. The system is proposed to have the capacity to grow 500 PL/m^3. The study is being conducted to optimize the stocking density, and system carrying capacity, and analyze the water quality, and efficiency of the system.

Techno-economic viability of three-tier cage farming of Asian seabass fish in open brackishwater bodies

Fingerling size fish (8-10g) is the stockable size in pre-grow out cages, and generally small size fry will not survive in running waters. Although fingerlings can be purchased from the nurseries operated by farmers, the cost is extremely high, and it is economically unfeasible. Therefore nursery rearing to raise fish fry to fingerling size is the better option, and a critical phase to get the fingerling stock for the cages. The group carried out four cycles of nursery rearing to raise fingerlings, and the weekly growth rates of fish

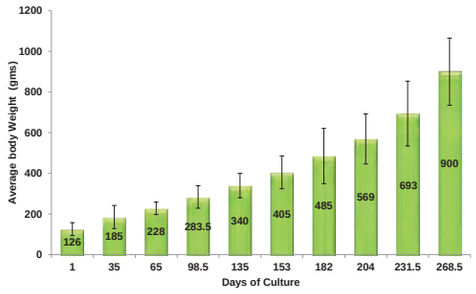
fry stocked in hapas are given in the Table. The average survival in the four cycles was 40%, and the mean growth rate in eight weeks duration was 7.3 cm (7-8 g). It was noted that nursery rearing in hapas in open waters did not give better survival when the water current was more than 10 cm/sec. Therefore it is suggested that nursery rearing unit need to be set up in a pond based system.

Rearing of fish fingerlings (7-8g) to a juvenile size (900-100g) was taken up in pre-grow out cages for 90-105 days. The average growth of fingerlings in pre-grow-out, and mean body weights were measured in fortnightly intervals, and the results are presented in the Table. The average daily growth was found to be one gram in pre-grow out stage, and at the end of 100 days, the fingerlings were grown to juvenile fishes with an average size of 126 g.

In the grow-out phase, the fish juveniles of 100-150 g size were transferred from pre-grow out cage into a larger grow out cage for rearing them to an adult size of around one kg. At 270 days of culture, the mean body weight of the fish was 900g. It was observed that the cages acted as fish aggregating devices, and fishers had good catch around the cage farming site. As the water quality was good in moving waters, and fishes were in the ideal rearing environment, the quality and taste of the fish was very good and fetched a premium price in the market. The Fisher group was linked with the Tamil Nadu Fisheries Development Corporation (TNFDC) the marketing arm of the Department of Fisheries, Govt. of Tamil Nadu, and they bought the fish at the cage site. Due to this market linkage, the Fisher group received a better price for their produce.

Average body weight, and length of fish in pre-grow out phase

Day of Culture	ABW (g)	Mean length (cm)
1	4.9±1.6	6.9±0.84
15	13.6±1.9	9.8±1.20
30	28.0±2.9	11.9±1.54
45	40.6±4.1	13.2±1.28
60	52.7±6.5	14.3±2.96
75	75.4±6.8	15.8±3.18
90	101.6±17.3	17.9±3.48
100	126.0±37.2	19.6±3.89



Mean growth rate of Asian Seabass in grow out phase

Growth rate, and weekly survival in nursery rearing

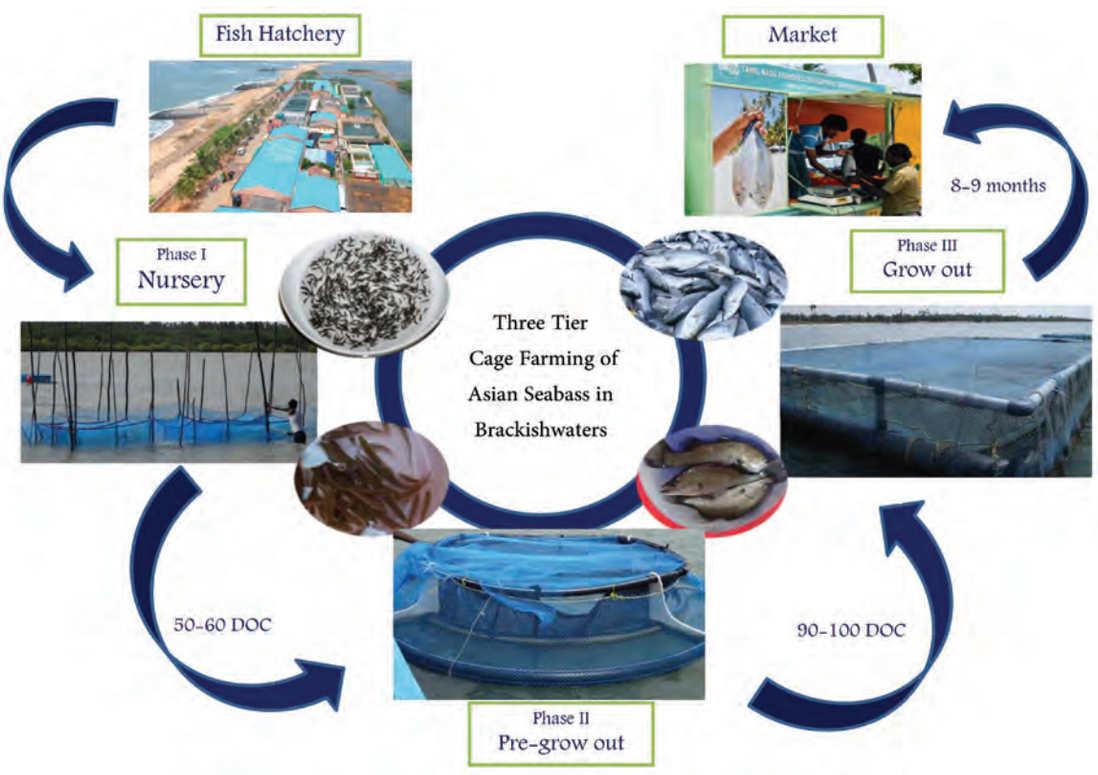
Nursery cycles	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Mean± SD
Initial Length (mm)	2.5	2	3	4	2.9±0.8539
Final Length (cm)	6.5	6.8	7.5	8.5	7.3±0.8884
The average survival in %					
Week 1	80.0	74.0	73.0	85.0	78.0±5.5976
Week 2	63.0	69.0	69.0	72.0	68.3±3.7749
Week 3	58.0	55.0	58.0	66.0	59.3±4.7170
Week 4	54.0	50.0	55.0	57.0	54.0±2.9439
Week 5	49.0	46.0	51.0	52.0	49.5±2.6458
Week 6	45.0	42.0	49.0	46.0	45.5±2.8868
Week 7	42.0	39.0	48.0	42.0	42.8±3.7749
Week 8	39.0	36.0	46.0	40.0	40.3±4.1932

Growth performance of seabass in grow out phase

The seabass fish were sold @ Rs.380-400/kg at the cage site itself. The fishers obtained a monthly income of Rs.8000, Rs.4900, and Rs.8500 respectively in nursery rearing, pre-grow out, and the grow-out farming. This shows that cage farming has provided them an alternative livelihood, and doubled their income. With proper management of cage erected at an ideal location in brackishwater can yield production of 20-25kg/m3 with various species of fishes. Since all the three phases require hardly two man hours per day to manage the system, the fishers could take up cage farming as an additional occupation. With proper planning, four cycles of nursery rearing, and two cycles of pre-grow out culture can be taken up in a year. Nursery rearing can provide eight months of employment in a year for four people. Two persons in the group can take care of pre-grow out farming, and an average one member can spend one hour in the morning, and one hour in the evening for feeding the fishes. All together for the 90 days of duration, 180 hours of manpower was required for one cycle of three months. Two cycles can be done in a year. Four fisher youth of the team can take up grow out farming. On average, one member can spend one hour in the morning, and one hour in the evening for feeding the fishes. All together for 300 days totally 600 man hours of manpower they need to spend for one total cycle. With the installation of one more grows out the cage in the site, two full cycles of the three-tier system could be taken up in a year.

The group members may subdivide among themselves to take up the nursery, pre-grow out, and grow out phases as this segmentation might provide interim returns to them, and they need not wait for the cycle to complete. In the subsequent culture, they could inter-change their portions among themselves. Since the water bodies are common property resources group of fishers of their families could jointly take up this system of farming. Nursery rearing can be taken up by fisher womenfolk as it requires smooth handling, and grading once in 4-5 days to avoid sibling cannibalism. For effective adoption of aquaculture technologies by the poor, and new entrants in the developing countries, the use of participatory rather than technology-driven approaches are highly convincing (Edwards, 2000). The fisheries

Three tier system of cage farming with forward and backward linkages



departments of the states should promote cage aquaculture in suitable locations by developing suitable schemes with an inbuilt subsidy to establish cage infrastructure. Location-specific cage designs using locally available materials could minimize the investment.

Demonstration of polyculture of finfish and mudcrab at Sadaraskuppam back waters, Kancheepuram district, Tamil Nadu

Polyculture of milkfish, pearlspot, and mud crabs was conducted in the open water system pen structure (size of 150 m2) among five tribal families (10 nos.) of Sadraskuppam, Kancheepuram district, Tamil Nadu. A total of 100 milkfish (avg. wt 49 g), 750 pearlspot (3 to 15 cm) size, and 125 mud crab (18. 5 kg; 95 to 250 g) were stocked in pen. After 60 DOC, due to obstruction at the bar mouth of Sadraskuppam backwater area followed by less water exchange to the pen structure, heavy mortality of mud crab was noticed. Mud crabs were harvested with 30 % of survival range from (225 to 685 g) size, and fish culture is in progress.

Harvested Mud crab at Sadaraskuppam backwaters, Kancheepuram district, Tamil Nadu

Installation of Fish waste Processing Unit, and Demonstration for preparing Planton*plus*, and Horti*plus*

ICAR-CIBA, Chennai has adopted fishermen villages viz., Srinivasapuram, Nambikkai Nagar, Mullikuppam, and Mullimanagar located near CIBA Headquarters in Chennai. This village cluster has about 4500 persons in 2000 households. Their main occupation is fishing, and selling of fish in the lighthouse fish market, which is located nearby these villages. In this fish market, fish waste is not properly disposed or recycled. Mostly fish trimming wastages are dumped nearby seashore. In this backdrop, "Fish Waste Processing Unit" was established for recycling of fish waste to high value-added products in the Nambikkai Nagar, Pattinapakkam, Chennai, Tamil Nadu based on the need, and interest shown by the Nambikkai Fish Farmers Group, Nambikkai Nagar, Pattinapakkam. After installation ICAR- CIBA staff has given a demonstration about the protocol for recycling of fish waste to value-added products to Nambikkai Fish Farmers Group, Nambikkai Nagar, Pattinapakkam, Chennai during February, and March 2019. Impact of this initiative, the group has produced 520 Kg of Plantonplus, and 65 Kg of Hortiplus during March 2019 , and received Rs. 16120/-. The group is processing the fish waste continually and producing Plantonplus, and Hortiplus as an alternative livelihoods activity. This initiative is not only cleaning, and hygienic disposal of fish market waste which is abundantly available in the village cluster but also will help to produce wealth from waste as a concept of the circular economy. This user-friendly technology will help in improving the environment in addition to enhancing their livelihood.

Fish Waste Processing Unit at Nambikkai Nagar, Pattinapakkam, Chennai

Protocol for recycling of fish waste to Plankton^{plus}, and Horti^{plus}, Nambikkai Fish

Ornamental fish farming for profitable income generation, and community development among coastal families of Kovalum village, Kancheepuram District. TN.

Pearlspot seeds for stocking being received by beneficiaries from Shri. Chhabilendra Roul, Special Secretary, DARE, Govt. of India & Secretary, ICAR in the presence of Dr. K.K.Vijayan, Director -CIBA

Homestead backyard pearl spot seed rearing unit as a livelihood support activity was established for the clam collecting coastal families at Kundrakadu village, Kovalum, Kancheepuram district. TN. Pearlspot (*Etroplus suratensis*) 2000 Nos, with the average size of 1.0 cm to 2.0 cm was stocked in 4 concrete tanks @ 500 nos — each (in a hatchery shed of 200 sq.ft (20x10ft.). After 52 days of culture, the fish attained the average size of 0.6g in size ranging from 2.5 cm to 3.13 cm, with the survival rate of 93.3%. A total of 1865 nos. of pearlspot was harvested from all the tanks indicating the successful nursery phase rearing. These beneficiaries earned Rs. 8000-12,000/- approx. per trial or month. These beneficiaries saved their profit money earned from this intervention by opening a joint bank savings account.

Homestead backyard pearlspot seed rearing unit

Demonstration of milkfish farming in unused shrimp ponds at Tiruvallur District, Tamil Nadu

Two tier Milkfish (*chanos chanos*) farming in brackishwater pen culture system was demonstrated as fish farming in an open water pen erected in the brackishwater body among the tribal families under Tribal Sub Plan. 0.5g milkfish fry stocked in the nursery pond @2 nos/m^2 attained an average body weight of 12 g with a survival rate of 70% in 43 days. Subsequently, these 12g size milkfish fingerlings were transferred to a pen culture enclosure erected in Pulicat lake area and stocked @ 2.5 nos/m2 in a 400 m2 pen system. After 55 days of grow out culture, the fish attained an average body weight of 125g - 180g with a survival rate of 70%.

A harvest mela was conducted on 23rd October 2018, at Kanavanthurai village A production of 60 kg milkfish was harvested. Bank accounts were opened , and the tribal beneficiaries deposited Rs.25,000/- the profit earned from this intervention in their bank account — officials from CPCL Company, local villages heads, bank manager & Govt. School children participated in this program. The present demonstration showed that milkfish farming in open water systems is technically feasible, economically viable, environmentally sustainable in providing livelihood to the tribal families, other communities with access to water bodies.

Pearlspot integrated with crab farming (in tide fed ponds) was demonstrated among Irular tribal families of Kulathumedu village, Tiruvallur District. TN. (in tide fed ponds)

Technology Transfer Mechanisms for improving the livelihood security of coastal families.

Hatchery produced seabass fish fry of size 1.8-2.0 cm was stocked @ 500 no. Per hapa , and four trials were conducted in Koovathur village of Kancheepuram district in Tamilnadu. CIBA seabass nursery Plus with 45% CP, and 12% lipid was used as feed. Feeding was done twice a day at 08.00hrs, and 16.00hrs. Grading of the fry and cleaning of the net was carried out once in 4-5 days. The nursery rearing was continued for 60 days. The total realized production was 2500, 2520, 2523, and 2850 fingerlings out of 5000 fries stocked in each trial. At the end of nursery rearing, an average total length size of 6.8, 7.1, 7.0 & 8.4 cm was harvested — survival of 50-57% in open waters.

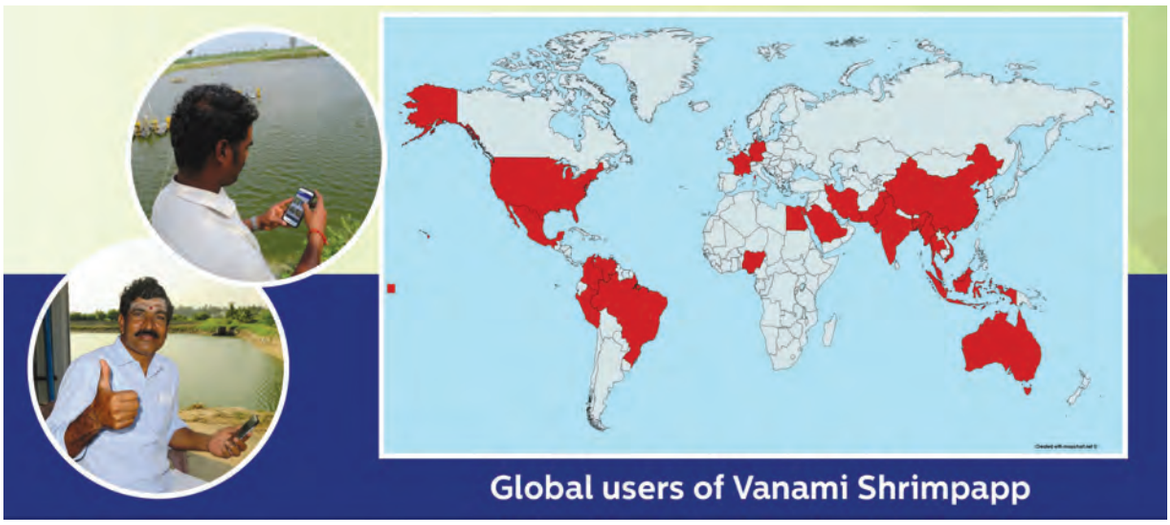
The net income from four cycles was Rs 1,14,000/-, and each member got an average income of Rs.7000 /- per head/ per cycle. It was an additional income, job-sharing employment which could be taken up throughout the year as a livelihood activity. Regular supply, and uniform size of fry, site specification, calendar of operation, standardization of transport mode, stocking density depending on the availability of feed, feeding frequency, and demand based marketing were the suggestions given by the farmers regarding technology refinement.

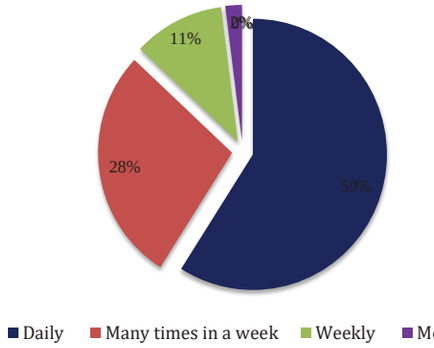
Farmers feedback on nursery rearing of seabass in hapas in open brackishwater sources

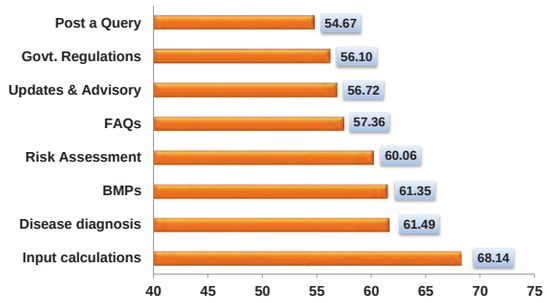
Effectiveness of mobile app in technology dissemination on shrimp farming

ICAR-CIBA launched a mobile application Vanami Shrimpapp in 2017 a platform to disseminate technical knowledge to the aqua farmers, and extension workers. The app has been regularly updated with new information as per the field requirements, and extensively consulted across the countries. As on date, it has more than 15300 downloads across the worldwide with 4.5/5.0 rating. India is the major user with 80% of downloads. A study was undertaken with 180 vanami shrimpapp users to assess its effectiveness in terms of the usefulness of its modules to the end users. It was noted that 85% of the respondents conveyed that it was a reliable source of information, and a farmer can decide on his farm using this app.

Similarly, 87% of them opined that it was a notable contribution by the institute to the sector. Majority of the app users referred to the app every day (59%), and 28% consulted on alternate days (28%). The users ranked input calculations; disease diagnosis, BMPs, and risk assessment were the most used modules. Based on the suggestions, the app was updated with additional modules, and in vernacular languages viz. Tamil, Telugu, Bengali, and Hindi, and renamed as CIBA Shrimpapp , and launched during the National Brackishwater Aquaculture Farmers Conclave-2019 on 22 January 2019 at CIBA campus.







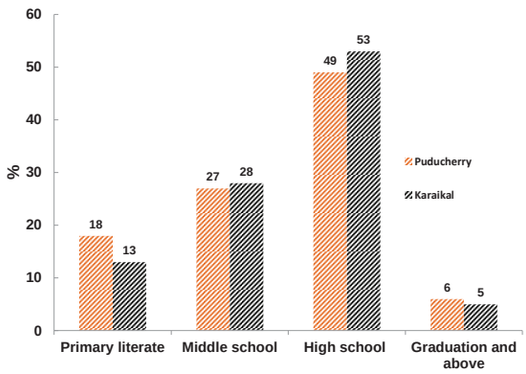
Usability of mobile app

Cage aquaculture in brackishwater of Puducherry, and Karaikal regions of Puducherry Union Territory

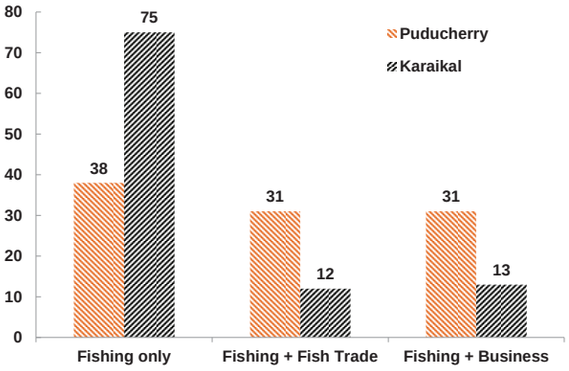
A feasibility study on Socio-economic status of coastal fishers Puducherry, and Karaikal region revealed the following:

Majority of the fisher families in Puducherry (69%) , and Karaikal (60%) were of a nuclear type, and the family sizes were also small with four members or less (66% , and 60%). However, about 30-40% of fisher families still live as joint families as this important in case of fishing avocation is concerned, and it shows that the family relationships were intact, and they help mutually one another during the needed situations. Almost half of the respondents in Puducherry (49%), and Karaikal (53%) were educated up to high school.

It is interesting to note that the majority of Puducherry (64%), and 37% of Karaikal fisher families had more than one source of income mainly through fish marketing. However, the majority of the fishers of Karaikal (63%) mostly depend on fishing for their livelihood, and they may be receptive to any fisheries development programs. This is explicitly indicated by the occupation status of the respondents wherein 75% of the Karaikal fishers were full-time fishers , and fishing was their only occupation.



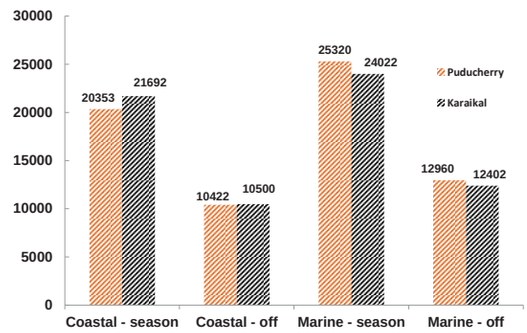
Education status of the fishers



Occupational status of fisherfolk

In terms of contact with the Fisheries Department, which is the nodal agency for their welfare, the majority of Karaikal respondents (65%) had contacted the Department officials for one or the other purpose. However, in case of Puducherry, one-third of respondents had monthly to occasional (28-33%) contacts with Fisheries Departments, and one-third of them (37%) had contacted the officials of the Fisheries Department. This may be because the Karaikal fishers were mostly dependent on fisheries for their livelihood, and they need to contact with fisheries department for getting advisories, and information about the scheme, etc.

The average monthly income realized by the coastal fishers was Rs.20,353-Rs.21692 while the marine fishers could realize Rs.24, 022 –Rs.25,320 during the fishing seasons. However, during the off-seasons, their monthly income was respectively Rs.10, 422-10,500, and Rs.12,402 -12,960 for the estuarine, and marine fishers. During the off season, their monthly income was reduced by 50% but their effort on fishing was the same.



Average income of inshore and marine fishers

The livelihood assessment of coastal fishers Puducherry, and Karaikal regions:

The livelihood assessment has indicated that the average livelihood score of coastal fishers was 70%. The mean livelihood score of Puducherry fishers was 67.50 %, and the fishers of Karaikal region had an average livelihood score of 72.50% However, about 40% of the Puducherry, and Karaikal fishers were in the category of below the average livelihood score. These results indicated the respondents needed support in the form of assets, capacities, and activities to improve their livelihood status. The statistical analysis carried out showed that there is a significant difference in the livelihood scores of Puducherry, and Karaikal fishers and both the samples are not belonging to the same set of the population ($p \leq 0.01$). Further, the analysis shows that Karaikal fishers (mean rank 87.80) had an edge in terms of their livelihood levels than their Puducherry (mean rank 62.55) counterparts.

Assessment of waterbodies for their suitability for aquaculture

Assessment of waterbodies considering the physical, chemical, and environmental conditions using geospatial analyses has indicated that Malattaru estuary, a portion of Chunnambar river in Puducherry , and Arasalaru creek in Karaikal regions were identified as relatively suitable for taking up culture-based fisheries. However, tourism and recreation were found to hamper the fisheries and initiating culture based alternative livelihood for the fishers in Puducherry.

Development of decision-making tool for aquaculture development at Adyar creek, and estuary

Web-based Adyar Creek and Estuary Information System based on Decision Making Tool was developed for the development of aquaculture in the water bodies. The system permits end users to fast, and easy access to large amounts of analyzed data which are collected in different sample locations, and details of culture practices which are suitable for the different sample locations for the development of brackishwater aquaculture. It has been developed using MySQL database management system, and PHP scripting language. In this tool, an information system was designed into different modules namely,

about Adyar creek, and estuary, System needs, and objectives, Sample location, Water parameters, Soil parameters, phytoplankton, zooplankton, and culture practices. The season wise, location-wise, month-wise, year-wise, salinity-wise, phytoplankton class/genus-wise, and/or zooplankton group-wise information is used for deciding to develop the aquaculture activities in the water bodies. Although illustrations are based on the six sample locations, the system is general and can act as a model to elaborate for the entire Adyar creek water bodies.

Development, and evaluation of the effectiveness of Web-based Knowledge Centre in brackishwater aquaculture

Web-based Knowledge Centre in brackishwater aquaculture was developed using Drupal content management software (CMS) based on the ADDIE model of Instructional System Design (ISD), including Analysis, Design, Development, Implementation, and Evaluation. This system is built-up with PHP, and MySQL for the design of pages, and database, respectively. The effectiveness of the centre was evaluated using a structured questionnaire consists of six categories such as related to contents; presentation of modules; interactivity, visual design, and accessibility; user friendliness; module applicability; and general assessment of the unit. For the pilot study, the questionnaire was distributed to twenty-five randomly selected users of Village Knowledge Centers (VKCs), MSSRF, Chennai, and their responses were analyzed for checking its reliability by Alpha-Cronbach test.

The results showed that the questionnaire was reliable since the alpha score produced was over 0.7 for each category of the questionnaire. After the pilot study, this tested evaluation questionnaire was used for evaluating the effectiveness of the centre by recording the responses of 30 sample ICT users, VKC, MSSRF, Chennai. A five-point rated scale was used where a respondent was asked to indicate their response to their statements on the centre. The possible scores were 1 for strongly disagree, 2 for disagree, 3 for undecided, 4 for agree, and 5 for strongly agree. The average score was obtained by adding the multiplication of frequencies with the respective weights and dividing them with a total number of respondents. The evaluation results revealed that the items related to contents produced, visual design, accessibility, and presentation style had good responses. Future provides a knowledge base which goes beyond the traditional approach of storing and retrieving of information of various aspects of brackishwater aquaculture as racks of hard copies or in removable media storages. This also safeguards the valuable information gathered on shrimp, crab, finfish, and policies over some time.

Flow diagram of Web-based Knowledge Centre Instructional System Design

Reliability, and evaluated results for web-based knowledge centre

Criteria	Reliably result (Alpha value (α))	Evaluated results (Average score)
Contents of the centre	0.85	4.1
Presentation, and Interactivity of the centre	0.78	3.3
Visual design, and accessibility of the centre	0.81	4.4
User friendliness, and motivation of the centre	0.73	3.3
Module applicability	0.82	2.9
General assessment	0.84	3.6

HUMAN RESOURCE DEVELOPMENT (HRD)

TRAINING, CAPACITY BUILDING AND SKILL DEVELOPMENT

TRAINING ATTENDED BY INDIVIDUALS

International

Dr. Aritra Bera, Scientist, attended the International Training Courseon Fish Culture Development at Egyptian International Centre for Agriculture (EICA) & World Fish at Arab Republic of Egypt during 01.10.18 – 15.12.2018

National

Dr. Debasis De, Principal Scientist attended the Training Programme on "Empanelled members in the evaluation committee under NPOP" organized by APEDA, New Delhi during 21-23 May 2018

Dr. M. Muralidhar, Principal Scientist attended the National Dialogue on "Artificial Intelligence and IoT applications in Agriculture" organized by ICAR – NAARM, Hyderabad during 1-2 June 2018

Dr. R. Geetha, Scientist attended the Training programme on "Advanced statistical methods and computational software for fisheries research and management" organized by Extension, Information & Statistics Division, ICAR-CIFT, Kochi during 17-26 July 2018

Dr. R. Ananda Raja attended the "Two Days Regional Workshop cum Training Programme for Nominees of CPCSEA" at Conference Hall, Madras Veterinary College, Vepery, Chennai- 600 007, Tamil Naduduring 19-20 July, 2018

Dr. Debasis De, Principal Scientist attended the Training programme on "Research Excellence in Organizations" organized by Administrative Staff College of India, Hyderabad during 8-10 August 2018

Shri T. Sivaramakrishnan, Scientist attended the Training Course on "LC-Ms based Proteomics" organized by CSIR – CCMB, Hyderabad during 3-13 October 2018

Dr. P. Kumararaja, Scientist attended the Training programme on "Winter School Climate Change impacts and resilience options for Indian marine Fisheries" organized by ICAR-CMFRI, Cochin during 8-29 Nov. 2018

Shri T. Sathish Kumar, Scientist attended the Workshop on "Basic course in Bio-Statistics for medical professionals and non-medical researchers" during 10-14 December, 2018 at NIE, Chennai

Dr. Krishna Sukumaran, Senior Scientist attended the "Training of Master Trainers" organized by Agricultural Skill Council of India during 7-9 January, 2019

Dr. T. Ravi Sankar, Principal Scientist attended the Incubator Manager Training Programme organized by American Corner, St. Francis College for Women, Uma Nagar, Begumpet, Hyderabad during 28-29 January 2019

Dr. J. Raymond Jani Angel, Scientist attended the Training Programme on "Bioinformatics for metagenome data analysis (NGSDAT 2019) Organized by ICAR- Indian Institute of Species Research, Kozhikode, at Keraladuring 19-22 March 2019

Dr. T.N. Vinay, Scientist attended the Training Programme on "Bioinformatics for metagenome data analysis (NGSDAT 2019) Organized by ICAR-Indian Institute of Species Research, Kozhikode, at Keraladuring 19-22 March 2019

Technical Staff

Dr. Sivagnanam, CTO attended the Training of Trainers programmes under Skill Training Programme organized by ATARI Kanpur during 17-19 December 2018

Shri S. Rajamanickam, ACTO attended the Training of Trainers programmes under Skill Training Programme organized by ATARI Kanpur during 17-19 December 2018

Dr. Joseph Sahayarajan, ACTO attended the Training Course on "Molecular Cloning & Protein Expression" organized byCSIR – CCMB at Hyderabad during 19 June to 13 July 2018

Dr. A. Nagavel, ACTO attended the Training Programme for Technical Personnel on "Experimental data analysis" organized by IASRI, New Delhi during 27 August - 1 Sept 2018

Shri S. Prabhu, Technical Assistant attended theTraining programme on Green Buildings organized by IGBC, Chennai during 14-15th February 2019

Administrative Staff

Shri S. Pari, AAO (C&B) attended the Training programme on PFMS & FMS organized by ICAR-NAARM, Hyderabad during 10-12th September 2018

Shri A. Sekar, Assistant attended the Training programme on PFMS & FMS organized by ICAR-NAARM, Hyderabad during 10-12th September 2018

Supporting Staff

Shri V. Kishor Kumar, SSSattended the Training programme on PFMS & FMS organized by ICAR-NAARM, Hyderabad during 10-12th September 2018.

TRAININGS PROGRAMMES ORGANIZED

Headquarters

Sl. No	Name of the Training /FGD	Duration	No. of participants
1	Training Course on "Skill Enhancement in the marine sector (SEMS) for Sustainable Export Opportunities"	7-11 May, 2018	16
2	Training course on "Sustainable crustacean farming in brackish water systems"	14-19 May, 2018	9
3	Skill Development Training programme on "Recent Advances in Soil and Water Management in Brackishwater Aquaculture"	25 - 30 June 2018	20
4	Customized training on Identification, isolation and pure culture of microalgae from sea and brackishwater	11-13 July 2018	10
5	NFDB Sponsored Training Progamme on "Seed Production and farming of brackishwater finfish species"	30 July – 3 August 2018	12

6	Training Programme on "Hatchery production and farming of milkfish and mullets"	16-20 August 2018	10
7	Customized Training Programme on "Water and Soil Treatment Applications in Aquaculture"	27-28 August, 2018	7
8	Hands-on training on "Aquaculture Genomics and Bioinformatics"	27 August to 1 September, 2018	11
9	NFDB sponsored training on Recent advances in farming of pacific white shrimp	10-14 September, 2018	8
10	Training Programme on Seed Production and culture of Brackishwater Finfishes	18-22 September 2018	2
11	Hands-on Training on "Waste to wealth: Recycling of fish and domestic waste to value added products" at Srinivasapuram, Pattinapakkam, Chennai, Tamil Nadu	28 September 2018	70
12	Hands-on training to women self-help group on recycling of fish waste to value added products at Muttukadu Experimental Station, Muttukadu, Tamil Nadu	1 October 2018	14
13	Customized training on Aqua feed Processing and Quality Control	30 Oct.- 3 Nov. 2018	4
14	Training cum demonstration on "Waste to Wealth" by recycling of fish waste to value added products at Nambikkai Nagar, Pattinapakkam	22 December, 2018	30
15	Customized training on aqua feed processing and quality control	1-5 February 2019	2

16	Advanced Training in Aquaculture Nutrition and Feed Technology	19-28 February 2019	12
17	Hands on Training on Nursery rearing of Seabass (*Lates calcarifer*)	25-27 February 2019	6
18	Hands-on Training on "Waste to wealth: Recycling of fish waste to value added products" at Nambikkai Nagar, Pattinapakkam, Chennai, Tamil Nadu	4-7 March 2019	12
19	National Workshop-cum-Training Programme on "Biofloc Technology for Nursery and Grow-out shrimp aquaculture"	12-16 March 2019	20

Kakdwip Research Centre

Sl. No	Name of the Training /FGD	Duration	No. of participants
1	Training programme on "Seed production and farming technology of brackishwater catfish, Mystus gulio"	2-7 July 2018	25
2	Training Programme on "Advances in Brackishwater Aquaculture"	23-28 July 2018	13
3	Training Programme (Training of Trainer) on "Advances in brackishwater aquaculture practices"	20-24 August 2018	11
4	Training programme on "Brackishwater fish, shrimp and crab culture with feed formulation and feed management "	10-15 September 2018	15
5	Training-cum-awareness programme on integrated farming of Fish and Livestock for the livelihood improvement of tribal people of Sundarban region, organized at Mundapara, Manmathapur, South 24 Parganas.	9 October 2018	50
6	Need based training for IFB Technical Staff on Advances in Brackishwater Aquaculture Practices	26-28 December 2018	19
7	Skill development training for Shrimp farmers	5-29 March 2019	20
8	Hands-on training on "Aquaculture Genomics and Bioinformatics"	27 August to 1 September, 2018	11
9	NFDB sponsored training on Recent advances in farming of pacific white shrimp	10-14 September, 2018	8

Navsari Gujarat Research Centre

Sl. No	Name of the Training /FGD	Duration	No. of participants
1	Training Programme on "Seabass Nursery and Pre Grow out Rearing in happas as a livelihood activity" to Nursery Self-help group beneficiaries (No.s) of Nivati and Redi Villages, Taluka-Vengurla District- Sindhudurg, Maharashtra	17 May, 2018	48
2	Training Programme on "Brackishwater finfish cage culture models as livelihood opportunities for rural folks"	27 October, 2018	80

PhD Obtained

Shri S Sivakumar, was awarded PhD degreree by University of Madras, for his doctoral thesis, "Development of Cell culture system from crustacean and insect cell lines and adaptation of white spot syndrome virus (WSSV). The research work was carried out under the supervision of Dr N. Kalaimani, Retired Principal Scientist, ICAR-CIBA.

WORKSHOPS, SEMINARS AND MEETINGS

SCAFi-CIBA lecture series: GPS and Natural System Research

Dr. K.K. Ramachandran, Scientist & Head, Central Geomatics Lab, ESSO, delivered a presentation on GPS and Natural System Research at ICAR-CIBA on 20th April 2018. He elaborated the different techniques used in and advancement made in the field of GPS and imaging. He also highlighted the applications of GPS in daily life and resource mapping. More than 100 participants comprising scientists, technical officers, research scholars and other staff of CIBA attended the interesting presentation.

CIBA-SCAFi Lecture Series: Technological Advances in Global Shrimp farming (1st May, 2018)

Dr. George Chamberlain delivered a invited talk on technological advancements in global shrimp farming on 1st May, 2018. In his talk he highlighted the importance of seafood and production scenarios and related challenges. He said, being one of the leading producers of farmed shrimp, He said, India has a major role to play in keeping the sustainability in production. He further pointed that, India can achieve newer heights in shrimp production, through the adoption of new technologies, new investments and new markets.

Skill enhancement programme for Fisheries officials

Export Inspection Council (EIC), Govt. of India, in coordination with ICAR-CIBA, conducted a five day 'trainers-training' course on 'Skill enhancement in the marine sector (SEMS) for sustainable export opportunities: during 7-11 May, 2018 at ICAR-CIBA Chennai. A batch of 16 fisheries officials from the states of Andhra Pradesh, Tamil Nadu and Puducherry participated in the programme. The participants were trained on the quality requirements in the primary production chain, processing centres and standards enforced by the major importing nations.

World Environment Day was celebrated on 5th June, 2018

ICAR-CIBA in association with the Society of Coastal Aquaculture and Fisheries (SCAFi), organized an interaction on the occasion of World Environment Day with a theme "Beat Plastic Pollution" on 5th June, 2018 at CIBA headquarters, with a lead talk delivered by Dr.E.Vivekanandan, National Consultant, Bay of Bengal Programme an Inter-Governmental Organization. The talk brought to the focus on "Human Interventions in Coastal Environment" emphasizing that people should strive to change their everyday lives to reduce the heavy burden of plastic pollution.

World Ocean Day was Celebrated on 8th June 2018

Society of Coastal Aquaculture and fisheries (SCAFi) and ICAR-CIBA jointly celebrated "World Ocean Day' on 8th June 2018 at CIBA. On this occasion, Dr. R. Venkatesan, Head, Ocean Observation Systems, National Institute of Ocean Technology (NIOT), Ministry of Earth Sciences, Chennai has delivered a lecture on "India's Ocean Observation Programme - Relevant to the Society". In his lecture he related the Indian subcontinental ocean research and its relevance vis-a-vis the global counterparts as "WE SEE MORE SEA THAN OTHERS SEE".

Inauguration first CIBA's Regional Research Centre on the West Coast in Gujarat

ICAR-CIBA has inaugurated its Navsari-Gujarat Research Centre (NGRC) in Navsari Agricultural University (NAU) campus, Navsari, on 7th June, 2018 by Dr. J.K. Jena, Deputy Director General (Fisheries), ICAR, in the presence of Shri. R.C. Patel, Member of Legislative Assembly, Navsari, Dr. C.J. Dangaria, Vice Chancellor, NAU and Dr. K.K. Vijayan, Director, ICAR-CIBA, Chennai. Shri. R.C. Patel, Member of Legislative Assembly, Navsari, in his presidential remarks, expressed his happiness on establishing CIBA's centre

in Navsari and sought the help of CIBA to bring the technologies for quality seed, cost-effective and quality feed and diseases management products to the shrimp farming sector of Gujrat, so that the cost of production can be reduced.

Dr. J.K. Jena, Deputy Director General (Fisheries) in his inaugural address thanked Vice Chancellor and all the officers of NAU for hosting the NRGC in Navsari Agricultural University campus. Dr. C.J. Dangaria, Vice Chancellor of NAU underlined the opportunities in working together of CIBA and NAU in addressing the needs of the aquaculture farmers, also called for the cost-effective technologies for the benefit of the farmers.

High lighting the importance of CIBA centre in the west coast, Dr K.K. Vijayan, Director, CIBA articulated that CIBA has the expertise in quality seed production, feed technology and aquatic animal health and underlined the importance of having partnership between fisheries college of NAU and CIBA in extending the technological support to the aqua farmers in the region.

During the occasion, Dr. C. Gopal, Member Secretary, Coastal Aquaculture Authority, Govt. of India, Chennai, Dr. Pravin Puthra, Assistant Director General (Fisheries), ICAR and Dr. N.H. Kelawala, Dean, Veterinary College, gave their facilitations and offered support for the newly established centre.

Fourth international Day of yoga celebrations at ICAR- CIBA

The fourth international day of Yoga was celebrated on 21st June 2018 at Central Institute of Brackishwater Aquaculture Chennai. Two guest speakers of eminence have been invited for the program. Dr Saravanan Palaniappan from MIOT hospital, Chennai and Yoga guru and Reader from Government Yoga and Naturopathy Medical College, Dr Indiradevi Subramaniam gave lecture on Lifestyle modifications and cardiac ailments and different types of yoga respectively

Skill development training programme on Recent Advances in Soil and Water Management in Brackishwater Aquaculture

A six-day hands-on training programme on "Recent Advances in Soil and Water Management in Brackishwater Aquaculture" was organized by Environment Section of Aquatic Animal Health & Environment Division (AAHED) during 25 - 30 June 2018.

National Fish Farmers Day with the costal fishers of Puducherry

ICAR-CIBA celebrated the National Fish Farmers Day on 10th July, 2018 with the costal fishers of the Puducherry. Scientist of CIBA, sensitized fishers and other villagers from the coastal areas of Puducherry. Thiru. K. Deivasigamani, Additional Director of Fisheries, Puducherry presided over the interaction. Dr. S. Vasanthakumar, Additional Director of Agriculture and Head, KVK, Puducherry expressed that efforts should be made to enhance the production and income levels of the fishers by adopting the viable technologies developed by ICAR institutions such as CIBA.

ICAR Foundation Day as 'Aquaculture Start-up Day'

Startup initiatives are common in sectors other than aquaculture, and hence an aquaculture startup day has been organized on the occasion of 90th ICAR-foundation at CIBA on 16th July 2018, to infuse innovations and attract entrepreneurship in aquafarming. A Brainstorming workshop on "Startup India programme on aquaculture sector" brought the outgoing students from Fisheries Colleges of Andhra Pradesh, Karnataka, Kerala, and TamilNadu together on the startup platform at CIBA. Shri.Ruban Hobday, Additional Director, FICCI, Chennai was the Chief Guest and he assured that FICCI will give the best possible support for the startups in aquaculture sector. About 70 participants including officials from State Fisheries Departments, Development Agencies like NFDB, MPEDA, MSME, CII, FICCI, Investors, Startups, Professors and students from State Fisheries Universities attended the workshop and participated in the panel discussions.

Independence Day Celebrations at ICAR-CIBA, Chennai

ICAR-CIBA celebrated the Independence Day with colourful illumination of the campus symbolizing the growth and prosperity of the country. Dr K K Vijayan, Director of the institute hoisted the tricolour flag and delivered the speech. In his address he remembered the great sacrifices made by the great leaders and freedom fighters for getting the Independence and highlighted that it is the duty of every Indian citizen to protect the same and to strive hard for sustainable growth and prosperity of the country.

Training programme for state fisheries officials

A need based training programme for the Kerala State fisheries officials on "Hatchery production & farming of milkfish and mullets" from 16th to 20th August 2018. Dr. Baskaran Manimaran, former Vice chancellor, Tamil Nadu Fisheries University inaugurated the training. He appreciated the holistic efforts of CIBA in developing technologies for seabass, milkfish, mullet, pearlspot and other ornamental fish breeding and culture in the development of brackishwater aquaculture in the country.

Skill development programme on Water and Soil Treatment Applications in Aquaculture

A customized training program on "Water and Soil Treatment Applications in Aquaculture" during 27-28 August, 2018 to a group of seven technical persons from Grasim Industries Ltd - Aditya Birla Group. The focus of the training was on application of chemical and biological products in improving aquaculture pond water and soil environment.

Inauguration of Community Development Centres under Corporate Social Responsibility (CSR)

ICAR-CIBA in collaboration with the Karam Chand Thapar (KCT) group established Community Development Centre for Learning, Livelihood and Research (CDC-LLR) at Bhimavaram, West Godavari district, Andhra Pradesh (AP). The farmers community centre and state-of-the-art aquaculture diagnostic laboratory, the second in AP was inaugurated on 12th September 2018. Shri.P.Koteeswara Rao, Additional Director of Fisheries, Govt. of Andhra Pradesh, Shri.Ramakanth V.Akula, CEO, the Waterbase Limited (TWL), Ms. Shomasree Dey, Head of CSR, KCT group graced the event.

Training-cum-awareness programme on integrated farming of fish and livestock in Sundarban region

Kakdwip Research Centre (KRC) of ICAR-CIBA has organized day training-cum-demonstration programme on integrated farming of Vegetables, Fish and Livestock at Mundapara, Manmathapur, South 24 Parganas for the livelihood improvement of tribal people on 9th October 2018. The training was attended by 50 farmers along with local Gram Panchayat representatives, Pradhan and social activists. In the interaction meeting Dr. Ananta Das, Veterinary Officer, Kakdwip block sensitized the people about the practices and problems of animal husbandry.

Mahila Kisan Divas with Irula Tribal Women

ICAR-CIBA celebrated Mahila Kisan Divas on 15th October, 2018 at Karathittu village, Vayalur Panchayat of Kancheepuram district of Tamil Nadu to recognize the contribution of women in fisheries and aquaculture. About 60 tribal women from the village participated in the programme. Two successful women farmers from Thirividanthai village who have successfully adopted CIBA's Pearlspot fish larval rearing technology shared their experiences the way the technology provided them a viable livelihood option.

Interaction meeting of the second sub committee of parliament on official language

The second sub-committee of Parliament on Official Language had interaction meeting with officials of Central Institute of Brackishwater Aquaculture, Chennai on 4th October, 2018. The meeting was convened by Honorable Dr. Prasanna Kumar Patasani, Member of Parliament (Lok Sabha) and Convenor of the second sub-committee of Parliament on Official Language. The other honorable members of this committee were Dr. Sunil Baliram Gaikwad, Member of Parliament (Lok Sabha), Shri Prataprao Ganpatrao Jadhav, Member of Parliament (Lok Sabha), Shri Pradeep Tamta, Member of Parliament (Rajya Sabha), and Mr. Harnath Singh Yadav, Member of Parliament (Rajya Sabha). The interaction meeting, was attended by Dr P. Praveen, Assistant Director General (My.F.), ICAR, New Delhi, Shri M.L Gupta, Deputy Director (Official Language), ICAR, New Delhi, Mr. Manoj Kumar, ACTO, ICAR, New Delhi. Dr. M. S. Shekhar, Principal Scientist and Officer, In-charge Hindi Cell.

Milkfish harvest mela in Pulicat, Tamilnadu

ICAR-CIBA has successfully demonstrated an innovative two-tier milkfish farming, nursery rearing and grow-out in an open water pen erected in the brackishwater body, as a livelihood initiative for the benefit of tribal families. The harvest mela was conducted on 23rd October 2018 at the demonstration site Kanavanthurai village, Tiruvallur district, Tamil Nadu. Around 100 participants including village panchayat president, progressive farmers, tribal families, officials from Chennai Petro Chemicals Ltd., who are partnering with CIBA in supporting the coastal families for their economic improvement elsewhere under corporate social responsibility (CSR) scheme, officials from Bank of India (BOI), participated in the function.

Annual review meeting of Consortium Research Platform (CRP) on vaccines and diagnostics

The Annual Review Meeting (2017-18) of the Consortium Research Platform on Vaccines and Diagnostics was held at ICAR-CIBA during 30-31, October, 2018 under the chairmanship of Dr. Joykrushna Jena, Deputy Director General (Fisheries) and DDG in-charge Animal Sciences, ICAR. Dr. Ashok Kumar, ADG (AH), ICAR, Dr. K. K. Vijayan, Director, CIBA, Dr. Aniket Sanyal, Co-ordinator, CRP on V & D, sectoral coordinators and all Principal investigators under CRP on Vaccines and Diagnostics participated in the event.

CIBA-SCAFi Lecture Series: Emotional Quotient and You

Prof. (Dr) Mohan Joseph Modayil, Former ASRB Chairman, Ex-Director CMFRI delivered invited talk on 15th November, 2018, at CIBA, Chennai. Prof. Modayil cited the importance of balanced Intelligence Quotient (IQ) and Emotional Quotient (EQ) in with a balance in personal life and career. The anecdotes on the attributes to be acquired by citing the 'Ant Philosophy' and 'Fish philosophy' was very captivating. The meeting was coordinated by the office bearers of Society of the Coastal Aquaculture and Fisheries (SCAFi).

World fisheries day with fishers of coastal village

ICAR-CIBA celebrated the World Fisheries Day with the coastal fishers at Karathittu village in Vayalur Panchayat of Kancheepuram district of Tamil Nadu. About 60 fishers' including, tribals and rural youth participated in the programme. The participants were sensitized about the importance of sustainable fishing, impact of habitat destruction and conservation of bio-diversity and opportunities for livelihood and income through the technologies developed by CIBA.

ICAR-CIBA distributed "soil and water heath cards" during world soil day

On the occasion of celebration of World Soil day, ICAR-CIBA organized Brackishwater Aquaculture Farmers Meet at B.Mutlur, village, Cuddalore District, Tamil Nadu on 5th December 2018 under the National Innovations in Climate Resilient Agriculture (NICRA) Project. On this occasion, 104 farmers participated in the meeting, and received Soil and Water Health Cards (SWHC), on a Public Private Partnership (PPP) initiative by CIBA. During the meeting, 55 SWHCs were distributed to aqua farmers from the shrimp farming belt in the presence of Dr. M. Srinivasan, Director and Dean, Faculty of Marine Sciences, Annamalai University, Parangipettai, Shri C. Subramanian, Assistant Director of Fisheries, Parangipettai, Shri Babu, RGCA (MPEDA).

Kisan Diwas with fishers and tribal farmers of Tamil Nadu

National Farmers Day or Kisan Diwas is celebrated every year on 23rd December in the honour of Chaudhary Charan Singh who was the fifth Prime Minister of India. ICAR-CIBA celebrated the Kisan Diwas with the fishers and tribal farmers of the Sadraskuppam village, Kancheepuram district, Tamil Nadu.

ICAR-CIBA Foundation and Annual day

ICAR-CIBA celebrated its Foundation and Annual Day on 29th December, 2018. On this occasion the institute observed "Open House" by making the laboratories open to the graduate and post graduate students of city colleges and the public to visit the state-of-the-art research facilities. The exhibition of brackishwater live fishes, shrimp and crab species, and an array of ornamental fishes, has been the main attraction.

The annual day was celebrated in the evening where Dr. M. A. Atmanand, Director, National Institute of Ocean Technology (NIOT), Chennai graced the occasion as Chief Guest. On the occasion, Dr. Atmanand appreciated the efforts and achievements of CIBA, and specially appreciated the efforts in bringing the green concepts to the CIBA campus. He appreciated the CIBA's lead role in the frontier areas of aquaculture and emphasized the necessity for the active co-operation between institutions such as CIBA and NIOT to pave the way for sustainable aquaculture. Dr K. K. Vijayan, Director, ICAR-CIBA, in his welcome address, briefed about the progress of the Institute during the past year.

Republic day celebrations

ICAR-CIBA celebrated republic day on 26th Jan, 2019 with CIBA scientist, staff and their family members. Dr K K Vijayan, Director of the institute hoisted the national flag and delivered the speech.

Inauguration of fish waste processing unit-an initiative under circular economy in fisheries & aquaculture

On 18th February,2019 ICAR-CIBA inaugurated a "Fish Waste Processing Unit" at Nambikkai Nagar, Pattinapakkam, Chennai, Tamil Nadu established by the institute which will be operated by a Self Help Group (SHG) of Nambikkai Nagar for recycling of fish waste to high value added products as an initiative towards Circular economy in fisheries and aquaculture.

National Productivity Week Celebrations

National productivity week was celebrated at ICAR-CIBA, Chennai from 12th to 18th February, 2019 in aligning with the theme of Circular Economy for Productivity & Sustainability". The celebrations were initiated by imparting hands on training to fisherwomen of Srinivasapuram village on 'converting fish waste to value added products' on 12th February, 2019.

The Brackishwater Aquaculture Farmers Conclave -2019

ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA) in collaboration with Society of Coastal Aquaculture and Fisheries (SCAFi) has organized the Brackishwater Aquaculture Farmers Conclave – 2019 on 22 January, 2019 a pan-Indian assembly of brackishwater aquaculture farmers in connection with the World Brackishwater Aquaculture Conference (Braqcon-2019). Dr.M.S. Swaminathan, the doyen of Indian agricultural research and education has inaugurated the Farmers Conclave in the presence of Thiru. D. Jayakumar, Hon'ble Minister for Fisheries, Personnel and Administrative Reforms, Govt. of Tamil Nadu, Dr. K. Gopal, IAS, Principal Secretary, Animal Husbandry, Dairying & Fisheries, Govt. of Tamil Nadu, Dr. B. Meenakumari, Chairperson, National Biodiversity Authority (NBA), Dr. J.K. Jena, Deputy Director General (Fisheries), Indian Council of Agricultural Research, Shri. N. Vasudevan, Additional Principal Conservator of Forest, Mangrove Foundation, Govt. of Maharashtra, Dr. K.K. Vijayan, Director, CIBA and Convener, Braqcon-2019. Dr. Swaminathan in his address highlighted the importance of fisheries in food and nutritional security, doubling the income of fish farmers and environment friendly aquaculture. Thiru.D. Jayakumar, Hon'ble Minister for Fisheries, Personnel and Administrative Reforms, Govt. of Tamil Nadu who is the Chief Guest of the programme released the diagnostic kits, publications, mobile smarts apps and inaugurated the Aquaculture Expo and Seafood court arranged in the CIBA campus. About 1200 participants including 950 aqua farmers representing all the coastal states, Haryana, Punjab and Rajasthan participated in the conclave. During the farmers' conclave 30 innovative farmers from all the coastal states and Haryana presented their innovative approaches and success stories in brackishwater aquaculture during the technical session on farmer presentations.

World Conference on Brackishwater Aquaculture (Braqcon-2019)

The World Brackishwater Aquaculture conference BRAQCON2019 was held at ICAR-CIBA, Chennai between Jan 23rd and 25th Jan, 2019. Dr. Trilochan Mohapatra, Secretary, Department of Agricultural Research and Education and Director-General, ICAR inaugurated World Brackishwater Aquaculture Conference (Braqcon-2019) on 23rd January in the presence of Dr. J.K. Jena, DDG, Fisheries and Animal Sciences, Dr. S.K. Saxena, Director, Export Inspection Council, GOI, Dr. K.K. Vijayan, Director, CIBA and Convener of Braqcon-2019. In his address he highlighted that seafoods exports contributed about 5 billion USD for the national income. In order to develop this sector on a sustainable basis, concerted efforts by research and development organizations need to be strategically planned and implemented in coordination with the private sectors, farmers and other related stakeholders. In the research angle, in addition to species diversification, nutrition and input supply, long term breeding programmes need to be evolved for improving the productivity of brackishwater aquaculture species need to be thought of. He emphasized that gene editing would be key for breeding of shrimps and fishes with specific characteristics like disease pathogen exclusion, faster growth and meat quality.

Dr.J.K.Jena, Deputy Director General (Fisheries), ICAR emphasized the importance of fisheries and aquaculture in India and the technology support rendered by the ICAR institutions. About 700 fishery scientists including 30 international fisheries experts presented their research achievements in the conference.

BRAQCON 2019 has come to the end in the evening on 25 Jan, 2019 with the valedictory function presided by Dr.Modadugu Vijay Gupta, the World Food Prize Laurate. In his address, Dr.Gupta congratulated ICAR-CIBA and Society of Coastal Aquaculture and Fisheries (SCAFi) for organizing this world conference on Brackishwater Aquaculture at appropriate time. Dr. S.D.Tripathi, former Director Central Institute of Freshwater Aquaculture and Central Institute of Fisheries Education, presented the recommendations of BRAQCON 2019. He highlighted recommendations on major issues in brackishwater aquaculture related to diversification of species and rearing system, fish nutrition, biotechnology, aquatic animal health, aquatic environment and climate change, ecosystem & biodiversity conservation, and socio economic issues

START-UP MEET 2019

As a part of the conference a Start-Up Meet was organized on 24th January 2019, chaired by Dr Sanjeev Saxena, ADG IPTM, ICAR, New Delhi, in which about 70 participants including scientists, business entrepreneurs, Start-Up entrepreneurs, prospective Start-Up personnel, Senior officials from NABARD, Patent Office, State Department officials from Tamil Nadu, Andhra Pradesh and Odisha, Oriental Insurance, faculty students from fisheries college have participated in the group-discussion meet on opportunities, problems and prospects of the Start-Ups in aquaculture sector

Workshop Cum Training On "Biofloc Technology

ICAR-CIBA conducted a five-day National workshop cum training programme on "Biofloc Technology for Nursery and row-out Aquaculture" between 12th and 16th March, 2019 at Chennai. The training programme was inaugurated on 12th March 2019 by Dr. A. K. Munirajan, Professor & Head, Department of Genetics, University of Madras, Chennai.

Awards and Recognizations

ICAR NATIONAL TEAM AWARD FOR NUTRITION AND FEED BIOTECHNOLOGY WON BY CIBA SCIENTISTS

ICAR-CIBA Nutrition team was awarded with Nanaji Deshmukh ICAR Award for outstanding interdisciplinary team research in Agriculture and allied sciences 2015-16 in the category of Animal and Fisheries Sciences. The nutrition team comprising of Dr. K. Ambasankar, Dr. J. Syama Dayal, Dr. K.P. Kumaraguru Vasagam, Late Shri. S. Stanline, Dr. P. Nila Rekha, Dr. Debasis De, Shri. Sandeep, K.P., Dr. T.K. Ghoshal and Dr. K.K. Vijayan. The team leader, Dr. K. Ambasankar, Principal Scientist received the award from Dr. T. Mohapatra, Hon'ble secretary DARE and Director General ICAR, on the occasion of Pusa Krishi Vigyan Mela organized at ICAR- IARI New Delhi on 5th March 2019. The Award carries a citation and cash prize of INR 5 Lakhs.

ICAR NATIONAL AWARD - SWAMI SAHAJANAND SARASWATI OUTSTANDING EXTENSION SCIENTIST AWARD-2017

Dr. M. Kumaran, Principal Scientist, Social Sciences Division, ICAR-CIBA has been conferred with Swami Sahajanand Saraswati Outstanding Extension Scientist Award-2017 (Individual category)of the ICAR on 16th July, 2018 for his outstanding and impactful contribution in the field of Brackishwater Aquaculture Extension Research, Capacity enhancement and Technology Transfer through innovative approaches.

ICAR-CIBA received Certificate of Appreciation from DG, ICAR on 4th December 2018 for proactively implementing ICAR-Research Data Management Guidelines and uploading more than 700 publications in KRISHI portal.

भारतीय कृषि अनुसन्धान परिषद
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
भा.कृ.अनु.प. में ज्ञान संवर्धन के लिए अनुसंधान आंकड़ों का कोष
ICAR Research Data Repository for Knowledge Management
CERTIFICATE OF APPRECIATION
प्रशंसा पत्र

यह प्रशंसा पत्र **भा.कृ.अनु.प. - केन्द्रीय खारा जल जीवपालन अनुसंधान संस्थान, चेन्नई** को भा.कृ.अनु.प. अनुसंधानिक आंकड़ों के प्रबंधन दिशानिर्देशों के सक्रिय क्रियान्वयन एवं कृषि पोर्टल में कृषि पोर्टल में 700 से अधिक **प्रकाशन** अपलोड करने के लिए प्रदान किया जाता है।

This certificate of appreciation is awarded to **ICAR- Central Institute of Brackishwater Aquaculture, Chennai** for proactively implementing ICAR Research Data Management Guidelines and uploading more than 700 **Publications** in KRISHI Portal.

(नरेन्द्र सिंह राठौड़)
उपमहानिदेशक (कृषि शिक्षा)
(Narendra Singh Rathore)
DDG (Agricultural Education)

(के. अलगुसुन्दरम)
उपमहानिदेशक (प्राकृतिक संसाधन प्रबंधन)
(K. Alagusundaram)
DDG (Natural Resource Management)

दिनांक : 04 दिसंबर 2018
Date: 04 December 2018

Dr. R.Ananda Raja and team got the best oral presentation award for the paper entitled "Fatty liver syndrome in pearlspot, *Etroplus suratensis*" in the "Fourth National Agricultural Science Tamil Research Conference" organized by Agricultural Scientific Tamil Society, New Delhi at The Directorate of Research, TNFU Campus, OMR, Vaniyanchavadi, Chennai during 10-20 November, 2018.

Dr. M. Kumaran, Principal Scientist, recieived Fellow Award by the Indian Society of Extension Education (Fellow of ISEE), New Delhi, for the outstanding contributions in the field of Extension Education during the National Seminar held at West Bengal Fisheries and Animal Sciences University during December, 2018.

Dr. M. Kailasam, Principal Scientist received best Scientist Award for the year 2017-18 by ICAR-CIBA &SCAFI in the CIBA Foundation cum Annual Day held on 29th December 2018.

Dr. Shyne Anand, Scientist received best Scientist Award for the year 2017-18 by ICAR-CIBA & SCAFI in the CIBA Foundation cum Annual Day held on 29th December 2018.

Dr.Joseph Sahaya Rajan, Asst. Chief Technical Officer received best Technical Award for the year 2017-18 by ICAR-CIBA & SCAFI in the CIBA Foundation cum Annual Day held on 29th December 2018.

Late Mr. Stanline, Technical Officer received best Technical Award posthumously for the year 2017-18 by ICAR-CIBA & SCAFI in the CIBA Foundation cum Annual Day held on 29th December 2018

Mrs. Mary Desouza, Assistant received best Administrative Award for the year 2017-18 by ICAR-CIBA & SCAFI in the CIBA Foundation cum Annual Day held on 29th December 2018.

Mr. Pichandi & Mr, Jeevanandam received best Supporting Staff Award for the year 2017-18 by ICAR-CIBA & SCAFI in the CIBA Foundation cum Annual Day held on 29 December 2018.

Dr. G. Biswas, Senior Scientist received the Best Oral Presentation Award (First Place) for the paper entitled "System Diversification in Brackishwater Aquaculture of India: Research Support on Fish Culture Options for Sundarban Producers" presented in the International Congress on Engineering and Life Science (ICELIS 2018) held during April 26-29, 2018 at Kastamonu, Turkey.

Dr. K.P. Jithendran, Principal Scientist received Springer Nature–Indian Virological Society Award for the best paper published in Virus Disease on Aquatic Virology during Virocon-2018, PGIMER, Chandigarh, India during 10-14 November 2018

Shri T. Sathish Kumar, Scientist awarded with best oral presentation in the Fourth National Agricultural science Tamil research conference" Nov 19-20, 2018 at TNJFU, Chennai for the oral presentation on "Rapid and specific loop mediated isothermal amplification detection of Enterocytozoon hepatopenaei (EHP)" in Tamil.

Dr. M.S. Shekhar, Principal Scientist received the Best poster award for for the paper entitled "Understanding the course of infection: determining gene expression changes with time in *Penaeus vannamei* infected with white spot syndrome virus" in the World Brackishwater Aquaculture Conference (BRAQCON, 2019) during 23-25 January, 2019 organized by ICAR-CIBA & SCAFIat ICAR-CIBA, Chennai

Dr. M. Makesh,Principal Scientist received theBest Oral Presentation Award for the paper entitled "Development of Inactivated oral NNV Vaccine for Asian Seabass, *Lates calcarifer*" in World Brackishwater Aquaculture Conference (BRAQCON, 2019) during 23-25 January, 2019 organized by ICAR-CIBA & SCAFI at ICAR-CIBA, Chennai

Dr.S.N.Sethi, Principal Scientist received theBest Poster Presentation Award in the field of Brackishwater/Marine Biodiversity and Conservation in World Brackishwater Aquaculture Conference (BRAQCON, 2019) during 23-25 January, 2019 organized by ICAR-CIBA & SCAFI at ICAR-CIBA, Chennai

Dr. Krishna Sukumaran, Senior Scientistreceived theBest Poster Presentation Award for the poster entitled "Growth and reproductive parameters of two geographical groups of grey mullet *Mugil cephalus*" in World Brackishwater Aquaculture Conference (BRAQCON, 2019) during 23-25 January, 2019 organized by ICAR-CIBA & SCAFI at ICAR-CIBA, Chennai

Dr. K.Vinaya Kumar, Senior Scientist received the Best Oral Presentation Award for the paper entitled "The applications of genomics and proteomics in Aquaculture, Fisheries and Marine biology (omicsAFM 2018)" at the National Symposium on ', Sathyabama Institute of Science and Technology, Chennai, 20th and 21st of June 2018.

Dr. K. Vinaya Kumar, Senior Scientist received the Best Poster Presentation Award in the International conference on World Brackishwater Aquaculture Conference (BRAQCON 2019) held during 23-25 January 2019 organized by ICAR-CIBA & SCAFI at ICAR-CIBA, Chennai.

Dr. Prem Kumar, Scientist received the Best Poster Presentation Award for paper entitled "Larval development, rearing and digestive tract ontogeny of Indian shad, *Tenulosa ilisha*" in the International conference on World Brackishwater Aquaculture Conference (BRAQCON 2019) held during 23-25 January 2019 organized by ICAR-CIBA & SCAFI at ICAR-CIBA, Chennai.

Shri Jose Antony, Scientist received the Best Poster Presentation Award for paper entitled "….."in the International conference on World Brackishwater Aquaculture Conference (BRAQCON 2019) held during 23-25 January 2019 organized by ICAR-CIBA & SCAFI at ICAR-CIBA, Chennai.

LINKAGES AND COLLABORATIONS

The institute maintained linkages with the following national and international organizations

National ICAR Institutes

- Central Institute of Fisheries Education, Mumbai
- Central Institute of Freshwater Aquaculture, Bhubaneswar
- Central Marine Fisheries Research Institute, Cochin
- Central Agricultural Research Institute, Port Blair
- Central Inland Fisheries Research Institute, Barrackpore
- Central Institute of Fisheries Technology, Cochin
- Central Research Institute for Dryland Agriculture, Hyderabad
- Directorate of Seed Research, Mau
- Directorate of Research on Women in Agriculture, Bhubaneswar
- National Academy for Agricultural Research Management, Hyderabad
- National Bureau of Agriculturally Important Microorganisms, Mau
- National Bureau of Fish Genetic Resources, Lucknow

Other Institutes / SAUs / State Agriculture Departments

- Agricultural & Processed Food Products Export Development Authority, New Delhi
- Center for Advanced Studies in Marine Biology, Annamalai University, Parangipettai
- Coastal Aquaculture Authority, Chennai
- College of Fisheries, University of Agricultural Sciences, Mangalore
- College of Fisheries, Sri Venkateswara Veterinary University, Muthukur
- Dept. of Horticulture, Govt. of Tamil Nadu, Chennai.
- Dept. of Animal Husbandry, Govt. of Tamil Nadu, Chennai.
- Department of Animal Husbandry, Dairying and Fisheries, New Delhi
- Department of Biotechnology, New Delhi
- Fisheries College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Thoothukudi
- Indian Institute of Tecnology, Chennai
- Mangrove Cell, Government of Maharashtra, Mumbai
- Ministry of Science and Technology, New Delhi
- Ministry of Water Resources, New Delhi
- Marine Products Export Development Authority, Cochin
- Navsari Agricultural University, Navsari, Gujarat
- National Fisheries Development Board (NFDB), Hyderabad
- National Institute of Ocean technology, Chennai
- Sundarban Development Board, Govt. of West Bengal
- Tamil Nadu Veterinary and Animal Sciences University, Chennai
- Tamil Nadu Agricultural University, Coimbatore
- University of Madras, Chennai
- West Bengal University of Animal and Fisheries Sciences, Kolkata

State Fisheries Departments/BFDAs

The Institute has well established linkages with State Fisheries Depts. /BFDAs mainly for transfer of technology programmes.

CONSULTANCIES, TECHNOLOGY DEVELOPMENT AND TRANSFER

INSTITUTE TECHNOLOGY MANAGEMENT AND AGRI BUSINESS INCUBATION UNIT (ITMU) & (ABI)

Institute Technology Management Unit and Agri Business Incubator have been functioning with ICAR-National Agricultural Innovation Fund at ICAR-CIBA. The Performance has been consistently good and CIBA is generating revenue of Rs.25 lakhs and above every year from commercialization of various technologies developed by ICAR-CIBA. In total CIBA has signed 112 MoUs and Rs.168 crores of revenue have been generated. In addition, CIBA also made partnership with various national and state level institutions, farmers and other stakeholders of the brackishwater sector for backstopping sustainable brackishwater aquaculture in the country.

MOUS SIGNED IN 2018-19

A total number of Twenty one MoUs have been signed during April 2018 to March 2019. A total amount of Rs.24.00 Lakhs (Rupees Twenty Four lakhs) was generated as one time license fee. Revenue share and royalty of 3 to 10% is expected to be received by the institute in the event of good crops in this year. Two patents have been granted and one patent application has been filed.

TECHNOLOGIES TRANSFERRED /COMMERCILAIZED

STRATEGIC ALLIANCE WITH 'THE WATERBASE LTD' IN THE PROMOTION OF BRACKISHWATER AQUACULTURE IN THE COUNTRY

The Waterbase Ltd, one of the pioneering Indian company that manufactures high-quality shrimp feed signed a Memorandum of Understanding (MoU) on 10th April 2018, for a collaborative programme of eco-friendly shrimp feed technology. The collaboration programme will cover technical collaboration and partnership in the development of ecofriendly shrimp feed, the Vanami Ecoplus

PARTNERSHIP WITH CORPORATE SOCIAL RESPONSIBILITY (CSR) INITIATIVES OF KCT

The KCT group signed a memorandum of understanding (MoU) at Thapar House in Delhi on 10th April 2018, as a knowledge partner. This collaborative effort is targeted to benefit aqua farmers in Nellore region for their needs with regard to testing and diagnostic services related to soil & water quality of aquaculture ponds, seed quality, DNA-based screening of disease causing microbial pathogens and feed quality.

FIRST SHRIMP FEED MILL DR ATTAR AQUA FEED, HARYANA IN NORTHERN INDIA

A new "make in India" shrimp feed mill has been inaugurated at Bhiwani, Haryana adopting the ICAR-CIBA's Desi VanamiPlus feed technology.The feed mill has been jointly inaugurated on 15th May 2018 by Dr K.K. Vijayan, Director CIBA and Dr Pravin Puthra Asst Director General of ICAR. Being a mechanical engineer by profession, Mr. Vinod Poonia, MD, Dr Attar Aqua Feed, got convinced with CIBA technology while he attended the training program on Nutrition and Feed technology during January this year at CIBA, Chennai.

TECHNOLOGY TRANSFER OF INDIGENOUS SHRIMP FEED

Vanami *Plus*' feed technology was transferred to Pranita Marines, Andhra Pradesh on 14th August 2018. The company envisaged to produce shrimp feed with the CIBA's technical guidance. The feed will meet the demand of aquaculture farmers in and around Bhimavaram which is expected to benefit the shrimp farmers, and to increase the profitability.

TECHNICAL PARTNERSHIP WITH MINISTRY OF EARTH SCIENCES (ESSO)-NIOT IN THE PROMOTION OF AQUACULTURE IN THE COUNTRY

Technical partnership with Ministry of Earth Sciences (ESSO)-NIOT in the promotion of aquaculture in the countrywas initiated on 25th September, 2018 through an MoU. The MOU will help to contribute towards the roadmap conceived by the MoES 'Farming the Oceans for the Future' to promote India's blue economy. Partnership of NIOT with its blend of engineering expertise in finfish cages and CIBA with its proven technologies in hatchery, farming and feed biotechnology for candidate finfish species such as Seabass, would help in expanding the finfish cage culture operation, in the depths from 5 m to 100m.

TECHNOLOGY TRANSFER OF SEABASS FISH HATCHERY TECHNOLOGY

Hatchery technology developed for the production of seabass seed and nursery rearing technology for the fingerlings, has been transferred to a young entrepreneur, Mr. Nishanth Reddy from Nellore, Andhra Pradesh through an MOU on 30th October 2018, at CIBA Headquarters, in the presence of Dr. J K Jena, DDG (Fy. Science), ICAR, New Delhi.

TRANSFER OF FORMULATED FISH AND SHRIMP FEED TECHNOLOGY TO PROMOTE BRACKISHWATER AQUACULTURE DEVELOPMENT IN THE WEST COAST OF INDIA

Strategic alliance was made with Aditi Enterprise, Porbandar, Gujarat by transferring Shrimp and Seabass Feed Processing Technologies to spread its feed biotechnology footprints in the West coast of the country. The feed will cater to the need of aquaculture farmers of West coast of the country, particularly the small and marginal farmers, who cannot afford the high cost feed. The proposed concept of 'factory to farm' promoted by CIBA would help the farmer to source the feed directly from the feed mill, enabling the farmers to save the usual marketing cost also.

TRANSFER OF "CMH MINERAL, AMMONIA, NITRITE & DO TECHNOLOGY

Maintenance of water quality parameters in optimum level is critical for successful aquaculture operations. It is essential to monitor pH, dissolved oxygen (DO) and the toxic metabolites like, ammonia and nitrite which are critical for the survival of aquatic animals. Different kits have been developed for detection of these parameters in hatcheries and grow-out farms will help in taking up immediate measures for preventing the economic loss. These kits was transferred the New Bio Science Company, Mysore on the 24th day of January, 2019 by signing MoU.

TRANSFER OF "CIBAMOX"- WATER PROBIOTIC TECHNOLOGY

ICAR-CIBA has developed a water probiotic "CIBAMOX" which has the innovative combination of ammonia oxidizing bacteria, nitrite oxidizing bacteria and denitrifying bacteria. The technology is being transferred to Rallis India Limited, (Tata Enterprise), Mumbai for up-scaling and commercial production. In this regard, CIBA signed the MoU on 15th February 2019.

TECHNOLOGY TRANSFER ON FISH FEED PROCESSING AND PRODUCTION

Institute has developed fish feed processing and production technology and transferred the fish feed technology for commercial production to various clients. The technology was licensed to Sanvika Feeds, Ernakulam, Kerala on 16th day of March 2019 by signing a MoU.

COLLABORATIVE PROGRAMME WITH AQUACULTURE DEVELOPMENT COOPERATIVE SOCIETY (ADCOS), PAYYANUR, KERALA- FOR CAPACITY DEVELOPMENT AND TRANSFER OF LOCATION SPECIFIC BRACKISHWATER AQUACULTURE TECHNOLOGIES

Aquaculture Development Cooperative Society (ADCOS), Payyanur, Kerala inked a MoU on the 25th March, 2019 to train the aqua farmers of the ADCOS and dissemination of CIBA technologies suitable for the agro-climatic situation of the west coast. Under the agreement CIBA will partner with the farmers group to provide technical guidance for the adoption of brackishwater technologies suitable for the region.

EVALUATING THE UTILITY OF KRILL MEAL IN SHRIMP DIET

M/S. Aker Biomarine private Limited, Mumbai made an alliance to harness the nutritional potency of Krill meal in shrimp and fish feeds on 28th March 2019. Aker Biomarine is a Oslo based Norwegian fishing and biotech company providing krill meal and value added products through a fully regulated and sustainable value chain, from the Antarctic region. As the major supplier of krill to the salmon farming industry, the nutritional superiority of the krill meal in salmon feeds has been proven. Aker Biomarine India Private Limited, Mumbai is a subsidiary of Norwegian company taking up the operations in India and wanted to promote krill mill as a functional component in shrimp and fish feeds with, which would benefit the Indian feed Industry and aquaculture sector.

PARTNERSHIP WITH FARMERS

BIOFLOC BASED SHRIMP NURSERY TECHNOLOGY DEMONSTRATED BY ICAR-CIBA

Frontline Demonstrations on Biofloc based Nursery rearing Technology for Pacific white shrimp *Penaeus vannamei* have been conducting in different parts of the country with support from the Department of Biotechnology, Govt. of India. The genesis of this demonstration was initiated with the MOU signed with one progressive farmer (Dandapat Aquatics) on 10th July, 2018 in presence of Hon'ble Member of Parliament Mr Rabindra Jena.

TECHNICAL SUPPORT AND PARTNERSHIP FARMING FOR ADOPTION OF PERIPHTYON BASED MILKFISH GROW-OUT CULTURE MODEL

MoUswere signed for technical support and Partnership farming for Adoption of Periphtyon based milkfish Grow-out culture Modelwith Sri. Animesh Das and Sri Krishnendu Gayan, Shibgobindapur - South 24 Parganas, Pin-743371, West Bengal on 28th June 2018

GOVERNMENT DEPARTMENT SUSTAINABLE DEVELOPMENT OF BRACKISHWATER AQUACULTURE

Memorandum of understanding was signed for the sustainable development of brackishwater aquaculture between Govt. of Gujarat and CIBA for the Brackishwater Aquaculture Development in the state on 5th September 2018. The MoU is for the development, refinement and transfer of technologies by CIBA in brackishwater aquaculture for the state of Gujarat and refine localized brackishwater aquaculture solutions on a partnership mode for farmers and entrepreneurs in Gujarat.

AGRI START-UP CONCLAVE

Young entrepreneurs of ICAR-CIBA at Agri Start-up conclave on 16 &17th October 2018 at NASC complex, New Delhi

REVENUE GENERATED DURING 2018-19

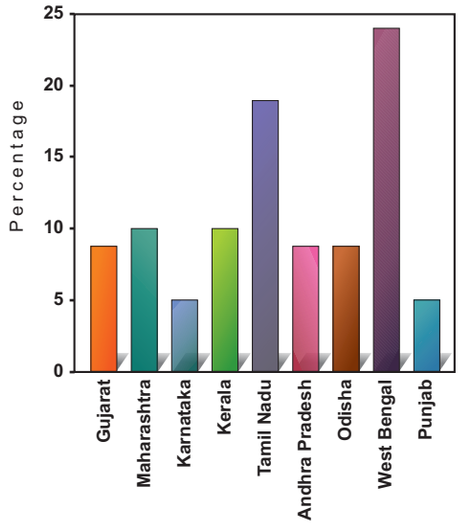
The Revenue earned from different types of activities and revenue from onetime payment and royalty/revenue share obtained in the total revenue generated.

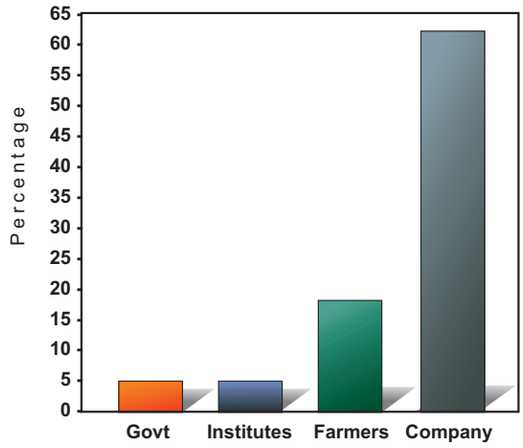
REVENUE GENERATED

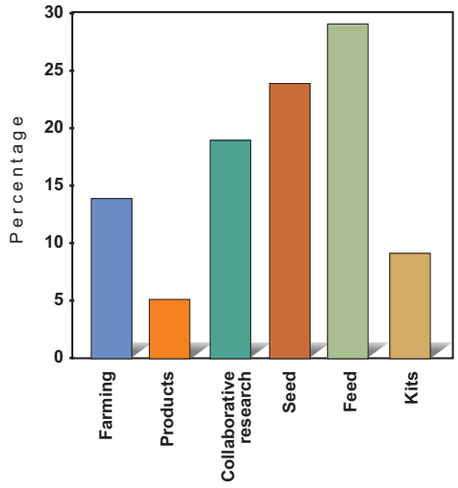
Client Name	Revenue Generated (Rs.)
The Water Base Ltd, Chennai 600 008.	2,36,000
Dr.Attar Aqua Feed, Haryana.	1,10,000
Mr.Suryakumar Boriah-CEO, Hitide Seafarms, Tamil Nadu	50,000
Shri. Anjan Kumar Dandapat, M/s. Laxmi Narayan Feeds, Odisha	88,500
Sri Krishnendu Gayan, West Bengal.	20,000
Sri. Esukapalli Nagaraju, M/s. Pranita Marines, AP	1,18,000
Sri Aniruddha Das, West Bengal	20,000
Shri. Nishanth Reddy, AP.	2,36,000
Shri. Keshav Odedara, M/s.Aditi Enterprises, Gujarat.	7,08,000
Mrs.B.Aarthi, New Bio Science Company, Mysore.	2,50,000
Dr. R. Singaravel, Coastra Biosolutions Pvt. Ltd.,Chennai.	1,47,500
Rallis India Limited, Mumbai.	2,36,000
Shri Alok Kumar Choudhury, Sri Jagannath Foods&Aquaculture Odisha	1,50,000
Oriental Insurance	27,000
Total	**23,97,000 (inclusive of tax)**

CIBA'S MOU WITH DIFFERENT STAKEHOLDERS

Nature of organizations which signed MoU with ICAR-CIBA







OFFICIAL LANGUAGE IMPLEMENTATION PROGRAMME

संसदीय राजभाषा की दूसरी उप समिति के द्वारा केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान, चेन्नै का राजभाषा संबंधी बैठक

संसदीय राजभाषा की दूसरी उप समिति के द्वारा केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान, चेन्नै का राजभाषा संबंधी बैठक 4.10.2018 को हुआ। इस समिति के संयोजक माननीय डॉ. प्रसन्न कुमार पाटसाणी, संसद सदस्य (लोक सभा) थे। इस समिति के अन्य माननीय संसद सदस्य डॉ सुबलिराम गायकवाड़, संसद सदस्य (लोक सभा), श्री प्रतापराव गणपतराव जाधव, संसद सदस्य (लोक सभा), श्री प्रदीप टम्टा, संसद सदस्य (राज्य सभा), एवं श्री हरनाथ सिंह यादव, संसद सदस्य (राज्य सभा) थे। इस बैठक के दौरान डॉ के के विजयन , निदेशक केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान, चेन्नै ने संस्थान के राजभाषा से संबंधित कार्यों का वर्णन किया।

इस बैठक बैठक में डॉ पी. प्रवीण, सहायक महानिदेशक (स. मा.), आईसीएआर, नई दिल्ली, श्री एम. एल गुप्ता उप निदेशक (राजभाषा), आईसीएआर, नई दिल्ली, श्री मनोज कुमार, ए.सी.टी.ओ., आईसीएआर, नई दिल्ली एवं केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान, चेन्नै से डॉ एम. एस. शेखर, प्रधान वैज्ञानिक और प्रभारी अधिकारी, हिंदी कक्ष, श्री के. वी. एस. सत्यनारायण, प्रशासनिक अधिकारी, श्री आर.के. बाबू , वित्त और लेखा अधिकारी, और श्री के. जी. जी. के. मूर्ति, निजी सहायक शामिल थे। इस अवसर पर केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान ने माननीय संसद सदस्यों के लिए राजभाषा संबंधी पुस्तकों की प्रदर्शनी भी लगायी।

Interaction meeting of the Second Sub Committee of Parliament on Official Language

The second sub-committee of Parliament on Official Language had interaction meeting with officials of Central Institute of Brackishwater Aquaculture, Chennai on 4.10.2018. The meeting was convened by Honorable Dr. Prasanna Kumar Patasani, Member of Parliament (Lok Sabha) and Convenor of the second sub-committee of Parliament on Official Language. The other honorable members of this committee were Dr. Sunil Baliram Gaikwad, Member of Parliament (Lok Sabha), Shri Prataprao Ganpatrao Jadhav, Member of Parliament (Lok Sabha), Shri Pradeep Tamta, Member of Parliament (Rajya Sabha), and Mr. Harnath Singh Yadav, Member of Parliament (Rajya Sabha). During this interaction meeting, Dr. K. K. Vijayan, Director, Central Institute of Brackishwater Aquaculture, Chennai apprised the Honorable Members of Parliament on the progress related to the implementation of the official language at the Institute. The interaction meeting, was attended by Dr P. Praveen, Assistant Director General (My.F.), ICAR, New Delhi, Shri M.L Gupta, Deputy Director (Official Language), ICAR, New Delhi, Mr. Manoj Kumar, ACTO, ICAR, New Delhi. Dr. M. S. Shekhar, Principal Scientist and Officer, In-charge Hindi Cell, Shri K. V. S. Satyanarayan, Administrative Officer, Shri R.K. Babu, Finance and Accounts Officer, and Mr. K. G. G. K. Murthy, personal assistant, were other personnel from Central Institute of Brackishwater Aquaculture, Chennai who attended this meeting. In this occasion, the Institute also exhibited books, publications and other documents of the Institute related to official language for the honorable members of the Parliament.

RESEARCH & ADMINISTRATIVE MEETINGS

RESEARCH ADVISORY COMMITTEE (RAC)

The Research Advisory Committee of CIBA was constituted by ICAR (Councils order F.No.18-3/2016-ASR-I dated 06.12.2016) for a period of three years with effect from 01.01.2017:

Chairman	**Dr. K. Gopakumar**
Members	Dr. V.V.Sugunan Dr. K.M.Shankar Dr. G.Gopakumar Dr. S.N. Mohanty Dr. Aparna Dixit Dr Pravin Puthra Dr.K.K.Vijayan
Member Secretary	Dr. Subhendu Kumar Otta

The 24th meeting of the Research Advisory Committee (RAC) held on 2nd March 2019 at Headquarters, Chennai.

INSTITUTE RESEARCH COUNCIL (IRC)

The Institute Research Council (IRC) of CIBA has been constituted as follows:

Chairman	**Dr. K.K.Vijayan, Director**
Members	Assistant Director General (M.Fy.), ICAR, New Delhi Dr. C. P. Balasubramanian Dr. S.V. Alavandi Dr. G.Gopikrishna Dr. M. Kailasam Dr. C.V.Sairam Dr. M. Muralidhar Dr. K. Ambasankar Principal Investigators of all the projects
Member Secretary	Dr. Subhendu Kumar Otta

The 35th IRC Meeting was held on 26-27th April 2018 and the progress of research work was reviewed.

INSTITUTE MANAGEMENT COMMITTEE (IMC)

The Institute Management Committee has been constituted as follows:

Chairman	**Dr. K.K.Vijayan, Director**
Members	Dr. Pravin Puthra, ADG (M.Fy.), ICAR Dr. Sudhansu Sekhar Mishra, Principal Scientist, ICAR- CIFA, Bhubaneswar Dr. V.R. Suresh, Principal Scientist, ICAR-CIFRI, Barrackpore, West Bengal Dr. Vindhya Mahendra, Principal Scientist, ICAR-NBFGR, Lucknow Dr. Shekarnath Ojha, Principal Scientist, ICAR-CIFE, Mumbai Commissioner of Fisheries, Govt. of Tamil Nadu, Chennai Commissioner of Fisheries, Govt. of Gujarat, Gandhi Nagar The Dean, FCRI, TANUVAS, Thoothukudi
Member Secretary	Dr. T. Ravisankar, Principal Scientist & Head of Office
Co-opted Members	Dr. S. K.Otta, Principal Scientist, OIC, PME Cell Dr. M. Jayanthi, Principal Scientist & OIC Engg. Cell Shri R.K.Babu, Finance & Accounts Officer Shri. R. Kandamani, AAO (Stores) Smt. V. Usharani, AAO (Estt.) Shri S. Pari, AAO & DDO Shri. P. Srikanth, Junior Accounts Officer
Non-Official Members	Sh. S. Satish Kumar, Farmers' Representative Sh. R.P. Venkatachalam, Farmers' Representative

The 50th IMC meeting held on 3rd September, 2018

INSTITUTE JOINT STAFF COUNCIL (IJSC)

Official Side	
Chairman	**Dr. K.K.Vijayan, Director**
Members	Dr. T. Ravisankar, P.S. Dr. K.Ambasankar, P.S. Dr. C.P.Balasubramanian, P.S. Dr. R.Saraswathy, P.S. Dr. M.Kumaran, P.S. Shri R.K.Babu, Finance & Accounts Officer Smt. V. Usharani, AAO (Estt.)
Staff Side	
Secretary	Shri A.Manoharan, Assistant
Members	Shri N.Jagan Mohan Raj, Sr. Technical Asst Shri K.Paranthaman, Technical Asst. Smt. E.Mary Desouza, UDC Shri M.Sakthivel, Skilled Support Staff Shri C.Raghu, Skilled Support Staff

The meeting of Institute Joint Staff Council was held on 14.03.2019

GRIEVANCE COMMITTEE

The composition of the Institute Grievance Committee (reconstituted by CIBA vide Office Order F.No.48-16/2010-Admn. Dated 06.06.2016) is as follows:

Chairman	**Dr. K.K.Vijayan, Director**
Elected Members	
Scientific Member Technical Member Administrative Member Staff Member	Dr. J. Syama Dayal, P.S & Dr. Nila Rekha, P.S Dr. A. Nagavel, Senior Technical Officer Mrs. Usha Rani, A.A.O Shri P. Srikanth, J.A.O Shri. A. Manoharan, Assistant Shri. M. Pichandi, Skilled Support Staff

LIAISONING COMMITTEE

Liaisoning Committee has been constituted as follows:

Chairman	**Dr. S. Kannappan, Principal Scientist**
Members	Dr. Ambasankar, K, Principal Scientist Dr. Saraswathy, R, Principal Scientist Dr. Akshaya Panigrahi, Principal Scientist Dr. Kumaran,M, Principal Scientist Dr. Patil, P.K, Principal Scientist
Member	Dr. Prasanna Kumar Patil, Principal Scientist Dr. P.Nila Rekha, Principal Scientist Shri N.Jagan Mohan Raj, Sr. Technical Asst Smt. E. Mary Desouza,

External Member Dr. A. Sumathi, Asst. Prof. & Head–in-Charge, Dept. of Biomedical Sciences , Sri Ramachandra Medical College, Porur, Chennai

WOMEN CELL

Women Cell has been constituted as follows:

Chairman	**Dr. D.Deboral Vimala, Principal Scientist**
Member	Dr. R.Saraswathy, Principal Scientist Smt. B.Amudavalli Smt. K.Subhashini, PA Smt. M.Mathuramuthubala
Member Secretary	Shri R. Kandamani, AAO

SERVICES AND ASSIGNMENTS

SERVICES IN COMMITTEES

Dr.K.K.Vijayan, Director

• Executive Committee and Governing Body, Rajiv Gandhi Centre for Aquaculture (MPEDA), Mayiladuthurai.

• ICAR Regional Committee No.VIII

• Executive Committee member - National Centre for Sustainable Aquaculture (NaCSA)

• Coastal Aquaculture Authority

• Scientific Advisory Committee, Krishi Vigyan Kendra, Tiruvallur.

• Scientific Advisory Committee for Dr.Perumal Krishi Vigyan Kendra

• State Level Committee on Animal Genetic Resources (SLCAnGR), constituted by Department of Animal Husbandry & Veterinary Services, Government of Tamil Nadu, Chennai.

• Board of Management of Tamil Nadu Fisheries University, Nagapattinam.

• Board of Management of Tamil Nadu Veterinary and Animal Sciences University, Chennai.

• Academic Council of Central Institute of Fisheries Education, Mumbai.

• Board of Management of Central Institute of Fisheries Education, Mumbai.

• National Committee on Introduction of Exotic Aquatic Organisms into Indian waters, constituted by the Ministry of Agriculture & Farmers Welfare, DAHDF, Govt. of India, New Delhi.

• Advisory Committee on Hilsa Conservation and Research

• Governing Body of State Fisheries Resource Management Society (FIRMA), Thiruvananthapuram.

• Advisory Board for Fisheries Sector Development, constituted by Special Chief Secretary (Planning), Planning Department, Govt. of Andhra Pradesh.

• Society of Coastal Aquaculture and Fisheries

• Society for Fisheries Technologists

• Marine Biological Association of India

• Project Monitoring Committee for monitoring the project works related to setting up of the Specific Pathogen Free Shrimp Seed Multiplication Centre at Mulapolam Village, Sompeta Mandal of Srikakulam District in Andhra Pradesh under the chairmanship of Chief Executive, National Fisheries Development Board, constituted by the Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Govt. of India, New Delhi.

• Technical Committee to examine as to whether the concepts and designs provided by MHKL for setting up Multiplication Centre for SPF *P. monodon* could be used for any alternative species of shrimp, constituted by the Department of Animal Husbandry Dairying and Fisheries, Ministry of Agriculture, Govt. of India.

• Member of Faculty in the Board of Studies of Cochin University of Science and Technology (CUSAT), Kochi.

• Selection Committee - Tamilnadu Scientist Award (TANSA) constituted by Tamil Nadu State Council for Science and Technology.

• High Power Society "Society for Promotion of Shrimp Farming in Punjab", headed by Additional Chief Secretary, Government of Punjab, Department of Animal Husbandry, Fisheries & Dairy Development, constituted by Department of Fisheries, Punjab.

• Selection Committee for the selection of the University Officers of the Tamil Nadu Dr J Jayalalitha Fisheries University, Nagapattinam.

• State-wise Coordination Committees for doubling Farmer's income by March, 2022, constituted by Secretary, DARE & Director General, ICAR, New Delhi.

• Kerala State Council for Science Technology and Environment, Thiruvananthapuram.

• Expert committee to study on Vembanad, Astamudi and Sasthamkotta lakes, constituted by Office of the Director of Fisheries, Govt. of Kerala, Thiruvananthapuram.

• Steering Committee for the Asian Pacific Aquaculture 2019 (APA 2019) event to be held on 18-21 June 2019 in Chennai.

• Sub-Committee to work out modalities for engaging Consultants in Coastal Aquaculture Authority.

Scientists

• Acted as External examiner to evaluate the Ph.D. thesis at CIFE and at Madras University - Dr. K. Ambasankar

• Acted as Expert member in the discipline of Fish Nutrition in the departmental selection committee for promotion of ARS scientist At CIFE, Mumbai - Dr. K. Ambasankar

• Member of Entrepreneurship Development and Innovation Institute (EDII), Chennai, constituted by Govt. of Tamil Nadu - Dr. K. Ambasankar

• Member of the Steering committee of the TN fisheries Department on 03.10.2018 - Dr. K. Ambasankar

• Participated as a Chief Guest in the inaugural Function of one year Diploma Programme in Industrial Aquaculture Technology on 27.10.2018 - Dr. K. Ambasankar

• Acted as Member of the Abstract and Poster Management committee for the XIV Agriculture Science Congress, New Delhi during 20-23 February, 2019 - Dr. K. Ambasankar

• Acted as observer in the ICAR's 23rd AIEEA – 2018-19 on 22-23rd June, 2018 at Mullai Infotech, 3/148, SBI building, 1st floor, Mount Poonamalle High Road, Ramapuram, Chennai – Dr. R. Ananda Raja

• Member Secretary in the Institutional Animal Ethics Committee (IAEC) – Dr. R. Ananda Raja

• Member in the Institutional Biosafety Committee (IBSC), Annual Physical Verification Committee, Library Advisory Committee, and job training for security guards for fire safety – Dr. R. Ananda Raja

• Acted as an expert with Coastal Aquaculture Authority (CAA) to inspect the hatchery located at Prakasam, Guntur and Krishna districts of Andhra Pradesh on 4th and 5th October, 2018– Dr. R. Ananda Raja

• Observer in ARS/NET Exam- 2018 during 9-10 April, 2018 held at Chennai Centre – Dr. Debasis De

• Observer for the Renewal audit of Karnataka State Organic Certification Agency (KSOCA), Bengaluru under National Programme for Organic Production (NPOP) held during 9 -11 July, 2018 - Dr. Debasis De

• Member, ICAR Regional Committee No. II. - Dr. T.K. Ghoshal

• Member, Scientific Advisory Committee of Ramkrisahna Ashram Krishi Vigyan Kendra, Nimpith ¬ Dr. T.K. Ghoshal

• Member, Scientific Advisory Committee of Sasya Shyamala Krishi Vigyan Kendra, Narendrapur - Dr. T.K. Ghoshal

• Acted as Expert Member in the assessment committee for staff of Ramakrishna Ashram Krishi Vigyan Kendra, Nimpith on 21.04.2018 and 27.07.2018 - Dr. T.K. Ghoshal

• Acted as External Examiner for evaluation of answer sheet and viva- voce of PG and Ph.D. students of Animal Nutrition of NDRI on 30.10.18 at NDRI-ERS, Kalyani - Dr. T.K. Ghoshal

• Acted as Member of Assessment Committee for scientist under CAS at ICAR-NINFET, Kolkata on 22.03.19 - Dr. T.K. Ghoshal

• Acted as an Organizing Committee Member for the International Congress on Engineering and Life Science (ICELIS 2018) held during 26-29 April 2018 at Kastamonu, Turkey - Dr. Gouranga Biswas

• Acted as a Member (Outside expert) in the Selection Committee Meeting for selection of JRF under a DBT funded project held on 4 August 2018 at ICAR-CIFA, Kalyani Field Centre, Kalyani, West Bengal - Dr. Gouranga Biswas

• Reviewer for Journal of Indian Society of Coastal Agricultural Research - Dr. T.K. Ghoshal

• Editorial Board Member for Menba Journal of Fisheries Faculty, Kastamonu University, Turkey - Dr. Gouranga Biswas

• Editorial Board Member for Marine Science and Technology Bulletin, Turkey ¬- Dr. Gouranga Biswas

• Associate Editor, Journal of Fisheries and Life Sciences, Mangaluru, India - Dr. Gouranga Biswas

• Reviewer for various international journals, such as Aquaculture, Aquaculture Research and Fish Physiology and Biochemistry - Dr. Gouranga Biswas

• Acted as member in the State level monitoring

committee for Tilapia aquaculture, at Department of Fisheries, Govt. of Tamil Nadu for approving Tilapia farms for the farmers of Tamil Nadu after screening the documents on 21.3.2019 – Dr. M.Kailasam

• Nodal person - State-of-the-art Community Development Centre for Learning, Livelihood & Research (CDC-LLR) Laboratories in Nellore, Bhimavaram and Surat by KCT with CIBA as technical partner - Dr. M. Muralidhar

• Expert member of Committee constituted by Coastal Aquaculture Authority to suggest suitable recommendations for amending the CAA Rules, 2015 and guidelines issued there under to facilitate implementing them at field level - Dr. M. Muralidhar

• Expert Member of Technical and Inspection Committee for regulating establishment and operation of SPF shrimp broodstock multiplication Centres in the coastal areas, Depart of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Family Welfare, Government of India - Dr. M. Muralidhar

• Expert member for Inspection of hatcheries applied for permission to import brood stock of SPF *L.vannamei* and its seed production - Dr. M. Muralidhar

• Expert Panel member to develop strategies for holistic development of marine and island fisheries of Andaman & Nicobar Islands - Dr. M. Muralidhar

• Expert member for interviewing the candidates for the post of "Subject Matter Specialist, Agricultural Extension" at RASS KVK, Tirupati, Andhra Pradesh on 18th August 2018 - Dr.P.Mahalakhsmi

• Expert member for conducting "Departmental Promotion Committee meeting for Technical Staff" at ICAR-NRC for Banana, Tiruchirappalli on 16 October 2018 - Dr.P.Mahalakhsmi

• Jury member for holding "Smart India Hackathon (SHS) 2019: software" at Sri Sivasubramaniya Nadar College of Engineering, Chennai, Tamil Nadu during 2-3 March 2019 - Dr.P.Mahalakhsmi

• Member, Doctoral Committee for a research scholar in School of Information Technology, VIT University, Vellore - Dr.P.Mahalakhsmi

• Reviewer for various international journals, such as Review of research papers from Aquaculture, aquaculture research and Indian Journal of Fisheries - Dr. Prem Kumar

• Programme Committee member in International Conference of Virology on Global Viral Epidemics: A Challenging Threat, Chandigarh, India – Dr. M.Poornima

• Doctoral Committee Member in Sathyabhama University, Chennai – Dr. M.Poornima

• External expert to set question papers for master degree examinations Madras Veterinary college, TANUVAS, Chennai – Dr. M.Poornima

• External examiner for comprehensive viva voce examination, VELs University, Chennai – Dr. M.Poornima

• Lead Invited Speaker for the Krishi Sammridhi Mela 2018 at CODISSIA Trade Complex, Coimbatore during 24-26th August 2018 – Dr. C V Sairam

• Observer for ICAR AIEEA-2018 (UG/PG/SRF) held on 22-23 June, 2018 – Dr. Sherly Tomy

• Doctoral committee member in Presidency College, Chennai - Dr. Sherly Tomy

• Nodal officer, Data Management of ICAR-CIBA - R. Saraswathy

• Acted as Co-chairman of session entitled 'Role of Muscle Food Safety and Human Health' of the 8th Conference of Indian Meat Science Association and International Symposium on Technological Innovation in Muscle Food Processing for Nutritional Security, Quality and Safety during 22-24 November 2018 at West Bengal University of Animal and Fishery Sciences, Kolkata - Dr. Sanjoy Das

• Acted as Evaluation Committee Member under National programme for organic production (NPOP) Committee member with APEDA – Shri T. Sathish Kumar

• Served as Assessment panel expert member for approving cold storage with EIA - Shri T. Sathish Kumar

• Served as Inspection committee member for inspecting hatcheries with CAA- Shri T. Sathish Kumar

• Member in IMC of CIFA, Bhubaneswar – Dr. S.K.Otta

• Examiner to conduct PhD viva, TNFU, 27th November 2018 - Dr. S.K.Otta

• Member of 'Technical and Inspection Committee' constituted by the DAHD&F, Ministry of Agriculture and Farmers' Welfare for the purpose.

ATTRACTING AND RETAINING YOUTH IN AGRICULTURE (ARYA): AN INITIATIVE TO ATTRACT YOUTH TO BRACKISHWATER AQUACULTURE

Farming in land and water is the noble occupation and farmers consider it as their way of life. In India, we have a self sufficient and self reliant food production system. However, most farmers do not want their next generation to be in agriculture, as income from agriculture is not sufficient, and quality of life is not that appreciative. Minds of youth are creative and socially networked and they are capable of handling risk factors such as climate changes using various technologies. At this context, Govt. of India initiated a new scheme ARYA and it is launched by ICAR.

More than 450 school / college students from 20 educational institutions visited CIBA HQ and MES Muttukadu and learned about brackishwater aquaculture technologies. In Government School at Pakkam village, in Tiruvallur district of Tamil Nadu, an ornamental fish unit was established under CPCL project. The unit is being maintained by high school children under the guidance of their teachers. The National Science Day was organized at Corporation School Mylapore, in which importance of science and brackishwater aquaculture farming in Indian agriculture were inculcated among the school children

MERA GAON MERA GAURAV

Under the flagship programme of the Honourable Prime Minister of India, Mera Gaon and Mera Gaurav (MGMG), ICAR-CIBA organised 65 visits by a team of scientists, 28 meetings and 8 training programmes; Under the patronage of the MGMG programme, 33 demonstrations were conducted,812 mobile advisories have been extended, 10 literature were distributed, in addition to the completion of 31 campaigns. The total number of activities conducted were 221 and 3428 fish/shrimp farmers benefitted out of it. These activities were taken up to hasten lab to land programmes and to create awareness among farmers about the organisations and the programmes related to the farming sector.

TECHNOLOGICAL INTERVENTIONS

• ICAR-CIBA's technological interventions such as three-tier system of cage aquaculture and nursery rearing of Seabass (*Lates calcarifer*) in open brackishwaters,family farming initiatives,homestead backyard Pearlspot larval rearing techniques, demonstration of "Waste to Wealth: Recycling of Fish and Domestic Waste"were demonstrated to the coastal families of MGMG villages for livelihood support and the security of communities and for doubling their income.

LESSONS LEARNT

• The lessons learnt out of the technological interventions were the development and successful implementation of appropriate policy guidelines for optimal utilization of open brackishwaters involving coastal fishers, technical empowerment of coastal communities in pen and cage culture of milkfish and mud crab, skill development of fisherwomen in the recycling of fish and domestic waste,providing opportunities to improve the livelihood of coastal women and their families and provision of alternative and additional income during the lean period.

LINKAGES DEVELOPED

• The fishers were linked with the Tamil Nadu Fisheries Development Corporation, CRRT, Department of Fisheries, Govt. of Tamil Nadu, and private fish farmers for procurement and marketing of seabass fingerlings as well as research institutes such as ICAR-CIBA and Kolathur ornamental hub, Chennai, for marketing.

Demonstration of recycling of fish waste to value added products at Nambikkai Nagar, Srinivaspuram, Chennai, Tamil Nadu

SWACHH BHARAT MISSION

The Swachh Bharat or Clean India Mission was conceived by the Hon'ble Prime Minister, Sri Narendra Modi to motivate and galvanise Indian citizens from all walks of life to achieve by 2019 Mahatma Gandhi's dream of a clean India. In response to the noble call, Swachh Bharat Mission, the following Swachhta Hi Seva and Swachhta Pakhwada programmes were conducted at ICAR-CIBA, Chennai and Kakdwip Research Centre (KRC) of CIBA, Kakdwip, West Bangal, and Navsari Gujarat Research Center (NGRC) of CIBA, Navsari, Gujarat with due gravity and purposefulness during 15th September to 1st October 2018 and December 16-31 2018 respectively.

• Awareness campaign among the school children and villagers about the importance of hygiene and health aspects with displaying of sentences related with cleanliness and hygiene and importance of reducingopen defecation and water management to thechildren at Panchayat Union Primary School, Keelarkollaivillage, Kanchipuram District, Tamil Nadu, on 20th September 2018.

Displaying of cleanliness and hygiene related sentences at panchayat union primary school. Keelarkollai village, Kanchipuram District, Tamil Nadu.

• Swachhta Hi Seva 2018 programme at Kannavanduraivillage, Tiruvallurdistrict, Tamil Nadu, on 21st September 2018 to create awareness on cleanliness, hygiene and sanitation among the villagers and removal of waste from the village and coastline premises.

Cleaning of village roads - Dakshin Lakshminarayanpur, South 24 Parganas, West Bengal - ICAR-CIBA, Chennai

• Swachhta workshop on "Waste to Wealth" by recycling of fish and domestic waste under Swachhata pakhwada programme on 28th September, 2018 at Srinivasapuram, Mullikuppam, Mullimanagar fishermen villages cluster located near CIBA headquarters in Chennai.

Hand on training on composting of domestic waste in three steps - Srinivasapuram, Adyar creek and estuary, Tamil Nadu – ICAR-CIBA, Chennai.

• Awareness programme on cleanliness, usage of toilet, health aspects hygiene and sanitation among the villagers and removal of waste from the village premises at Karathittu village, Kancheepuram district, Tamil Nadu on 29th September 2018.

Cleaning and collecting of wastes - Kakdwip Buddhapur road, West bengal

• Awareness on cleanliness, hygiene and sanitation among the villagers; door to door meeting and removal of waste from the households activities on 18th December 2018 at Keelarkollai village, Kancheepuram district, Tamil Nadu.

School competition, Aadarsh buniyadi prathamik shala, Matwad, Navsari, Gujarat

DISTINGUISHED VISITORS

HEADQUARTERS, CIBA, CHENNAI

Sl. No	Details of visitors	Date of visit
1	Dr. K.K. Ramachandran, Scientist and Head, Central Geomatics Lab, Group Head atmospheric process group, Ministry of Earth Science, Government of India	20.04.2018
2	Dr. George Chamberlain Managing Director, Kona Bay & President - Global Aquaculture Alliance	01.05.2018
3	Dr. M.R.Ramesh Kumar, Chief Scientist, Physical Oceanography Division, CSIR – National Institute of Oceanography- Goa	15.05.2018
4	Dr.E.Vivekanandan, National Consultant, Bay of Bengal Programme	05.06.2018
5	Dr. R. Venkatesan, Scientist G & Head and Ocean Observation systems, National Institute of Ocean Technology, Pallikaranai, Chennai	08.06.2018
6	Mr Rabindra Jena, Hon'ble Member of Parliament	10.07.2018
7	Dr.G.S.Sameeran, IAS, Director of Fisheries, Government of Tamil Nadu	30.07.2018
8	Dr.K.Narayana Gowda, Former Vice-Chancellor, UAS, Bangalore & Chairman, ARYA Programme of ICAR	29.08.2018
9	Dr.Vipin Chandra, Joint Secretary, MoES, at NIOT campus, Chennai.	25.09.2018
10	Dr. Madhavan Rajeevan, Secretary, Ministry of Earth Sciences(MoES)	25.09.2018
11	Dr. M.A. Atmanand, the Director of NIOT, Chennai	25.09.2018
12	Mr. Harnath Singh Yadav, Member of Parliament (Rajya Sabha)	04.10.2018
13	Shri Pradeep Tamta, Member of Parliament (Rajya Sabha)	04.10.2018
14	Shri Prataprao Ganpatrao Jadhav, Member of Parliament (Lok Sabha)	04.10.2018
15	Dr. Sunil Baliram Gaikwad, Member of Parliament (Lok Sabha)	04.10.2018
16	Dr. Prasanna Kumar Patasani, Member of Parliament (Lok Sabha) and Convenor of the second sub-committee of Parliament on Official Language	04.10.2018
17	Dr. Malathi, Adjunct Professor, Department of Plant Pathology, TNAU, Coimbatore	30.10.2018
18	Dr. K.S. Palaniswami, Former Director (Research), TANUVAS	30.10.2018
19	Dr. Aniket Sanyal, Co-ordinator, CRP on Vaccines & Diagnostics	30.10.2018
20	Dr. Ashok Kumar, ADG (AH), ICAR	30.10.2018
21	Dr. J K Jena, DDG (Fy. Science), ICAR, New Delhi	30.10.2018
22	Mr. Nishanth Reddy, Nellore, Andhra Pradesh	30.10.2018
23	Prof. (Dr) Mohan Joseph Modayil, Former ASRB Chairman, Ex-Director CMFRI	15.11.2018
24	Joint Secretary, Department of Animal Husbandry, Dairying & Fisheries, New Delhi	10.12.2018
25	Dr. M. A. Atmanand, Director, National Institute of Ocean Technology (NIOT), Chennai	29.12.2018
26	Shri.N.Vasudevan, Additional Principal Conservator of Forest, Mangrove Foundation, Govt. of Maharashtra	22.01.2019
27	Dr.M.S. Swaminathan, The doyen of Indian Agricultural Research and Education	22.01.2019
28	Thiru.D.Jayakumar, Hon'ble Minister for Fisheries, Personnel and Administrative Reforms, Govt. of Tamil Nadu	22.01.2019

29	Dr.K.Gopal, IAS, Principal Secretary, Animal Husbandry, Dairying & Fisheries, Govt. of Tamil Nadu,	22.01.2019
30	Dr.B.Meenakumari, Chairperson, National Biodiversity Authority (NBA), Chennai	22.01.2019
31	Dr.J.K.Jena, Deputy Director General (Fisheries) and Animal Sciences, ICAR, New Delhi	23.01.2019
32	Dr.S.K.Saxena, Director, Export Inspection Council, GOI	23.01.2019
33	Dr.Trilochan Mohapatra, Secretary, DARE & DG, ICAR, New Delhi	23.01.2019
34	Dr. S.D.Tripathi, Former Director Central Institute of Freshwater Aquaculture and Central Institute of Fisheries Education	25.01.2019
35	Dr.Modadugu Vijay Gupta, World Food Prize Laurate	25.01.2019
36	Prof. Chris Hauton, University of South Hampton, UK	25.01.2019
37	Mr. Mathew Jose, CEO, Paperman Foundation, Chennai	13.02.2019
38	Shri.N K Uppal, Vice President (Corporate Growth Projects), Rallis India limited	15.02.2019
39	Mr. Atul Barman, Director, Aker Bio marine India Private Limited, Mumbai	28.03.2019
40	Dr. A. K. Munirajan, Professor & Head, Department of Genetics, University of Madras, Chennai	12.03.2019
41	Shri. T. Purushothaman, President, Aquaculture Development Cooperative Society (ADCOS), Payyanur, Kerala	25.03.2019

KAKDWIP RESEARCH CENTRE, KAKDWIP

Sl. No	Details of visitors	Date of visit
1	Dr. J.K. Jena, DDG (Fisheries & Animal Science), ICAR	10.05.2018
2	Dr. S.S. Mishra, Director, ICAR-CIFA	12.06.2018

NAVSARI GUJARAT RESEARCH CENTRE, GUJARAT

Sl. No	Details of visitors	Date of visit
1	Dr. J.K. Jena, Deputy Director General (Fisheries), ICAR	07.06.2018
2	Shri. R.C. Patel, Member of Legislative Assembly, Navsari	07.06.2018
3	Dr. C.J. Dangaria, Vice Chancellor, NAU	07.06.2018
4	Dr.C.Gopal, Member Secretary, Coastal Aquaculture Authority, Govt. of India, Chennai	07.06.2018
5	Dr. Pravin Puthra, Assistant Director General (Fisheries), ICAR	07.06.2018
6	Dr. N.H. Kelawala, Dean, Veterinary College	07.06.2018
7	Shri. Mohammed Shahid (IAS), Commissioner of Fisheries, Department of Fisheries, Gujarat	05.09.2018
8	Shri. R. C. Faldu, Hon'ble Cabinet Minister for Agriculture, Rural Development, Fisheries, Animal Husbandry and Transport, Government of Gujarat	05.09.2018

PERSONNEL

PERSONNEL AS ON 31.03.2019

Sl.No.	NAME	DESIGNATION	
1	Dr. K.K. Vijayan	Director	
2	Dr. G. Gopikrishna	Principal Scientist, HOD , NGBD	Retired on 30.11.2018
3	Dr. S.V. Alavandi	Principal Scientist, HOD , AAHED	
4	Dr. K. P. Jithendran	Principal Scientist	
5	Dr. C.V. Sairam	Principal Scientist	
6	Dr. T. Ravisankar	Principal Scientist	
7	Dr. M. Muralidhar	Principal Scientist	
8	Dr. (Smt.) M. Jayanthi	Principal Scientist	
9	Dr. (Smt.) B. Shanthi	Principal Scientist	
10	Dr. C. P. Balasubramanian	Principal Scientist	
11	Dr. M. Kailasam	Principal Scientist	
12	Dr. (Smt.) D. Deboral Vimala	Principal Scientist	
13	Dr. M. Shashi Shekhar	Principal Scientist	
14	Dr. (Smt.) P. Nila Rekha	Principal Scientist	
15	Dr. K. Ambasankar	Principal Scientist	
16	Dr. J. Syama Dayal	Principal Scientist	
17	Dr. Akshya Panigrahi	Principal Scientist	
18	Dr. M. Kumaran	Principal Scientist	
19	Dr. S. Kannappan	Principal Scientist	
20	Dr. (Smt.) M. Poornima	Principal Scientist	
21	Dr. (Smt.) R. Saraswathy	Principal Scientist	
22	Dr. M. Makesh	Principal Scientist	
23	Dr. (Smt.) Sherly Tomy	Principal Scientist	
24	Dr. Debasis De	Principal Scientist	
25	Dr. Prasanna Kumar Patil	Principal Scientist	
26	Dr. Subhendu Kumar Otta	Principal Scientist	
27	Dr. (Smt.) P. Mahalakshmi	Principal scientist	
28	Dr. Satyanarayan Sethi	Principal Scientist	Promoted on 15.05.2017
29	Dr. K.P. Kumaraguru vasagam	Principal Scientist	Promoted on 26.03.2018
30	Shri J. Ashok Kumar	Scientist	
31	Dr. K. Vinaya Kumar	Scientist	Promoted on 12.06.2016
32	Dr. R. Ananda Raja	Scientist	Promoted on 08.01.2017
33	Dr. (Smt.) Krishna Sukumaran	Scientist	Promoted on 07.01.2017
34	Dr. (Smt.) P. Ezhil Praveena	Scientist	Promoted on 07.01.2017
35	Dr. Sujeet Kumar	Scientist	
36	Dr. (Smt.) Shyne Anand	Scientist	
37	Dr. (Smt.) N. Lalitha	Scientist	
38	Dr. (Smt.) T. Bhuvaneswari	Scientist	

Sl.No.	NAME	DESIGNATION
39	Dr. P. Kumararaja	Scientist
40	Dr. B. Sivamani	Scientist
41	Dr. (Smt.) Vidya Rajendran	Scientist
42	Dr. Satheesha Avunje	Scientist
43	Shri K.P. Sandeep	Scientist
44	Ms. Babita Mandal	Scientist
45	Dr. Aritra Bera	Scientist
46	Shri T. Sathish Kumar	Scientist
47	Smt. M.U.Rekha	Scientist
48	Dr. N.S. Sudheer	Scientist
49	Dr. Suvana Sukumaran	Scientist
50	Dr. (Smt) K.C. Neethu	Scientist
51	Shri R. Aravind	Scientist
52	Shri Dani Thomas	Scientist
53	Shri I.F. Biju	Scientist
54	Ms. Misha Soman	Scientist
55	Smt. Mary Lini	Scientist
56	Dr. J. Raymond Jani Angel	Scientist
57	Shri T. Sivaramakrishnan	Scientist
58	Dr. Vinay Tharabenahalli Nagaraju	Scientist
59	Dr. (Smt.) R. Geetha	Scientist

TECHNICAL

Sl.No.	NAME	DESIGNATION	
1	Shri R. Elankovan	Chief Tech. Officer	
2	Dr. S. Sivagnanam	Chief Tech. Officer	Promoted on 14.02.2017
3	Shri D. Raja Babu	Chief Tech. Officer	Promoted on 13.03.2017
4	Shri M. Shenbagakumar	Chief Tech. Officer	Promoted on 07.07.2018
5	Shri R. Puthiavan	Assistant Chief Tech. Officer	
6	Smt. K. Jacquline	Assistant Chief Tech. Officer	
7	Shri Joseph Sahayarajan	Assistant Chief Tech. Officer	Promoted on 08.12.2015
8	Shri S. Rajamanickam	Assistant Chief Tech. Officer	Promoted on 28.10.2015
9	Shri S. Nagarajan	Assistant Chief Tech. Officer	Promoted on 03.01.2017
10	Dr. A. Nagavel	Assistant Chief Tech. Officer	Promoted on 02.08.2017
11	Shri R. Subburaj	Assistant Chief Tech. Officer	Promoted on 27.08.2017
12	Shri N. Ramesh	Tech. Officer	
13	Shri S. Saminathan	Tech. Officer	
14	Shri N. Jagan Mohan Raj	Tech. Officer	
15	Shri D. M. Ramesh Babu	Tech. Officer	Promoted on 24.07.2017
16	Shri G. Thiagarajan	Tech. Officer	Promoted on 04.08.2017
17	Shri K. Paranthaman	Senior Tech. Asst.	
18	Shri K. Karaian	Senior Tech. Asst.	Promoted on 10.09.2017
19	Shri S. Prabhu	Technical Asst.	Joined on 14.09.2018
20	Shri K.V. Delli Rao	Senior Technician	

ADMINISTRATION

Sl.No.	NAME	DESIGNATION	
1	Shri K.V.S. Satyanarayana	Administrative Officer	Retired on 31.10.2018
2	Shri. R.K. Babu	Finance & Accounts Officer	Joined on 23.05.2018
3	Shri R. Kandamani	Asst. Admn. Officer	
4	Smt. V. Usharani	Asst. Admn. Officer	
5	Shri S. Pari	Asst. Admn. Officer	
6	Shri P. Srikanth	Junior Accounts Officer	
7	Smt. S. Nalini	Private Secretary	Promoted on 08.05.2018
8	Shri K.G. Gopala Krishna Murthy	Personal Assistant	
9	Smt. K. Subhashini	Personal Assistant	Promoted on 06.12.2018
10	Shri A. Manoharan	Assistant	
11	Smt. E. Amudhavalli	Assistant	
12	Shri A. Sekar	Assistant	
13	Smt. E. Mary Desouza	Assistant	
14	Shri Raghavendra.K	Assistant	
15	Smt. K. Hemalatha	Stenographer, Grade – III	
16	Smt. R. Vetrichelvi	UDC	
17	Smt. M. Mathuramuthu Bala	UDC	
18	Smt. B. Prasanna Devi	UDC	Promoted on 27.10.2018
19	Shri B. Palanivelmurugan	UDC	Transferred to CMFRI, Mandapam on 31.10.2018
20	Shri R. Kumerasen	LDC	
21	Shri A. Paul peter	LDC	

SKILLED SUPPORT STAFF

Sl.No.	NAME	DESIGNATION	
1	Shri V. Jeevanantham	Skilled Support Staff	
2	Shri K. Nithyanandam	Skilled Support Staff	
3	Shri V. M. Dhanapal	Skilled Support Staff	
4	Shri V. Kumar	Skilled Support Staff	
5	Shri E. Manoharan	Skilled Support Staff	
6	Shri C. Saravanan	Skilled Support Staff	
7	Shri S. Kuppan	Skilled Support Staff	VRS on 03.04.2018
8	Shri M. Pichandi	Skilled Support Staff	
9	Shri S. Selvababu	Skilled Support Staff	
10	Shri D. Senthil Kumaran	Skilled Support Staff	
11	Shri C. Ragu	Skilled Support Staff	
12	Shri P.G. Samuvel	Skilled Support Staff	
13	Shri M. Sakthivel	Skilled Support Staff	
14	Shri R. Mathivanan	Skilled Support Staff	
15	Shri R. Indra Kumar	Skilled Support Staff	
16	Shri G. Dayalan	Skilled Support Staff	
17	Shri Kanaka Prasad	Skilled Support Staff	
18	Smt. S. Premavathy	Skilled Support Staff	
19	Shri J. Murugan	Skilled Support Staff	
20	Shri V. Kishorkumar	Skilled Support Staff	

NAVSARI RESEARCH CENTRE OF CIBA, GUJARAT

NGRC SCIENTISTS

Sl.No.	NAME	DESIGNATION	
1	Shri Pankaj Amrut Patil	Scientist	Transferred on 24.07.2018
2	Shri Tanveer Hussain	Scientist	Transferred on 20.09.2018
3	Shri Jose Antony	Scientist	Transferred on 17.09.2018

KAKDWIP RESEARCH CENTRE OF CIBA STAFF, WEST BENGAL

KRC SCIENTISTS

Sl.No.	NAME	DESIGNATION	
1	Dr. T.K. Ghoshal	Principal Scientist	
2	Dr. Sanjoy Das	Principal Scientist	
3	Dr. G. Biswas	Scientist	Promoted on 08.01.2017
4	Dr. Prem Kumar	Scientist	
5	Ms. Christina Lalramchhani	Scientist	
6	Ms. Leesa Priyadarsani		Scientist

KRC TECHNICAL

Sl.No.	NAME	DESIGNATION	
1	Shri P.S. Samanta	Tech. Officer	Retired on 30.09.2018
2	Smt. Chhanda Mazumder	Senior Tech. Asst.	

KRC ADMINISTRATION

Sl.No.	NAME	DESIGNATION
1	Shri S.K. Bindu	Assistant

KRC SKILLED SUPPORT STAFF

Sl.No.	NAME	DESIGNATION	
1	Shri N.N. Jana	Skilled Support Staff	Retired on 28.02.2019
2	Shri K.P. Naskar	Skilled Support Staff	
3	Smt. L.R. Bhuiya	Skilled Support Staff	
4	Shri U.K. Santra	Skilled Support Staff	
5	Shri P.C. Das	Skilled Support Staff	
6	Shri Sanjoy Some	Skilled Support Staff	

REDEPLOYED STAFF FROM PURI RESEARCH CENTER of CIBA TO CIFA, BHUBANESHWAR

Sl.No.	NAME	DESIGNATION
1	Shri P.C. Mohanty	Technical Assistant
2	Shri Premanadha Bisoi	Skilled Support Staff

INFRASTRUCTURE DEVELOPMENT

1. Construction of laboratory building at CIBA Head Quarters, Chennai
2. Replacement of floor tiles in 1st & 2nd floor corridor at Main Lab cum Admin building of CIBA Head Quarters, Chennai
3. Pavement blocks for car parking in back side of the main building at CIBA Head Quarters, Chennai
4. Renovation of storm water trench including earth filling at CIBA Head Quarters, Chennai
5. Construction of sewage collecting tank at CIBA Head Quarters, Chennai
6. Construction of atrium space at CIBA Head Quarters, Chennai
7. Providing gate in southern side of the compound wall at CIBA Head Quarters, Chennai
8. Providing Non- Essential panel including cabling for connecting the existing two generators and two transformers at CIBA Head Quarters, Chennai
9. Re-routing the existing wet raiser system at CIBA Head Quarters, Chennai
10. Supply & installation of Electrical Distribution panel board near Trainees hostel at CIBA Head Quarters, Chennai
11. Supply and fixing of exterior aluminium composite panel in the sit out area in the first floor at CIBA Head Quarters, Chennai
12. Fabrication and supply of glass water fountain at CIBA Head Quarters, Chennai
13. Renovation of internal road in CIBA Head Quarters, Chennai
14. Supplying and fixing LED light in the roof of court yard at CIBA Head Quarters, Chennai
15. Construction of Central drainage pond at Muttukadu Experimental Station, Muttukadu
16. Construction of 5000 litres RCC tanks in place of FRP tanks with pipe line for water and aerator at Muttukadu Experimental Station, Muttukadu
17. Construction of first floor over the existing wet laboratory building at KRC of CIBA, Kakdwip
18. Construction of Trainees Hostel under Tribal Sub-plan completed at KRC of CIBA, Kakdwip
19. Construction of Electrical Sub-station building completed and new transformer with enhanced load (200 KVA) installed at KRC of CIBA, Kakdwip
20. Barbed wire fencing at C-sector farm completed at KRC of CIBA, Kakdwip
21. Executed the work Re-excavation of inlet canal at Sector-B at KRC of CIBA, Kakdwip

LIBRARY AND DOCUMENTATION

A. LIBRARY HOLDINGS

CIBA Library procured 45 new books including official language books during the period 2018-19 and currently holds 2,776 books, subscriptions for fourinternational and national journals at the headquarters, Chennai and Kakdwip Research Centre in West Bengal. The details of Library holdings as on March 31, 2019 are provided in the diagram below.

B. LIBRARY AND E-RESOURCE CENTRE

The CIBA library has been upgraded as Library and e-Resource Centre with six workstations having the facility to access e-books, online journals, Institute publications and scientists publications for ease of use by scientists and scholars. This facility is now open to students, scholars and other researchers from Universities, Colleges and other academic Institutes. The timing of the facility also has been extended till 6 p.m. to enable students to use it effectively.

C. DIGITAL REPOSITORY

Under the digitalization initiative, all institute publications and individual scientist's publications have been digitized and uploaded in the KRISHI Portal. It will be further uploaded in the E-prints open sources software) and linked to the international databases to enhance visibility of CIBA research achievements across the globe.

D. ONLINE ACCESS TO THE CIBA SUBSCRIBED &CERA JOURNALS AND DOCUMENT DELIVERY SERVICES:

CIBA has access to e-books and journals published by Springer, John Wiley and Elsevier through ICAR- CeRA resource sharing platform. For the ease of use, the library has listed all the full content accessible online journals along with their access links in CIBA web portal. The library section supplied photocopies of journal articles requested from various ICAR institutes, scientists and research scholars under CeRA-Document Delivery Request (DDR).

E. EXCHANGE SERVICES

CIBA library maintained exchange relationship with various national and international organizations working on fisheries and aquaculture on mutual interest. The library maintained free mailing of institute's annual report and other Institute publications to various research organizations, universities and other agencies to provide updates on the institute research and development programmes.

F. INFORMATION SERVICES TO THE STAKEHOLDERS

CIBA library acted as a reference library by providing access to the reference books & journals available in the library to the scientific personnel of other research organizations, academia, university/ college students, research scholars, stakeholders and other related visitors. The library provided photocopying service to users on nominal payment basis.

G. UTILIZATION OF FUNDS

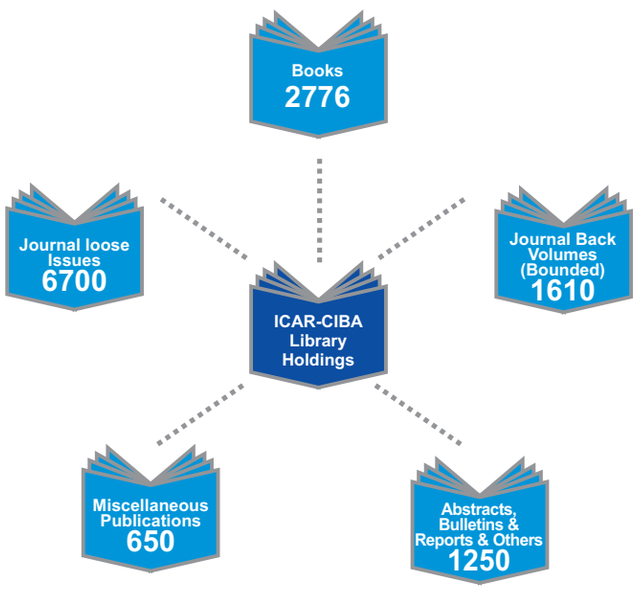
The funds available to the tune of Rs. 10.00 lakhs were effectively utilized towards the procurement of new books. Journals, Anti-plagiarism and Grammarly software for the library users, Scientists & Staff of Headquarters and KRC library of CIBA.

H. ISBN NUMBERS

CIBAhasobtained 50 ISBNs for five years from the Ministry of Human Resources Development for its publications. Fifteen books have been allotted ISBN numbers as of March 2019.

I. KRISHI PORTAL

ICAR-CIBA has uploaded more than 700 of its publications consisting of research papers and Institute publications in the ICAR-KRISHI Portal. The Institute was felicitated with a Certificate of Appreciation for proactively implementing ICAR-Research Data Management Guidelines and uploading the publications.



CIBA – Overview of Library Holdings

PUBLICATION, PARTICIPATION IN CONFERENCES, MEETINGS, WORKSHOPS, SYMPOSIA

Institute Publication List

Annual Report 2017-18
Training Calendar 2018-19 (http://krishi.icar.gov.in/jspui/handle/123456789/20307)
Jal Tarang Vol. 4 (Hindi magazine) (http://krishi.icar.gov.in/jspui/handle/123456789/20311)

CIBA Extension Series

- Information and communication technology for brackishwater aquaculture technology. ICAR-CIBA Extension Series No. 61. (http://krishi.icar.gov.in/jspui/handle/123456789/20216)
- Demonstration of brackishwater finfish farming in Gujarat - CIBA initiatives. ICAR-CIBA Extension Series No. 62. (http://krishi.icar.gov.in/jspui/handle/123456789/20215)
- Application of minerals in shrimp culture systems. ICAR-CIBA Extension Series No. 63. (http://krishi.icar.gov.in/jspui/handle/123456789/20217)
- Community and family farming initiatives for tribal and aqua farmers of Gujarat. ICAR-CIBA Extension Series No. 64. (http://krishi.icar.gov.in/jspui/handle/123456789/20218)
- Advisories on Infectious myonecrosis (IMN)(http://krishi.icar.gov.in/jspui/handle/123456789/20316)
- Hepatopancreatic microsporidiosis (HPM) (http://krishi.icar.gov.in/jspui/handle/123456789/20314)
- White spot disease (WSD) (http://krishi.icar.gov.in/jspui/handle/123456789/20317)
- Acute hepatopancreatic necrosis disease (AHPND) (http://krishi.icar.gov.in/jspui/handle/123456789/20315)
- Aquastat India 2018. ICAR-CIBA. Extension Series No.66.(http://krishi.icar.gov.in/jspui/handle/123456789/20293)

CIBA Technology Series

- Poly plus – a cost effective feed for brackishwater polyculture. CIBA Technology Series, 15.(KRISHI: Technology Repository)
- Metagenomics studies: an aquaculture perspective. CIBA e-publication series 2019 – No. 30. (http://krishi.icar.gov.in/jspui/handle/123456789/20252)

CIBA Training Manuals

- Recent advances in soil and water management in brackishwater aquaculture – a training manual. CIBA-TM Series-2018, No. 8. (http://krishi.icar.gov.in/jspui/handle/123456789/20211)
- Training manual on seed production and farming technology of brackishwater catfish, Mystus gulio. CIBA- TM Series 2018 No. 11.(http://krishi.icar.gov.in/jspui/handle/123456789/20308)
- Hands on training on aquaculture genomics and bioinformatics. CIBA-TM Series-2018-No. 12. (http://krishi.icar.gov.in/jspui/handle/123456789/20256)
- Training manual on seed production and farming of brackishwater finfishes (http://krishi.icar.gov.in/jspui/handle/123456789/20299)
- Water and soil treatment application in aquaculture - a training manual. CIBA- TM Series 2018, No. 13.(http://krishi.icar.gov.in/jspui/handle/123456789/20212)
- Training manual on recent advances in farming of Pacific white shrimp, *Penaeus vannamei*. CIBA- TM Series, 2018, No. 14.

  Training manual on hatchery production and farming of milkfish and mullets. (http://krishi.icar.gov.in/jspui/handle/123456789/20306)

- Fostering aquaculture Start-Ups: 2019(http://krishi.icar.gov.in/jspui/handle/123456789/20290)

- A Guide to milkfish *(Chanos chanos)* aquaculture. ISBN: 978-81-932937-5-1 (http://krishi.icar.gov.in/jspui/handle/123456789/20213)

- Family farming model in brackishwater aquaculture for livelihood support of communities living around Adyar Creek and Estuary. ISBN 978 - 81 - 932937 -9- 9. (http://krishi.icar.gov.in/jspui/handle/123456789/20214)

- Innovative approaches and success stories of brackishwater aquaculture farmers, *Farmers Conclave*. BRAQCON World Brackishwater Aquaculture Conference 22-25, January, 2019 (http://krishi.icar.gov.in/jspui/handle/123456789/20197)

- Souvenir book, BRAQCON World Brackishwater Aquaculture Conference 22-25, January, 2019.(http://krishi.icar.gov.in/jspui/handle/123456789/20289)

- Book of abstracts Braqcon 2019, BRAQCON World Brackishwater Aquaculture Conference 22-25, January, 2019 (http://krishi.icar.gov.in/jspui/handle/123456789/20295)

Peer Reviewed Journals

1. Alavandi, S.V., Muralidhar, M, Dayal, J.S., Rajan, J.S., Praveena, P.E., Bhuvaneswari, T, Saraswathy, R., Chitra, V., Vijayan, K.K., Otta, S.K., 2019. Investigation on the infectious nature of running mortality syndrome (RMS) of farmed Pacific white leg shrimp, *Penaeus vannamei* in shrimp farms of India. Aquaculture, 500, 278-289.(https://krishi.icar.gov.in/jspui/handle/123456789/11324)

2. Ali, S.S.R., Ambasankar, K., Praveena, P.E., Nandakumar, S., Musthafa, M.S., 2018. Effect of dietary prebiotic inulin on histology, immuno-hematological and biochemical parameters of Asian seabass (*Lates calcarifer*). Aquac. Res., 49, 2732–2740. (http://krishi.icar.gov.in/jspui/handle/123456789/10632)

3. Anand, P.S. S., Balasubramanian, C. P., Lalramchhani, C., Kumar, S., Biswas, G., De, D., Ghohsal, T. K., Vijayan, K. K., 2019. Substrate based black tiger shrimp, *Penaeus monodon* culture: Stocking density, aeration and their effect on growth performance, water quality and periphyton development. Aquaculture, 507, 411-418. (http://krishi.icar.gov.in/jspui/handle/123456789/20205)

4. Anand, P.S. S., Balasubramanian, C.P., Lalramchhani, C., Panigrahi, A., Gopal, C., Ghoshal, T.K., Vijayan, K.K., 2018. Comparison of mudcrab- based brackishwater polyculture systems with different finfish species combinations in Sundarban, India. Aquac. Res., 49(9), 2965-2976.(http://krishi.icar.gov.in/jspui/handle/123456789/20204)

5. Antony, J., Balasubramanian, C. P., Balamurugan, J., Sandeep, K. P., Biju, I. F., Vijayan, K. K., 2019. Optimization of nursery rearing for megalopa of giant tiger crab *Scylla serrata* (Forskaal, 1775). Indian J. Fish., 66(1), 43-50. (http://krishi.icar.gov.in/jspui/handle/123456789/20202)

6. Bedekar, M. K., Soman, P., Kole, S., Anand, D., Tripathi, G., Makesh, M., Rajendran, K.V., 2018. Evaluation of interferon gamma (IFN-γ) of *Labeo rohita* as an immunomodulator: in vitro expression model. Aquacult. Int., https://doi.org/10.1007/s10499-018-0292-9(http://krishi.icar.gov.in/jspui/handle/123456789/20286)

7. De, D., Ghoshal, T.K., Biswas, G., Mukherjee, S., Kumar, S., Anand, P.S.S., Raja, R.A., Vijayan, K.K., 2018. Evaluation of growth performance in *Mugil cephalus* L. juveniles fed diets incorporated with fermented plant feedstuffs replacing fishmeal or diets supplemented with fish gut bacteria. J. Food. Process. Technol., 9(4), 728. (http://krishi.icar.gov.in/jspui/handle/123456789/20193)

8. De, D., Raja, R.A., Ghoshal, T.K., Mukherjee, S., Vijayan, K.K., 2018. Evaluation of growth, feed utilization efficiency and immune parameters in tiger shrimp (*Penaeus monodon*) fed diets supplemented with or diet fermented with gut bacterium Bacillus sp. DDKRC1. isolated from gut of Asian seabass (*Lates calcarifer*). Aquac. Res., 49, 2147-2155. (http://krishi.icar.gov.in:8080/jspui/handle/123456789/9660)

9. Duvvuru, J.A., Arjun, R., Sethi, S.N., Kasthuri, R., 2018. Inhibition and recovery of aquatic macrophyte *Lemna gibba* exposed to a combination pesticide. Indian J. Natur. Sci., Vol.8 (46), Feb. 2018. (http://krishi.icar.gov.in/jspui/handle/123456789/20291)

10. Gora, A.H., Ambasankar, K., Sandeep, K. P., Rehman, S., Agarwal, D., Ahmad, I., Ramachandran, K., 2019. Effect of dietary supplementation of crude microalgal extracts on growth performance, survival and disease resistance of *Lates calcarifer* (Bloch, 1790) larvae. Indian J. Fish., 66(1), 64-72. (http://krishi.icar.gov.in/jspui/handle/123456789/20194)

11. Jannathulla, R., Ambasankar, K., Dayal, J.S., Rajamohmed, M.K., Sravanthi, O., Rajesh, B., 2019. Studies on functional properties and chemical composition of commercial shrimp feeds used in Andhra Pradesh, India. Int. J. Fish. Aquat. Stud., 7(2), 84-89. (http://krishi.icar.gov.in/jspui/handle/123456789/20195)

12. Jannathulla, R., Dayal, J.S., Ambasankar, K., Claret, E.A., Muralidhar, M., 2018. Fungus, *Aspergillus niger* fermented groundnut oil cake as a fishmeal alternative in the diet of *Penaeus vannamei*. Aquac. Res., 49:2891-2902. doi.org/10.1111/are.13756. (http://krishi.icar.gov.in:8080/jspui/handle/123456789/14492)

13. Jannathulla, R., Dayal, J.S., Ambasankar, K., D. Thulasi, D. Vasanthakumar, and Muralidhar, M. 2018. Carcass amino acid, fatty acid and mineral composition of *Penaeus vannamei* Boone, 1931 fed diets with fermented oilseed meals/cakes. Int. J. Fish. Aquat. Stud., 6(6), 233-240. (http://krishi.icar.gov.in:8080/jspui/handle/123456789/14492)

14. Jannathulla, R., Dayal, J.S., Vasanthakumar, D., Ambasankar, K., Muralidhar, M., 2018. Effect of fungal fermentation on apparent digestibility coefficient for dry matter, crude protein and amino acids of various plant protein sources in *Penaeus vannamei*. Aquacult. Nutr., 24 (4): 1318-1329 doi.org/10.1111/anu.12699. (http://krishi.icar.gov.in:8080/jspui/handle/123456789/10740)

15. Jaseera, K.V., Kaladharan, P., Vijayan, K.K., Sandhya, S.V., Antony, M.L., Pradeep, M.A., 2018. Isolation and phylogenetic identification of heterotrophic thraustochytrids from mangrove habitats along the southwest coast of India and prospecting their PUFA accumulation. J. Appl. Phycol.,(http://krishi.icar.gov.in/jspui/handle/123456789/20313)

16. Jayanthi, M., Thirumurthy, S., Muralidhar, M., Ravichandran, P., 2018. Impact of shrimp aquaculture development on important ecosystems in India. Global Environ. Chang., 52, 10-21. (http://krishi.icar.gov.in/jspui/handle/123456789/20198)

17. Jayanthi, M., Thirumurthy, S., Nagaraj, G., Muralidhar, M., Ravichandran, P., 2018. Spatial and temporal changes in mangrove cover across the protected and unprotected forests of India. Estuar. Coast. Shelf Sci., 213, 81-91. (http://krishi.icar.gov.in/jspui/handle/123456789/20199)

18. Kannappan, S., Sivakumar, K., Sethi, S.N., 2018. Protective effect of mangrove (*Rhizophora apiculata*) leaves extract in shrimp (*Penaeus monodon*) larvae against bio-luminescent disease-causing *Vibrio harveyi* bacteria. Spanish J. Agri. Res., 16 (1), e0501. (http://krishi.icar.gov.in:8080/jspui/handle/123456789/12308)

19. Khan, H.I., Madhubabu, E.P., Jannathulla, R., Ambasankar, K., Dayal, J.S., 2018. Effect of partial replacement of marine

protein and oil sources in the presence of lysolecithin in Tiger shrimp, *Penaeus monodon* Fabricus, 1978. Indian J. Fish., 65 (2), 100-107. DOI: 10.21077/ijf.2018.65.2.74154-12. (http://krishi.icar.gov.in/jspui/handle/123456789/20196)

20. Kirti, K., Praveena, P.E., Bhuvaneswari, T., Jithendran, K.P., 2019. Evaluation of flinders technology associates cards as a non-lethal sampling device for molecular diagnosis of betanodavirus in Asian seabass, *Lates calcarifer* (Bloch, 1790). Virol. Curr. Res., 3(1).(http://krishi.icar.gov.in/jspui/handle/123456789/20190)

21. Kumar, K.V., Shekhar, M.S., Otta, S.K., Karthic, K., Kumar, J.A., Gopikrishna, G., Vijayan, K.K., 2018. First report of a complete genome sequence of white spot syndrome virus from India. Genome Announc. 6(8), e00055-18. (http://krishi.icar.gov.in:8080/jspui/handle/123456789/13634)

22. Kumar, P., Biswas, G., Ghoshal, T.K., Kailasam, M., Lalramchhani, C., Vijayan, K.K., 2018. Current knowledge on the biology, captive breeding and aquaculture of the brackishwater catfish, *Mystus gulio* (Hamilton, 1822): A review. Aquaculture, 499, 243-250. (http://krishi.icar.gov.in/jspui/handle/123456789/20281)

23. Kumar, P., Biswas, G., Ghoshal, T.K., Kailasam, M., Vijayan, K.K., 2018. Embryonic and larval developments of brackish water catfish, *Mystus gulio* (Hamilton and Buchanan, 1822) induced with human chorionic gonadotropin and consequent larval rearing. Aquacul. Res. 49, 2466-2476. (http://krishi.icar.gov.in/jspui/handle/123456789/20282)

24. Kumar, S., Mashooq, M., Gandham, R.K., AlavandiS.V., Viswas, K.N., 2018. Characterization of quorum sensing system in *Clostridium chauvoei*.Anaerobe, 52, 92-99.(http://krishi.icar.gov.in/jspui/handle/123456789/20186)

25. Kumaran, M., Sundaram, M., Mathew, S., Anand, P.R., 2018. Socio-personal contour, Information flow and productivity of brackishwater aquaculture systems - an appraisal.J. Ext. Educ., 30(3), 6119-6128.(http://krishi.icar.gov.in/jspui/handle/123456789/20184)

26. Kumararaja, P., Manjaiah, K. M., Datta, S.C., Shabeer, T.P.A., Sarkar, B., 2018. Chitosan-g-poly (acrylic acid)-bentonite composite: a potential immobilizing agent of heavy metals in soil. Cellul., 25(7), 3985-3999. (http://krishi.icar.gov.in:8080/jspui/handle/123456789/9684)

27. Mahalakshmi, P., 2018. Predictive mathematical optimal location model based on multi criteria evaluation: validation by aquaculture. 2018. Int. J. Math. Comput. Appl. Res., 8(4), 27-36. (http://krishi.icar.gov.in/jspui/handle/123456789/12143)

28. Mahalakshmi, P., Panigrahi, A., Ghoshal, T. K., Biswas, G., Raja, R.A., Kumar, S., 2018. Aquaculture database system for culture practices. Fish. Technol., 55, 212-217. (http://krishi.icar.gov.in:8080/jspui/handle/123456789/12127)

29. Mahalakshmi, P., Ravisankar, T., Shanthi, B., Kumar, J.A., 2018. Empowerment assessment tool for evaluating projects in aquaculture. Indian J. Soc. Res., 59(5), 597-608. (http://krishi.icar.gov.in/jspui/handle/123456789/20185)

30. Makesh, M., Aathithya, R., Satyanarayana, V.N., Sukumaran, K., Bera, A., Sivaramakrishnan, T., Thiagarajan, G., Kailasam, M., Vijayan, K.K., 2018. Resistance of pearlspot larvae, *Etroplus suratensis*, to redspotted grouper nervous necrosis virus by immersion challenge. J. Fish Dis., 42, 249–256, https://doi.org/10.1111/jfd.12930. (http://krishi.icar.gov.in/jspui/handle/123456789/20285)

31. Otta, S.K., Praveena, P.E., Raj, R.A., Saravanan, P., Priya, M.S., Amarnath, C.B., Bhuvaneswari, T., Panigrahi, A., Ravichandran, P., 2018. *Pythium insidisum* as a new opportunistic fungal pathogen for Pacific white shrimp, *L. vannamei.* Indian J. Geomarine Sci., 47, 1036-1041. (http://krishi.icar.gov.in/jspui/handle/123456789/20187)

32. Panigrahi, A., Saranya, C., Sundaram, M., Kannan, S.V., Das, R.R., Kumar, R.S., Rajesh, P., Otta, S.K., 2018. Carbon: nitrogen (C: N) ratio level variation influences microbial community of the system and growth as well as immunity of shrimp (*Litopenaeus vannamei*) in biofloc based culture system. Fish Shellfish Immunol., 81, 329-337. (http://krishi.icar.gov.in:8080/jspui/handle/123456789/12177)

33. Panigrahi, A., Sundaram, M., Chakrapani, S., Rajasekar, S., Dayal, J.S., Gopal, C. 2019. Effect of carbon and nitrogen ratio (C: N) manipulation on the production performance and immunity of Pacific white shrimp *Litopenaeus vannamei* (Boone, 1931) in a biofloc based rearing system. Aquac. Res.,50(1), 29-41. (http://krishi.icar.gov.in/jspui/handle/123456789/20200)

34. Panigrahi, A., Sundaram, M., Saranya, C., Kumar, R.S., Dayal, J.S., Saraswathy, R., Otta, S.K., Anand, P.S., Rekha, P.N., Gopal, C., 2019. Influence of differential protein levels of feed on production performance and immune response of pacific white leg shrimp in a biofloc–based system. Aquaculture, 503,118-127. (http://krishi.icar.gov.in/jspui/handle/123456789/20201)

35. Panigrahi, A., Sundaram, M., Saranya, C., Swain, S., Dash, R.R., Dayal, J.S. 2019. Carbohydrate sources deferentially influence growth performances, microbial dynamics and immunomodulation in Pacific white shrimp (*Litopenaeus vannamei*) under biofloc system. Fish Shellfish Immunol., 86, 1207-1216. (http://krishi.icar.gov.in/jspui/handle/123456789/20203)

36. Patil, P. A., Dube, K., Verma, A. K., Chadha, N. K., Sundaray, J. K., Jayasankar, P., 2019. Growth performance of goldfish, *Carassius auratusand basil, Ocimum basilicum* in media bed aquaponics, 2019. Indian J. Fish., 66(1), 112-118.

37. Praveena, P.E., Bhuvaneswari, T., Krishnan, A.N., Jagadeesan, V., Rajan, J.J.S., Jithendran, K.P., 2018. An improved microscopic method for the rapid diagnosis of emerging microsporidian parasite, *Enterocytozoon hepatopenaei* in shrimp farms. Curr. Sci., 115, 758-763. (http://krishi.icar.gov.in/jspui/handle/123456789/20188)

38. Qadiri, S.S.N., Makesh, M., Rajendran, K.V., Rathore, G., Purushothaman, C.S., 2018. Specific immune response in mucosal and systemic compartments of *Cirrhinus mrigala* vaccinated against *Edwardsiella tarda*: In vivo kinetics using different antigen delivery routes. J. World Aquacult. Soc., 2018, 1–10. https://doi.org/10.1111/jwas.12584(http://krishi.icar.gov.in/jspui/handle/123456789/20283)

39. Saikrithi, P., Balasubramanian, C.P., Otta, S.K., Tomy, S., 2019. Characterization and expression profile of farnesoic acid O-methyltransferase gene from Indian white shrimp, *Penaeus indicus.* Comp. Biochem. Physiol. B Biochem. Mol. Biol., 232, 79-86. (http://krishi.icar.gov.in/jspui/handle/123456789/20191).

40. Sandeep, K.P., Vasagam, K.P.K., Kumararaja, P., Dayal, J.S., Sreekanth, G.B., Ambasankar, K., Vijayan, K. K., 2019. Microalgal diversity of a tropical estuary in south India with special reference to isolation of potential species for aquaculture. J. Coast. Conserv., 23(1), 253-267. (http://krishi.icar.gov.in/jspui/handle/123456789/20251)

41. Saraswathy, R., Muralidhar, M., Das, S., Kumararaja, P., Suvana, S., Katneni, V.K., Lalitha, N., Nagavel, A., Vijayan, K.K., 2019. Changes in soil and water quality at sediment–water interface of *Penaeus vannamei* culture pond at varying salinities. Aquac. Res., 50 (4), 1096-1106. (http://krishi.icar.gov.in/jspui/handle/123456789/19276)

42. Shamal, P., Zacharia, P.U., Binesh, C.P., Pranav, P., Suja, G., Asokan, P.K., Pradeep, M.A., Rithesh, R., Vijayan, K.K., Sanil, N.K., 2018. *Perkinsus olseni* in the short neck

yellow clam, Paphia malabarica (Chemnitz, 1782) from the southwest coast of India. J. Invertebr. Pathol., doi: 10.1016/j.jip.2018.10.001.(http://krishi.icar.gov.in/jspui/handle/123456789/20310)

43. Sivakumar, P., Praveena, P. E., Singh, N., 2018. Effects of *Pasteurella multocida* lipopolysaccharides on bovine leukocytes. Microb. Patho., 119, 225-232. (http://krishi.icar.gov.in/jspui/handle/123456789/20189)

44. Subburaj, R., Maran, B.A.V., Thirunavukaarasu, A.R., Kailasam, M., S. Elangeshwaran, Kumar, P., G.Thiagarajan, K. Sukumaran, 2018. First report on infection of *Argulus quadristriatus* (Arthrop Crustacea: Branchiura) on marine fish cobia in brood stock pond culture. Natl. Acad. Sci. Lett., https://doi.org/10.1007/s40009-018-0724-0. (http://krishi.icar.gov.in/jspui/handle/123456789/20292)

45. Swathi, A., Shekhar, M. S., Kumar, K. V., Vijayan, K. K., 2018. Genome size estimation of brackishwater fishes and penaeid shrimps by flow cytometry. Mol. Biol. Rep., 45: 951-960. (http://krishi.icar.gov.in/jspui/handle/123456789/20309)

Popular Articles

1. Kumar, T.S., Rajan, J.J.S., Makesh, M., Alavandi, S.V., Vijayan, K. K., 2018. Rapid and specific loop mediated isothermal amplification detection of Enterocytozoon hepatopenaei (EHP) (in Tamil). Fourth National Agricultural Science Tamil Research Conference.

2. Kumar, T.S., Vidya, R., Kumar, S., Alavandi, S.V., Vijayan, K.K., 2018. Tackling shrimp hatchery disease : India's efforts to investigate Zoea-2 Syndrome. Hatchery International, 35.(http://krishi.icar.gov.in/jspui/handle/123456789/20312)

3. Mahalakshmi, P., Balasubramanian, C. P., Kailasam, M., Saraswathy, R., Ravisankar, T., Bera, A., Sairam, C. V., Aravind, R., Sivagnanam, S., Vijayan. K. K., 2018. Bringing the Adyar creek back to life can also mean restoring livelihoods of the local population. Inmathi (English online magazine), 16 July 2018. https://inmathi.com/2018/07/16/7786/. (http://krishi.icar.gov.in/jspui/handle/123456789/12304)

4. Mahalakshmi, P., Balasubramanian, C. P., Kailasam, M., Saraswathy, R., Ravisankar, T., Bera, A., Sairam, C. V., Aravind, R., Sivagnanam, S., Vijayan. K. K., 2018. Meendum uueer parumaa Adyar river? Inmathi (Tamil online magazine), 17 July 2018. https://inmathi.com/2018/07/16/7786/. (http://krishi.icar.gov.in/jspui/handle/123456789/12305)

5. Patil, P.A., Antony, J., Hussain, T., Vijayan, K.K., 2019. ICAR-CIBA innovative technologies for sustainable development of brackishwater aquaculture and prosperity. In :Souvenir of State Level Convention Latest Technology for Prosperity and Sustainable Development in Agriculture, jointly organized by Navsari Agricultural University in Collaboration of AGRIVISON-Gujarat held on 8th November, 2018 at Navsari Agricultural University, Navsari, Gujarat, p. 94.

6. Shanthi, B., Sukumaran, K.,Thiagarajan, G., Kailasam, M., Sairam, C.V., 2018. Enhanced livelihood of coastal communities through backyard pearl spot seed rearing. Asian Fisheries Society, e-Newsletter, www.asianfisheriessociety.org, Issue 27, Dec. 18. (http://krishi.icar.gov.in/jspui/handle/123456789/20547)

Books/Book Chapter

1. Ambasankar, K., Dayal, J.S., Vasagam, K.P. K., Sandeep, K.P., 2018. Nutrient requirements of cultivable brackishwater fish and aquafeed processing techniques. In: Training Manual Molecular Biology and Biotechnology for Fisheries Professionals. CMFRI Training Manual Series No. 15/2018. ISBN 978-93-82263-24-1 pp 403-408.

2. Balasubramanian, C. P., Vijayan, K. K., 2018. Reproductive endocrinology in aquaculture with special reference to captive maturation of penaeid shrimps. In: Molecular Biology and Biotechnology for Fisheries Professionals, CMFRI training manual series No. 15/2018:460- 473.

3. Bindu, J., Das, S., 2018. High-pressure applications for preservation of fish and fishery products. In: Mohan, C.O., Carvajal-Millan, E., Ravishankar, C.N. (eds.), Research Methodology in Food Sciences. Apple Academic Press and CRC Press, pp. 341-367.

4. Das, S., Lalitha, K. V., Alavandi, S. V., Vijayan, K. K., 2018. Seafood-borne pathogens and their role in public health and export. In :Compendium cum Souvenir of 8th Conference of Indian Meat Science Association and International Symposium on Technological Innovation in Muscle Food Processing for Nutritional Security, Quality and Safety at West Bengal University of Animal and Fishery Sciences, Kolkata, pp 267-272.

5. Dayal, J.S., Ambasankar, K., Vasagam, K.P.K., 2018. Shrimp nutrition. In: Training Manual Molecular Biology and Biotechnology for Fisheries Professionals. CMFRI Training Manual Series No. 15/2018, pp 409-415, ISBN 978-93-82263-24-1.

6. Ghoshal, T.K., De, D., Biswas, G., Kumar, P., Vijayan, K.K., 2019. Brackishwater aquaculture: opportunities and challenges for meeting livelihood demand in Indian Sundarbans. In: Sen, H. (Ed.), The Sundarbans: A Disaster-Prone Eco-Region. Coastal Research Library, vol. 30. Springer, Cham, pp 321-349.

7. Manjaiah, K. M., Mukhopadhyay, R., Paul, R., Datta, S. C., Kumararaja, P., Sarkar, B., 2019. Clay minerals and zeolites for environmentally sustainable agriculture. In: Mariano Mercurio, Binoy Sarkar, Alessio Langella (Eds.,), Modified Clay and Zeolite Nanocomposite Materials: Environmental and Pharmaceutical Applications, Elsevier, pp.309-329.

8. Muralidhar, M., Vijayan, K.K., 2019. Adaptation and mitigation strategies for climate-smart shrimp aquaculture. In: Souvenir Book, National Seminar on Climate-Smart Aquaculture and Fisheries, 15-16 January, 2019 at College of Fisheries, CAU (Imphal) Tripura.

9. Shekhar, M.S., Gopikrishna, G., Vijayan, K.K., 2019. Abiotic stress-response of black tiger shrimp *penaeus monodon* to salinity stress. In :Advances in Fish Research, Vol.VII, Pages 151–163. Eds.: B.P. Mohanty, Narendra Publishing House, Delhi, India.

10. Vijayan, K.K., Mahalakshmi, P., Ghoshal, T.K., Patil, P.A., Antony, J., 2019. Opportunities in brackishwater aquaculture technologies for upliftment of livelihood of tribals. In: Barat, A., Kumar, R., Siddaiah, G. M., Sivaraman, I., Mahapatra, B.C., Pillai, B. R. (Eds.). Souvenir: National Workshop on Aquaculture as a Livelihood Option for Tribal Farmers of India. ICAR-Central Institute of Freshwater aquaculture, Bhubaneswar, Odisha, India., pp 22-29.

Oral Presentations

1. Abraham, T.J., Priyadarsani, L., 2019. Surveillance of diseases in farmed *Penaeus vannamei* in the Indian Sunderbans. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 165.

2. Amarnath, C.B., Saravanan, P., Otta, S.K., 2019. Determining the dosage and time of injection for WSSV VP28 double stranded RNA to *Penaeus indicus* in providing effective protection against the virus. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 184.

3. Anand, P.R., Kumaran, M., Kumar, J. A., Vimala, D. D., Vijayan, K. K., 2019. Vanami Shrimpapp a dynamic mobile application for technology diffusion and feedback in shrimp aquaculture. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 296.

4. Anand, P.S.S., Balasubramanian, C. P., Balamurugan, J., Rajamanickam, S., Francis, B., Aravind, R., Christina, L., 2019. Nursery rearing of mud crab: Effect of size grading, hideout provision and removal of cheliped. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 100.

5. Anand, P.S.S., Balasubramanian, C.P., Francis, B., Panigrahi, A., Aravind, R., Das, R., Sudheer, Rajamanickam, S., Vijayan, K.K., 2019. Potential and challenges in the reproductive and larval performance of wild stock of Indian white shrimp, *Penaeus indicus* along the east coast of India. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 123.

6. Antony, J., Biju, I. F., Saraswathy, R., Balasubramanian, C. P., 2019. Osmoregulation and growth characterization of Pacific white shrimp *Penaeus vannamei* post larvae acclimatised to freshwater and seawater of different salinities. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 87

7. Antony, J., Gopal, C., Ambasankar, K., Balasubramanian, C.P., Vijayan, K.K., 2019. Farming of white leg shrimp, *Penaeus vannamei* using high alkaline and low saline ground water in south western Punjab, India.In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 80.

8. Antony, J., Sandeep, K. P., Aravind, R., Panigrahi, A., Balasubramanian, C. P., 2019.Effects of salinity on the growth, survival, and osmoregulation of Indian white shrimp, *Penaeus indicus* juveniles reared in seawater and amended inland saline groundwater. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 87.

9. Antony, M.L., Baskaran, V., Avunje, S., Patil, P. K., 2019. Enrichment and characterisation of nitrifying bacteria from low-saline water bodies. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 252.

10. Anusha, S., Neeraja, T., Lavanya, C., Haribabu, P., Panigrahi, A., Ramana, T. V., 2019. Growth and immune responses of nile tilapia, *Oreochromis niloticus* reared in biofloc and substrate integrated biofloc based systems. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 209.

11. Aravind, R., Sandeep, K. P., Biju, I. F., Jose, A., Vinay, T. N., Raymond, J. A., 2019.Complete or partial replacement

of *Artemia* nauplii by Cladoceran species during early post larval stages of Indian white shrimp (*Penaeus indicus*). In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 133.

12. Arulraj, R., Saravanan, P., Bala, C. A., Otta, S.K., 2019. Prevalence and genetic variation of WSSV in *Litopenaeus vannamei* cultivated ponds in India. National Awareness Conference on the values of biodiversity and its conservation. 7 & 8th Mar 2019. Dr. Ambedkar Arts and Science college, Chennai – 39

13. Arulraj, R., Saravanan, P., Bala, C. A., Otta, S.K., 2019. Shrimp white spot syndrome virus (WSSV) maintains similar genotype and virulence during co-infections with infectious hypodermal and haematopoetic necrosis virus (IHHNV). In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 184.

14. Ashok, S., Kumar, J.A., Kumar, K.V., Avunje, S., Grover, M., Alavandi, S.V., Vijayan, K. K., 2019. On improving functional annotations in RIMD 2210633O3:K6 strain of *Vibrio parahaemolyticus* through in silico reannotation approaches. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 224.

15. Balachandran, S., Vasagam, K.P.K., Ambasankar, K., 2019.Intensive rearing of pearlspot (*Etroplus suratensis*) fish fry under different feed and feed management tactics. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 157.

16. Balamurugan, J., Balasubramanian, C. P., Anand, P.S.S., Biju, I. F., Aravind, R., Vijayan, K. K., 2019.In-vitro fertilization and hybridization potential of Indian white shrimp, *Penaeus indicus.* In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 134.

17. Balasubramanian, C. P., Antony, J., Balamurgan, J., Anand, P.S.S., Biju, I. F., Vijayan, K. K., 2019. Development of small scale hatchery for mud crab, *Scylla serrata.* In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 138.

18. Balasubramanium, A. A. K., Jayanthi, M., Prakash, S.S., Gnanavel, S., Arvindan, 2019.Assessment of variation in energy use for aeration in *Penaeus vannamei* culture ponds. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 103.

19. Baskaran, V., Antony, L.M., Kumar, D.N., Avunje, S., Alavandi, S.V., Patil, P.K., 2019.Metagenomic analysis of microbial consortia involved in mitigation of nitrogen and ammonia from brackishwater aquaculture system. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 252.

20. Bera, A., Kailasam, M., Biswas, G.,

Mandal, B., Kumar, P., Sivaramakishnan, T., Thiagarajan, G., 2019. Dissemination of milkfish (*Chanos chanos*) farming technology among the farmers in West Bengal – ICAR-CIBA initiatives. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 102.

21. Bhuvaneswari, T., Krishnan, A. N., Jithendran, K.P., Alavandi, S.V., 2019. Exploring the susceptibility of mammalian and fish cell lines for in *vitro* cultivation of shrimp microsporidian, *Enterocytozoon hepatopenaei.* In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 180.

22. Biju, I. F., Balasubramanian, C. P., Anand, P.S.S., Antony, J., 2019.Effect of molting stages on the spermatophore quality of male *Penaeus indicus* (Indian white shrimp) broodstock. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 132.

23. Biswas, G., Kumar, P., Ghoshal, T.K., Kailasam, M., Vijayan, K.K., 2018. System diversification in brackishwater aquaculture of India: research support on fish culture options for sundarban producers. In: Sonmez, A.Y., Bilen, S., Terzi, E., Kadak, A.E. (Eds.), International Congress on Engineering and Life Science (ICELIS 2018)- Book of Abstracts, 26-29 April, 2018, Kastamonu, Turkey, pp. 405.

24. Biswas, G., Kumar, P., Kailasam, M., Ghoshal, T.K., Bera, A., Vijayan, K.K., 2019. Application of integrated multi-trophic aquaculture (IMTA) concept in brackishwater eco-system: The first exploratory trial in Sundarban, India. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.79

25. Chrisolite, B., Thiyagarajan, S., Alavandi, S.V., 2019.DNA fingerprinting of *Vibrio harveyi* from south-east coast of India by pulsed field gel electrophoresis (PFGE) and their relationship with virulence factors. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 177.

26. Das, R.R.,Ranjan, R., Panigrahi, A., Saravanan, A., Biju, I.F., Ambikanandham, K., Anand, P.S.S., Arumugam, S., Kannappan, S., 2019. Growth and survival of post larvae of *Penaeus indicus* (H.Milne Edwards, 1937), Indian white shrimp in different salinities with biofloc system during nursery phase. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 110.

27. Das, S., De, D., Biswas, G., Kumar, P., Lalramchhani, C., Kumar, S., Ghoshal, T.K., 2019. Effect of molasses supplementation on growth and water microbial dynamics during indoor rearing of Pacific white shrimp (*Penaeus vannamei*). In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 231.

28. Dayal, J.S., Ambasankar, K., Vasagam, K.P.K., Jannathulla, R., Kumaran, M., Kailasam, M., 2019. Influence of farming systems on nutrient profile of Asian seabass, *Lates calcarifer.* In: World

Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 156.

29. Dayal, J.S., Ambasankar, K., Vasagam, K.P.K., Jannathulla, R., Kumaran, M., Kailasam, M., 2019. Influence of farming systems on nutrient profile of Asian seabass, *Lates calcarifer.* In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 156.

30. Dayal, J.S., Vasanth, M., Jannathulla, R., Kathyayani, S., Ambasankar, K., Muralidhar, M., 2019. Effect of dietary protein level on nutrient utilization and greenhouse gases emission in *Penaeus vannamei.* In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 240.

31. De, D., Anand, P.S.S., Mukherjee, S., Suresh, V. R., 2019.Embryonic development, larval advancement and appearance of digestive enzyme in gut of hilsa, *Tenualosa ilisha.* In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 130

32. De, D., Mukherjee, S., Naha, S., Kumar, P., Vijayan, K. K., 2019.Weaning of hilsa (*Tenualosa ilisha*) fry to formulated feed and study on their dietary protein and lipid requirement. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 155.

33. De, D., Sivaramakrishnan, T., Sandeep, K. P., Vasagam, K.P.K., Dayal, J.S., Ambasankar, K., 2019.Effect of dietary taurine supplementation on growth and feed efficiency of milkfish (*Chanos chanos*) larvae. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 155.

34. Debnath, D., Manna, S.K., Devnath, D.J., Payeng, L.K., Bandopadhyay, C., Das, N., Das, B. K., Bhattacharjya, B. K., Patil, P. K., Avunje, S., Geetha, R., Vijayan, K.K., 2019. Aquaculture practices, major diseases and economic loss due to fish diseases in Assam, Northeast India. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 85

35. Duraisamy, M., Jayanthi, M., Thirumurthy, S., Samynathan, M., Vijayakumar, S., Nagaraj, G., 2019. Assessment of coastal resource use for aquaculture in Nellore district, India using remote sensing and GIS. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 253.

36. Geetha, R., Halesh, K., Avunje, S., Patil, P. K., Ravisankar, T., 2019. Meta-analysis of impact of veterinary medical products (VMPs) and chemical usage in brackishwater ecosystem. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 255

37. Geetha, R., Ravisankar, T., Sairam, C. V., Avunje, S., Vinoth, S., Patil, P. K., 2019.

Export performance of Indian farmed shrimp and way forward. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 289

38. Ghoshal, T.K., Mondal, A., Das, S., Biswas, G., Kumar, P., Lalramchhani, C., Leesa, P., 2019. Performance of orange mud crab, *Scylla olivacea* co-cultured with fishes in earthen brackishwater ponds of sundarban. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 97.

39. Halesha, K., Nithin, M.S., Avunje, S., Muralidhar, M., Alavandi, S.V., Patil, P. K., 2019.Development and implementation of hazard analysis and critical control point for shrimp hatcheries in India. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 89.

40. Hussain, T., Kailasam, M., Bera, A., Sivaramakrishnan, T., Kumararaja, P., Babu, D.R., Thiagarajan, G., 2019. Evaluation on the growth of milkfish *Chanos chanos* fry using different carbon sources in biofloc based nursery rearing system. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 97.

41. Jagadeesan, V., Praveena, P. E., Otta, S. K., Jithendran, K. P., 2019. Classical runt deformity syndrome cases in farmed *Penaeus vannamei* along the east coast of India. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 204.

42. Jangam, A.K., Dyane, P., Kumar, K.V., Avunje, S., Grover, M., Alavandi, S.V., Vijayan, K. K., 2019.VpSNP: SNP visualisation tool for *Vibrio parahaemolyticus.* In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 226.

43. Jannathulla, R., Dayal, J.S., Ambasankar, K., Yuvapushpa, R., Kumar, J.A., Muralidhar, M., 2019. Evaluation of fungal fermented rapeseed meal as a fishmeal substitute in the diet of *Penaeus vannamei.* In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 148.

44. Jayanthi, M., Samynathan, M., Thirumurthy, S., Duraisamy, M., Muralidhar, M., Vijayan, K. K., 2019. Geospatial mapping of coastal resources for sustainable aquaculture expansion-A case study from India. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 238.

45. Kabira, S., Jayanthi, M., Thirumurthy, S., Saminathan, M., Duraisamy, M., Vijaykumar, S., 2019. Assessment of soil salinity in coastal Tamil Nadu using remote sensing techniques. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi),

January 23-25, 2019, Chennai, p. 245.

46. Kailasam, M., Hussain, T., Sivaramakrishnan, T., Bera, A., Thomas, D., Ambasankar, K., Sathishkumar, T., Kumar, S., Subburaj, R., Thiagarajan, G., Babu, D.R., 2019.Development of mangrove red snapper *Lutjanus argentimaculatus* broodstock in tank based rearing system. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 136.

47. Kannappan, S., Krishnan, A. N., Jithendran, K. P., Sivagnanam, S., Lini, R.M., Balasubramanian, C. P., 2019. Development of production system for mud worm polychaete (*Marphysa gravelyi*) with a note on biochemical composition. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.

48. Karthikeyan, V., Balachandran, S., Vasagam, K. P. K., Raja, R.A., Sathishkumar, K., Ambasankar, K., 2019. Contribution of biofloc to growth and survival of *Penaeus vannamei* evidenced by electron microscopical and histological observations of the digestive tract. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.159.

49. Kathyayani, S.A., Muralidhar, M., Kumar, T.S., Alavandi, S.V., 2019. Stress quantification in *Penaeus vannamei* exposed to varying levels of turbidity. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 241.

50. Krishnan, A.N., Aneesh, P.T., Kannappan, S., Praveena, P.E., Jithendran, K.P., 2019.Role of the polychaete worms in the transmission of *Enterocytozoon hepatopenaei* in shrimp-field and laboratory studies. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 202.

51. Krishnan, A.N., Jagadeesan, V., Anushya, S., Praveena, P.E., Rajan, J.J.S., Jithendran, K.P., 2019.Detection of mixed infection of *Enterocytozoon hepatopenaei* and infectious myonecrosis virus in *Penaeus vannamei* farm in the east coast of India. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 204.

52. Kumar, K.V., Karthic, K., Shekhar, M.S., Kumar, J.A., Ashok, S., Vijayan, K. K., 2019.Missing Region Finder (MRF): A tool to identify deletions in genomes. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 223.

53. Kumar, K.V., Kumar, J.A., Shekhar, M.S., Nimisha, K., Karthic, K., Vijayan, K. K., 2019. dbVAST: Database of variations in annotated shrimp transcripts. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 222.

54. Kumar, K.V., Shekhar, M.S., Kumar, J.A.,

Karthic, K., Gopikrishna, G., Vijayan.K.K., 2018. Assembling complete genome of *Penaeus indicus*: A glimpse. In: National Symposium on 'The applications of genomics and proteomics in Aquaculture, Fisheries and Marine biology (omicsAFM 2018)', Sathyabama Institute of Science and Technology, June 20-21, 2018, Chennai.

55. Kumar, P. B., Shekhar, M.S., Angel, J.R.J., Swathi, A., Karthic, K., Kumar, K.V., Vijayan, K. K., 2019. Flow cytometry analysis of the genome size of three important brackishwater fish species. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 223.

56. Kumar, P., Biswas, G., Ghoshal, T.K., De, D., 2019. Larval development, rearing and digestive tract ontogeny of Indian Shad, *Tenualosa ilisha.* In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.126.

57. Kumar, S., Vidya, R., Rajan, J.J.S., Kumar, J. A., Katneni, V. K., Viswas, K. N., Alavandi, S.V., Vijayan, K. K., 2019.Virulence and metabolic characterization of emerging bacterial pathogen, *Vibrio campbellii* – A genomic perspective. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.197.

58. Kumar, S.S., Bharathi, R.A., Rajan, J.J.S., Balasubramanian, C.P., Alavandi, S.V., 2019. Role of bivalve mollusk (*Meretrix meretrix*) in the transmission of white spot syndrome virus (WSSV) in shrimp. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 196.

59. Kumar, T. S., Bhaskar, V., Alavandi, S. V., Vijayan, K. K., 2019. Physiological status and microbes associated with *Peneaus vannamei* larvae affected by zoea-2 syndrome. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 205.

60. Kumar, T.S., Alavandi, S.V., Jithendran, K.P., Vijayan, K.K., 2019. Enterocytozoonhepatopenaei(EHP)–A probable causative agent of white feces syndrome. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 186.

61. Kumaran, M., Ghoshal, T. K., De, D., Biswas, G., Vijayan, K. K., 2018. Impact of brackishwater aquaculture based farming system models in enhancing the livelihood security of coastal farm families in the sundarban region of West Bengal. Paper presented in the National Seminar on Integrated farming System for enhancing the Farmers Income and Nutritional Security held at Kolkata during 5-8th December, 2018 organized by the Indian Society of Extension Education, T3-024, Book of Souvenir and Abstracts, p.211.

62. Kumaran, M., Vasagam, K. P. K., Kailasam, M., Subburaj, R., Anand, P.R., Kumar, S., Santhanakumar, J., Vijayan, K. K., 2019. Three tier system of cage aquaculture in opern brackishwaters for livelihood security and doubling the income of coastal fishers. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture

(CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 286.

63. Kumararaja, P., Aravind, R., Suvana, S., Saraswathy, R., Muralidhar, M., Vijayan, K.K., 2019. Suitability of sites for inland saline aquaculture in arid and semi-arid regions of Rajasthan. In: Book of abstracts, Golden Jubilee International Salinity Conference on Resilient Agriculture in Saline Environments under Changing Climate: Challenges and Opportunities (GJISC), conducted during 7-9 February, 2019, Karnal. p.8.

64. Kumararaja, P., Premi, O.P., 2019. Optimization of method and timing of boron fertilizer application for enhancing Indian mustard yield under semi-arid condition. In: Book of abstracts, Golden Jubilee International Salinity Conference on Resilient Agriculture in Saline Environments under Changing Climate: Challenges and Opportunities (GJISC), conducted during 7-9 February, 2019, Karnal. p.190.

65. Kumararaja, P., Suvana, S., Muralidhar, M., 2019. Effect of oxidising agents on enzyme activity and quality of shrimp pond sediment. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 238.

66. Lalitha, N., Patil, P. K., Rajesh, R., Muralidhar, M., 2019. Usage of edible mushroom to degrade oxytetracycline in varying water salinity in brackishwater rearing system. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.175.

67. Lalramchhani, C., Balusubramanian, C.P., Panigrahi, A., Das, S., Anand, P.S.S., Ghoshal, T.K., Vijayan, K.K., 2019. Polyculture of Indian white shrimp (*Penaeus indicus*) with milkfish (*Chanos chanos*) and its effect on growth performances, water quality and microbial load in brackishwater pond. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 97.

68. Mahalakshmi, P., Balasubramanian, C. P., Kailasam, M., Saraswathy, R., Ravisankar, T., Bera, A., Sairam, C. V., Aravind, R., Sivagnanam, S., Vijayan. K. K., 2019. Family farming in brackishwater aquaculture for livelihood support of coastal communities near Adyar creek. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 295.

69. Makesh, M., Aathithya, R., Satyanarayana, N., Kumar, S., Patil, P. K., Jithendran, K. P., Subburaj, R., Thiagarajan, G., Kailasam, M., Vijayan, K. K., 2019. Development of inactivated oral NNV vaccine for Asian seabass, *Lates calcarifer.* In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.166.

70. Mandal, B., Kailasam, M., Makesh, M., Bera, A., Sukumaran, K., Sivaramakrishnan, T., Thiagarajan, G., Subburaj, R., 2019. Reproductive hormone profile and gonadal recrudescence of female spotted scat (*Scatophagus argus*) in captivity. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 129.

71. Manimaran, K., Prabu, V.A., Jayanthi, M., Karthikeyan, P., Veerapandiyan, N., 2019. Effect of cadmium on growth, biomass and morphological changes of centric diatom *Odontella mobiliensis* (J.W.Bailey Grunow, 1884). In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 266.

72. Merlin, J. R., Mohanlal, D. L., Balasubramanian, C. P., Murugan, B., Vijayan, K. K., 2019.Expression profile of ecdysteroid receptor mRNA in wild broodstock of giant tiger shrimp, *Penaeus monodon*. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 123.

73. Muralidhar, M., Kumararaja, P., Jayanthi, M., Balasubramanian, C.P., Nagavel, A., Vijayan, K.K., 2019.Carrying capacity assessment of creeks and environmental impact assessment for mangrove crab farming. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 243.

74. Nandakumar, S., Ambasankar, K., Dayal, J.S., Vasagam, K.P.K., Ali, S.R., 2019. Corn protein concentrate as an alternate for fishmeal in the diet of Asian seabass, *Lates calcarifer*. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 142.

75. Neethu, K. C., Dhinesh, G., Dharani, G., 2019.Analysis of mixing system and paddlewheel design for algal biomass production in raceway ponds. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 99.

76. Palanichamy, E., Panigrahi, A., Sundaresan, J., Saranya, C., Yuvaraj, S., Sudheer, N.S., Anand, P.S.S., 2019. Enzymatic and other beneficial role of gut microbes isolated from the shrimp *Penaeus vannamei* reared in heterotrophic farming system. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 199.

77. Panigrahi, A., Das, R.R., Saravanan, A., Anand, P.S.S., Vasagam, K.P.K., Christina, L., Ambasankar, K., Kumar, K.V., Kannappan, S., Mahalakshmi, P., Balasubramanium, C. P., Gopikrishna, G., Vijayan, K. K., 2019.Production performance and genetic potential of Indian white shrimp: ICAR-CIBA initiatives and strategy for its propagation. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 112.

78. Panigrahi, A., Sundaram, M., Saranya, C., Das, R.R., Dayal, J.S., 2019.Evaluation of different carbon source for growth performances, immunomodulation and protective response of pacific white shrimp *Penaeus vannamei* under biofloc system. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 98.

79. Patil, P. A., Kailasam, M., Sairam, C. V., Hussain, T., Subburaj, R.,

Sivaramakrishnan, T., Thiyagarajan, G., Palav, K.V., Bhalekar, M.S., Mallick, S., Vijayan, K. K., Vasedevan, N., 2019. Promotion of three tier seabass (*LatesCalcifer*) farming technologies among self help groups, to support rural livelihood in Sindhudurg district of Maharashtra. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 296.

80. Peruzza, L., Shekhar, M.S., Swathi, A., Karthic, K., Kumar, P.B., Sudeesh, K. P., Kumar, K.V., Gopikrishna, G., Hauton, C., Vijayan, K. K., 2019.Understanding the course of infection: Determining gene expression changes with time in *Penaeus vannamei* infected with white spot syndrome virus. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 212.

81. Poornima, M., Raja, R.A., Alavandi, S.V., Vijayan, K.K., 2019. Disease outbreaks in cultured mud crab (*Scylla* spp.) and health management with special reference to white spot disease. Presented in awareness programme on crab culture and disease aspects conducted on 6th March, 2019 at Bhavadevarapalli, Krishna district by Department of Fisheries, Krishna district, Government of Andhra Pradesh.

82. Poornima, M., Rajan, J.J.S., Alavandi, S.V., Vijayan, K.K., 2019. Challenges to diversification of fish farming with special reference to endemic and emerging viral diseases. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.173.

83. Poornima, M., Saravanan, P., Rajan, J.J.S., Alavandi, S.V., Vijayan, K.K., 2019. Development of SYBR Green based real time PCR technique for detection of Penaeus stylirostris densovirus (PstDNV). In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.174

84. Praveena, P.E., Jagadeesan, V., Otta, S.K., Jithendran, K.P., Alavandi, S.V., 2019. Loop-mediated isothermal amplification method for diagnosis of infectious hypodermal haematopoietic disease of shrimps. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 198.

85. Preetha, K., Sandeep, K. P., Nair, N.P., Vijayan, K. K., Philip, R., 2019. Prospective use of *Aurantiochytrium* sp. MBT21 (Thraustochytrid) in aquaculture as a nutritional supplement. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 142.

86. Priyadarsani, L., Ghoshal, T.K., Das, S., Ambasankar, K., 2019. Effect of seaweed as a growth and health promoting feed ingredient in the diet of milkfish (*Chanos chanos*) fingerlings. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 192.

87. Raja, R.A., Jithendran, K.P., Kailasam, M., Subburaj, R., Thiagarajan, G., 2019. Prevalence of parasitic infestations in candidate brackishwater finfishes in

south-east coast of India. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.205.

88. Raja, R.A., Patil, P.K., Avunje, S., Jithendran, K.P., Ambasankar, K., De, D., 2019. Biosafety of anti-parasitic drug emamectin benzoate (EB) in Asian seabass, *Lates calcarifer*. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.196.

89. Raja, R.A., Vasagam, K. P. K., Bhuvaneswari, T., 2018. Fatty liver syndrome in pearlspot, *Etroplus suratensis*. Presented in the Fourth National Agricultural Science Tamil Research Conference organized by Agricultural Scientific Tamil Society, New Delhi at The Directorate of Research, TNFU Campus, OMR, Vaniyanchavadi, Chennai during 10-20th November 2018.

90. Raja, R.N., Rekha, P.N., Naresh, V., Sarkar, C., Kumar, M.C., 2019.Empirical algorithm for estimating Chlorophyll-a, turbidity and salinity in Pulicat lake using remote sensing and GIS. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 281.

91. Ramachandran, K., Ambasankar, K., Balachandran, S., 2019.Fish silage as a novel ingredient in the diet of milkfish, *Chanos chanos*. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 152.

92. Ravisankar, T., Geetha, R., Patil, P. K., Sairam, C. V., Vinoth, S., 2019. Economic impacts of commercialization of brackishwater aquaculture technologies. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 291.

93. Ravisankar, T., Vijayan, K.K., 2018. Brackishwater Aquaculture Technologies. In: Souvenir of National Workshop on "Chola Aqua'18 scientific and societal challenges in industrial aquaculture" organized by Tamil Nadu Dr. J.Jayalalitha Fisheries University, held on 25th September 2018 at TNJFU Headquarters, Vettar River View Campus, Nagapattinam.

94. Ray, A.K., Halesha, K., Vinay, T.N., Avunje, S., Kumar, T.S., Patil, P.K., 2019.Inactivated *Vibrio harveyi* biofilm, developed on chitin flakes improves growth, survival and health status of *Penaeus vannamei*. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 195.

95. Ray, A.K., Patil, P.K., Solanki, H.G., Bhuvaneswari, T., Sivakumar, K., Kannappan, S., Gopal, C., 2019. Incidence of Vibrio infection causing mass mortality in Indian cage culture of pearl spot fish (*Etroplus suratensis*). In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 94.

96. Raymond, J.A.J., Vinay, T. N., Kumar, K.V., Thomas, D., Satheesha, A., Sandeep, K. P., Aravind, R., Shekhar, M.S., 2019. Ricefish, *Oryzias* sp. (Family: Adrianichthyidae), as a model brackishwater fish species with notes on its breeding and early developmental stages. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 220.

97. Rekha, M. U., Sukumaran, K., Tomy, S., Vidya, R., Balasubramanian, C.P., Kailasam, M., Vijayan, K.K., 2019. Reproductive biology of *Mugil cephalus* (Linnaeus 1758) F. Mugilidae from Cochin back waters, south west coast of India. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 139.

98. Rekha, P.N., Sarkar, S., Biswas, G., Ghoshal, T.K., Ambasankar, K., Balasubramanian, C.P., 2019.Culture potential of the seaweed, *Gracilaria tenuistipitata* (Rhodophyta) in brackishwater tide-fed pond system of Sundarban, India. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 266.

99. Sagar, L.V., Karunakaran, R., Dayal, J.S., Ambasankar, K., Rani, P.V., Gnanaraj, T., Bharathidhasan, A., Venkateswarlu, S., 2019. Biochemical composition of marine macroalgae from south-eastern coast of India (Gulf of Mannar). In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 154.

100. Saikrithi, P., Balasubramanian, C. P., Otta, S.K., Tomy, S., 2019. Identifcation and characterization of dopamine receptor and its role in ovarian maturation in the Indian white shrimp, *Penaeus indicus.* In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 127.

101. Sairam, C.V., Ravisankar, T., Geetha, R., Vijayan, K. K., Pradeep, B., Vikas, P. A., Ravi, S., 2019. Brackishwater aquaculture farming- a profitable enterprise for doubling farmers income. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.284

102. Samynathan, M., Jayanthi, M., Thirumurthy, S., Duraisamy, M., Vijayakumar, S., Nagaraj, G., 2019.Spatial and temporal changes in mangrove cover in Goa using multi-decadal satellite data and GIS. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 274.

103. Sandeep, K. P., Avunje, S., Sivaramakrishnan, T., Biju, I. F., Dayal, J.S., Ambasankar, K., Vijayan, K. K., 2019. Efficiency of different microalgae in larval rearing of *Penaeus indicus*. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 137.

104. Sandeep, K.P., Sivaramakrishnan, T., Angel, J.R.J., De, D., Ambasankar, K., Vijayan, K.K., 2019. Potential of C-Phycocyanin production from spirulina (*Arthrospira maxima*) isolated from a tropical estuary

in South India. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 152.

105. Saranya, C., Panigrahi, A., Jayashree, S., Sundaram, M., Arvind, R., Otta, S.K., 2019. Efficacy of carbon source supplementation in biofloc system on water quality, microbial composition, growth and digestive enzyme activity of shrimp *P. vannamei* culture. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 111.

106. Saraswathy, R., Muralidhar, M., Rajesh, R., Balasubramanian, C.P., Antony, J., Vijayan, K.K., 2019. Pacific white shrimp *Penaeus vannamei* for climate resilient aquaculture and livelihood. World disaster management congress conducted during 29 January - 1 February, 2019 at Mumbai. pp.76 - 77

107. Saraswathy, R., Muralidhar, M., Ravisankar, T., Suvana, S., Kumaraja, P., 2019. An evaluation of economic benefits of lined and earthen ponds in shrimp farming. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.117.

108. Saravanan, P., Amarnath, C. B., Otta, S.K., 2019. Flow cytometry analysis to determine the status of shrimp haemocytes during white spot syndrome virus (WSSV) infection. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 185.

109. Sarkar, P.S., Rekha, P.N., Balasubramanian, C. P., Rajamanickam, S., Ambasankar, K., 2019.Bioremediation potential of the brackishwater macroalga *Gracilaria tenuistipitata* (Rhodophyta) co-cultured with *Penaeus vannamei* (Boone). In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 255.

110. Satheesha, A., Sandeep, K.P., Raja, R.A., Wasim, E., Alavandi, S.V., Patil, P.K., 2019. Safety of oxytetracycline for indicator organisms of brackishwater ecosystems. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.190.

111. Sethi, S.N., Kailasam, M., Kumararaja, P., Thiagarajan, G., 2019.Length weight relationship and reproductive biology of endangered canara pearlspot, *Etroplus canarensis*. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 268.

112. Shanthi, B., Mahalakshmi, P., Balasubramanian, C.P., Ambasankar, K., 2019. Brackishwater aquaculture transforms irula tribal woman -a case study from Pulicat lake. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) &Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 295.

113. Shanthi, B., Mahalakshmi, P., Kailasam, M., Sairam, C. V., Balasubramanian, C.P., Ambasankar, K., Sethi, S., Dayal, J.S., Kumararaja, P., Mandal, B., Rajababu, D., 2019. Enhancing the livelihood security

in food production among youth, coastal and tribal families through brackishwater aquaculture technologies. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 293.

114. Shekhar, M.S., Kumar, K.V., Kumar, J.A., Balasubramanian, C. P., Karthic, K., Vijayan, K. K., 2019. From gaps to bridges: Challenges in whole genome sequencing of *Penaeus indicus*, a white shrimp farmed across the south east Asia. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 213.

115. Shyam, S.S., Geetha, R., 2019. Economic recession and Indian seafood exports: reflections and paradigms. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 284.

116. Sivakumar, K., Kannappan, S., Vijayakumar, B., 2019. Molecular docking analysis of bio-inhibitors extracted from the marine macro alga, Ulva fasciata against hemolysin protein of luminescent disease-causing *Vibrio harveyi*. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 215.

117. Sivamani, B., Soman, M., Aravind, R., Kumar, K.V., Sukumaran, K., Shekhar M. S., Vijayan, K. K., 2019.Genetic diversity studies on pearlspot fish in Indian waters. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 220.

118. Sivamani, B., Soman, M., Kumar, K.V., Tomy, S., Shekhar, M. S., Gopikrishna, G., 2019. *Etroplus maculatus* fishfrom Pulicat and Vembanad are genetically divergent. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 218.

119. Sivaramakrishnan, T., Ambasankar, K., Vasagam, K.P.K., Sandeep, K. P., Bera, A., Hussain, T., Makesh, M., Kailasam, M., Vijayan, K. K., 2019.Effect of dietary vitamin C supplementation on growth and survival of milkfish, *Chanos chanos* larvae. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 141.

120. Sivaramakrishnan, T., Kailasam, M., Vasagam, K.P.K., Mandal, B., Sandeep, K.P., Thomas, D., Makesh, M., Ambasankar, K., 2019.Dietary effects of two carotenoid sources on growth and skin colouration of spotted scat, *Scatophagus argus*. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 149.

121. Soman, M., Sivamani, B., Kumar, K.V., Tomy, S., Shekhar, M. S., Gopikrishna G., Vijayan, K. K., 2019.Population genetic structure of *Chanos chanos*, milkfish along the Indian coast inferred from mitochondrial DNA markers. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater

Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 221.

122. Subburaj, R., Thiagarajan, G., Sukumaran, K., Patil, P.A., Kumar, P., Hussain, T., Kailasam, M., Vijayan, K.K., 2019. Management strategies for economically viable operation of seabass fingerling production during nursery rearing. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.

123. Suganya, N., Kumar, J. A., Ashok, S., Kumar, K.V., Kumar, S., Sivamani, B., Grover, M., Alavandi, S.V., Vijayan, K.K., 2019.Deciphering inter and intra specific genomic diversity of *Vibrio* spp. through pangenome analysis. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 224.

124. Sukumaran, K., Thomas, D., Rekha, M.U., Bera, A., Mandal, B., Makesh, M., Ambasankar, K., Subburaj, R., Thiagarajan, G., Kailasam, M., Vijayan, K.K., 2019. Growth and reproductive parameters of two geographical groups of grey mullet *Mugil cephalus* Linnaeus, 1758 in captivity. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.133.

125. Sundaram, M., Panigrahi, A., Vijay, M., Saranya, C., Otta, S.K., 2019. Distillery effuent as a carbon source at various levels on growth performances, water quality and immune responses with biofoc system. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 98.

126. Suvana, S., Lalitha, N., Avunje, S., Baldev, E., Kumararaja, P., Saraswathy, R., Nagavel, A., Muralidhar, M., 2019. Comparative disinfection and residual effect of peracetic acid with other disinfectants in aquaculture. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.246a.

127. Swathi, A., Kumar, P.B., Karthic, K., Kumar, K.V., Gopikrishna, G., Muralidhar, M., Hauton, C., Shekhar, M.S., 2019. Influence of abiotic factors variations on white spot syndrome disease outbreak in shrimp culture ponds: A case study. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 198.

128. Swathi, A., Shekhar, M.S., Karthic, K., Kumar, P.B., Sudeesh, K., Kumar, K.V., Gopikrishna, G., Hauton, C., Peruzza, L., Vijayan, K. K., 2019.Molecular characterization of genes regulating apoptosis in *Penaeus vannamei* and their functional role against white spot syndrome virus (WSSV). In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 221.

129. Swathi, A., Shekhar, M.S., Kumar, P.B., Karthic, K., Kumar, K.V., Gopikrishna, G., Muralidhar, M., Hauton, C., Vijayan, K.K., 2018. Variations in pond abiotic factors associated with white spot syndrome virus (WSSV) outbreak in shrimp culture ponds: A case study. In: Proceedings of the National Symposium on the Application of

Genomics and Proteomics in Aquaculture, Fisheries, & Marine Biology (omicsAFM 2018), Sathyabama Institute of Science and Technology, June 20-21, 2018, Chennai, P.9.

130. Thirumurthy, S., Jayanthi, M., Samynathan, M., Duraisamy, M., Nagaraj, G., Anbazhahan, N., 2019. Quantitative analysis of shoreline changes in Tiruvallur district, India using digital shoreline analysis system (DSAS) techniques. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 251.

131. Thomas, D., Raymond, J. A., Kumar, T.S., Sukumaran, K., Kailasam, M., 2019. Ultrastructure and spermatological characteristics of spermatozoa of silver moony, *Monodactylus argenteus.* In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 134.

132. Tomy, S., Bera, A., Hussain, T., Rekha, M.U., Thiagarajan, G., Sukumaran, K., Kailasam, M., 2019.Sex identification in grey mullet, *Mugil cephalus*, using plasma levels of vitellogenin and sex steroids. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 126.

133. Veerapandiyan, N., Karthikeyan, P., Jayanthi, M., Manimaran, K., Sampathkumar, P., 2019. Effect of cadmium on growth, chlorophyllaand malondialdehyde of the diatom *Asterionellopsis glacialis*. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 269.

134. Vidya, R., Bera, A., Kumar, T.S., Makesh, M., Kilasam, M., Alavandi, S.V., 2019. Microbial flora of milkfish and Asian seabass laraval rearing systems. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.192

135. Vijayakumar, S., Sakthivel, M., Jayanthi, M., Duraisamy, M., Samynathan, M., Thirumurthy, S., Kabiraj, S., 2019.Appraisal of groundwater quality using water quality index and geostatistical algorithms. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 254.

136. Vijayan, K. K., Anand, P.S.S., Balasubramanian, C. P., Biju, I. F., Praveena, P.E., Aravind, R., Panigrahi, A., Otta, S.K., 2019. Evaluation of white spot syndrome virus in the wild spawning population of Indian white shrimp, *Penaeus indicus*. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 167.

137. Vijayan, K. K., Sairam, C. V., Ravisankar, T., Geetha, R., 2019. Brackishwater aquaculture- the prospective sector for doubling farmer's income. Paper presented in the National Conference on Doubling of Farmers Income from 18-19th May 2018 at Doon Business School Dehra Dun

138. Vijayan, K.K., 2019. Towards domestication and genetic improvement of native Indian white shrimp, *Penaeus*

indicus : a complimentary desi option to exotic *Penaeus vannamei.* In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, pp. 34-39.

139. Vijayan, K.K., Mahalakshmi, P., Ghoshal, T.K., Patil, P.A., Antony, J., 2019. Opportunities in brackishwater aquaculture technologies for upliftment of livelihood of tribals. In: e-Souvenir cum Extended Abstracts of National Workshop - Aquaculture as a Livelihood Option for Tribal Farmers of India at ICAR-CIFA, Bhubaneswar, February 18-19, pp. 22-29.

140. Vimala, D.D., Sairam, C. V., Kailasam, M., Ambasankar, K., Subburaj, R., Thiagarajan, G., 2019. Utilization of open brackishwater bodies for seabass fingerling production as livelihood support activity among the rural community. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 292.

141. Vinay, T. N., Raymond, J. A., Aravind, R., Kumar, K.V., Balasubramanian, C. P., Shekhar, M. S., Gopikrishna, G., Vijayan, K. K., 2019.Mitochondrial DNA study reveals the cryptic species *Penaeus japonicus* (form- II) in Indian waters. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p. 218.

142. Vinoth, S., Ravisankar, T., Geetha, R., Vijayan, K. K., Patil, P. K., Sairam, C. V., 2019. Impact of vannamei introduction in place of monodon culture in India. In: World Brackishwater Aquaculture Conference (BRAQCON 2019). Book of Abstracts, ICAR-Central Institute of Brackishwater Aquaculture (CIBA) & Society of Coastal Aquaculture and Fisheries (SCAFi), January 23-25, 2019, Chennai, p.293

PARTICIPATION IN CONFERENCES, MEETINGS, WORKSHOPS AND SYMPOSIA

Director

1. Workshop on 'Brackishwater Fish Farming', an initiative for the development of brackishwater aquaculture, organized by Anthoor Municipality at Kannur on 5 April 2018
2. Review Meeting of ICAR Regional Committee No.VIII at Sugarcane Breeding Institute, Coimbatore on 17th April 2018
3. 61st Foundation Day of Central Institute of Fisheries Technology, Kochi on 28th April 2018
4. Review Meeting of the Directors of Fisheries Institutes of ICAR and DADF Institutes to discuss regarding Skill Development Programmes, organized by National Fisheries Development Board (NFDB) at Hyderabad on 2May 2018.
5. Inauguration of the first customized shrimp feed mill at Bhiwani, Haryana and Farmers Meet-cum-MOU signing ceremony with Dr.Attar Aqua Feed at Bhiwani, Harayana, under the ARYA initiative in connection with Vanamiplus feed technology transfer on 15 May 2018.
6. Inauguration of the Navsari-Gujarat Research Centre of CIBA at Navsari Agricultural University Campus, Navsari on 7 June 2018.
7. Inter-session Meeting of the Consultative Committee of the Ministry of Agriculture and Farmers Welfare, held on 2 July 2018 at Hotel Hyatt Rameshwaram
8. 90th Foundation Day of Indian Council of Agricultural Research (ICAR) at A.P.Shinde Hall, NASC Complex, Pusa , New Delhi held on 16 July 2018
9. National conference "PONSHRIMP 2018" Organized by Tamil Nadu Dr. MGR Fisheries College and Research Institute, Ponneri , TNFU on 25 July 2018 - Dr. K. Ambasankar
10. Brainstorming Workshop on "Fisheries and aquaculture development in Malabar Region", organized by Kerala University of Fisheries and Ocean Studies (KUFOS) at KUFOS, Payyanur, Kerala on 3 August 2018.
11. Consultancy Evaluation Committee of National Biodiversity Authority (NBA) at NBA, Chennai on 14 August 2018.
12. Assessment Committee Meeting for the promotion from Senior Scientist to Principal Scientist, under the Revised Career Advancement Scheme at ASRB, New Delhi on 30 August 2018
13. Inauguration of the Community Development Centre for Learning, Livelihood and Research under the CSR initiative, by KCT Group, at Bhimavaram on 12 September 2018
14. 58th Executive Committee Meeting and 24th Annual General Body Meetings of RGCA, 12th Annual General Body Meeting of NaCSA and 32nd AGM of OSSPARC organized by MPEDA at Kochi on 5 October 2018
15. Inauguration of the Aquaculture Development Cooperative Society (ADCOS) at Payyanur on 11 October 2018
16. Curtain Raiser Programme of the 80th Anniversary Celebrations, School of Marine Sciences, Cochin University of Science and Technology (CUSAT), Kochi on 2 November 2018.
17. Meeting of the Fisheries Minister of South India, at Central Marine Fisheries Research Institute, Kochi on 10-11 November 2018.
18. Fourteenth Meeting of the Project Screening Committee constituted under the Guidelines for establishment of operation of SPF Shrimp Broodstock Multiplication Centre (BMC), at Krishi Bhavan, New Delhi held on 16 November 2018.

19. 61st Meeting of the Coastal Aquaculture Authority organized by CAA at Chennai on 10December 2018
20. Fifteenth Meeting of the Project Screening Committee constituted under the Guidelines for establishment and operation of SPF Shrimp Broodstock Multiplication Centre (BMC), at Krishi Bhavan, New Delhi held on 17December 2018
21. Selection Committee Meeting for appointment of Dean (Fisheries) and Associate Professor (Aquaculture) for Kerala University of Fisheries and Ocean Studies, at KUFOS, Kochi held on 22 December 2018
22. DST-INSPIRE Internship Science Programme, hosted by Central University of Kerala, Periye, Kasargod on 26 December 2018
23. Director's Conference of ICAR Institutes held at A.P.Shinde Symposium Hall, NASC Complex, New Delhi during 31 January – 1 February 2019
24. Meeting of the Directors of Fisheries Institutes at SMD (Fisheries), ICAR, New Delhi on 2 February 2019
25. Selection Committee Meeting for the Selection of "Senior Administrative Officer" and Sixty Second meeting of the Coastal Aquaculture Authority at CAA, Chennai on 14 February 2019
26. Stakeholders Meeting to discuss various issues of shrimp aquaculture sector held at GRT Radison Blue Hotel, Chennai on 14 February 2019
27. Expert Consultation on biosecurity measures in shrimp aquaculture organized by Kerala University of Fisheries and Ocean Studies (KUFOS) in association with ReAct Asia Pacific, at Kochi on 8 March 2019

Scientists

1. Brainstorming session on Fish reproduction Biotechnology: current and Future prospects during 6-7 April 2018 at Visva-Bharati, Santiniketan, West Bengal- Dr. Premkumar
2. International Congress on Engineering and Life Science (ICELIS 2018) during 26-29 April 2018 at Kastamonu, Turkey - Dr. Gouranga Biswas
3. Syllabus Review Meet for updating postgraduate and doctoral syllabi of disciplines offered by the University, ICAR-CIFE, Mumbai on May 19-20, 2018 – Dr. M. S. Shekhar
4. Interface Meeting with developmental Departments in Tamil Nadu organized by ICAR-CRIDA, Hyderabad along with Department of Agriculture, Govt. of Tamil Nadu on 25 May 2018 at Chennai – Dr. M. Muralidhar, Dr. R. Saraswathy
5. National dialogue on Application of Artificial intelligence and Internet of Things (IoTs) in Agriculture organized by NAARM during 1-2, June 2018 at Hyderabad - Dr. M. Muralidhar
6. 16th Aquaculture Expo organized by Aqua Tech at Bhimavaram during 16-17 June, 2018 - Dr. M. Muralidhar
7. Seminar on Climate Change and Sustainable Development Jointly organized by MSSRF and Center for Environment Education on 26 June, 2018 at Chennai - Dr. M. Muralidhar
8. National Symposium on the Application of Genomics and Proteomics in Aquaculture, Fisheries and Marine Biology (omics AFM 2018) at Centre for Ocean Research, Sathyabama Institute of Science and Technology, organized by Centre for Ocean Research Col. Dr. Jeppiaar Research Park, Sathyabama Institute of Science and Technology, June 20-21, 2018, Chennai - Dr. M. S. Shekhar, Dr. K. Vinaya Kumar
9. Regional Committee meeting for Zone-II during June 21-14 2018 at ICAR-CIFA, Bhubaneswar - Dr. T.K. Ghoshal
10. Brainstorming Workshop on Start-up India Programme for Aquaculture Sector on the occasion of ICAR Industry Day Celebration organized by CIBA on 16 July 2018 at Chennai - Dr. M. Muralidhar, Dr. B. Sivamani
11. One day workshop on ranking of ICAR institutes at NAARM, Hyderabad, 20 July 2018 – Dr. S. K. Otta

12. Meeting with delegation of Minister of State for Universities, Science, Research and Innovation UK on Poverty alleviation through prevention and future control of the two major socio-economically important pathogens in Asian aquaculture IIT, Chennai on 27 July 2018 - Dr. M. S. Shekhar
13. Launching programme of Network Project on "Ornamental fish breeding and Culture"(NPOFBC) held at CMFRI, Kochi on 28 July 2018 - Dr. Krishna Sukumaran
14. 6th Annual NICRA Workshop organized by CRIDA, Hyderabad during 7-8, August 2018 at New Delhi- Dr. M. Muralidhar
15. International consultation on water: Augmentation of supply and management of demand during 7-9 August 2018 at MSSRF, Chennai in partnership with various national and international agencies. – Dr. R. Saraswathy, Dr. P. Kumararaja, Dr. S. Suvana
16. Workshop on Carrying capacity assessment of water bodies organized by Fisheries Department on 11 Sept, 2018 at Bhimavaram, Andhra Pradesh - Dr. M. Muralidhar
17. Meeting of Inauguration of state-of-the-art Community Development Centre for Learning, Livelihood & Research (CDC-LLR) Laboratory in Bhimavaram by KCT on 12Sept, 2018. - Dr. M. Muralidhar
18. Aquaculture Seminar for "RAS and Krill as a feed ingredient" organized by Innovation Norway at Trident hotel, Chennai on 19 September 2018 – Dr. Krishna Sukumaran
19. Workshop "Norwegian Technology for land based RAS and Krill; an important ingredient for fish & shrimp feed" organized by Norwegian Embassy at Hotel Trident, Chennai on 19 September, 2018 - Dr. K. Ambasankar
20. Parliamentary Committee on Official language, October 3-5, 2018, Chennai - Dr. M. S. Shekhar
21. 4th India International Science Festival (IISF-2018) during 5-8 October, 2018 at Lucknow" – Shri T. Sathish Kumar
22. First Steering committee meeting of Tamil Nadu Irrigated Agriculture Modernization Project at Directorate of Fisheries, Chennai on 10 October, 2018 - Dr. K. Ambasankar
23. 13th Annual convention of Central Information Commission, New Delhi, held on 12 October 2018 – Dr.S.K.Otta
24. Workshop on knowledge management in Marine Fisheries conducted by BOBP, Chennai on 12 October 2018 – Dr. C. P. Balasubramanian
25. Workshop on "Knowledge Management in Marine Fisheries Sector" Organized by BOBP-IGO at Hotel Raintree, Chennai on 12 October, 2018 - Dr. Debasis De
26. Annual Review meeting 2017-2018 of Consortium Research Platform on Vaccines and Diagnostics held at ICAR-CIBA, Chennai during 30-31 October, 2018 – Dr. K.P.Jithendran, Dr. R. Ananda Raja
27. Workshop on "Framing guidelines for culture of *P. vannamei* outside the jurisdiction of CAA " on 8 Nov, 2018 at DOF, Chennai – Dr. R. Saraswathy
28. "FourthNational Agricultural Science Tamil Research Conference" organized by Agricultural Scientific Tamil Society, New Delhi at the Directorate of Research, TNFU Campus, OMR, Vaniyanchavadi, Chennai during 10-20 November 2018 – Dr.R.Ananda Raja
29. Meeting with Hon'ble Union Minister of Agriculture on 16 November 2018 in Kolkata - Dr. T.K. Ghoshal
30. Seminar on "Ion Chromatography Uses" during 16 November 2018 at Chennai organized by Metrohm India Ltd, Chennai - Dr. S. Suvana
31. Fourth National Agricultural Science Tamil Research conference during 19-20th November 2018 at TNJFU, Chennai – Shri T. Sathish Kumar
32. Eighth Conference of Indian Meat Science Association and International Symposium on Technological Innovation in Muscle Food Processing for Nutritional Security, Quality and Safety during 22-24 November 2018 at West Bengal University of Animal and Fishery Sciences, Kolkata - Dr. Sanjoy Das

33. Conference on Revisiting Agricultural Research and Monitoring system for developing innovations during 24-25 November 2018 at ICAR-CIWA, Bhubaneswar – Dr.Premkumar

34. Workshop of nodal officers of ICAR Research Data Repository for Knowledge Management during 4-5, December, 2018 at ICAR, New Delhi – Dr. R. Saraswathy

35. Dissemination workshop by National Biodiversity Authority at India Habitat Centre, New Delhi held on 5 December 2018 – Dr. S.K.Otta

36. Scientist's interaction meet of ICAR-CIBA, Chennai and IISER, Thiruvananthapuram conducted by ICAR-CIBA, 13 December 2018, Chennai - Dr. M. S. Shekhar, Dr. Sherly Tomy, Dr. B. Sivamani, Ms. Misha Somen

37. Town Official Language Implementation Committee (TOLIC) meeting during 18 December, 2018 at NIOT, Chennai - Dr. S. Suvana

38. World Disaster Management Congress organized by IIT, Mumbai during 29 January – 1 February, 2019 – Dr. R. Saraswathy

39. Meeting with the Secretary and Director of Department of Industrial Policy and Promotion (DIPP) for transfer of surplus salt pan land ICAR-CIBA on 4 January 2019 - Dr. S. Kannappan

40. Golden Jubilee International Salinity Conference on "Resilient Agriculture in Saline Environments under Changing Climate: Challenges and Opportunities" during 7-9 February 2019 at ICAR-CSSRI, Karnal - Dr. P. Kumararaja

41. National Workshop - Aquaculture as a Livelihood Option for Tribal Farmers of India during 18-19 February 2019 at ICAR-CIFA, Bhubaneswar - Dr. T.K. Ghoshal

42. Expert Committee Meeting of Hilsa Project Phase-II at NASC complex, New Delhi on 14 February, 2019 - Dr. Debasis De

43. Fourth HLMC meeting on Aquazonation organized by Fisheries Departmrnt at Secretariat, Velagapudi, Amaravati, Andhra Pradesh on 21 February, 2019 - Dr. M. Muralidhar

44. "Interactive meeting-cum-workshop of Scientists in IT/Computer Application" with Secretary DARE & DG ICAR scheduled for 6 March 2019 at NASC Complex, New Delhi – Dr. P. Mahalakshmi

45. Brain storming session on Metagenomics applications in brackishwater aquaculture under the Network Project for Agricultural Bioinformatics and Computational Biology (CABin) during 8 March, 2019 at ICAR-CIBA, Chennai - Dr. M. Muralidhar, - Dr. M.S.Shekhar, Dr. N. Lalitha, Dr.R.Ananda Raja

46. Technical and Inspection Committee on Establishment of Shrimp Broodstock Multiplication Centres for *Penaeus monodon* and *P. vannamei* by Government of Andhra Pradesh Submitted to the Ministry of Agriculture and Farmers' Welfare on 12 March, 2019 – Dr. C. P. Balasubramanian

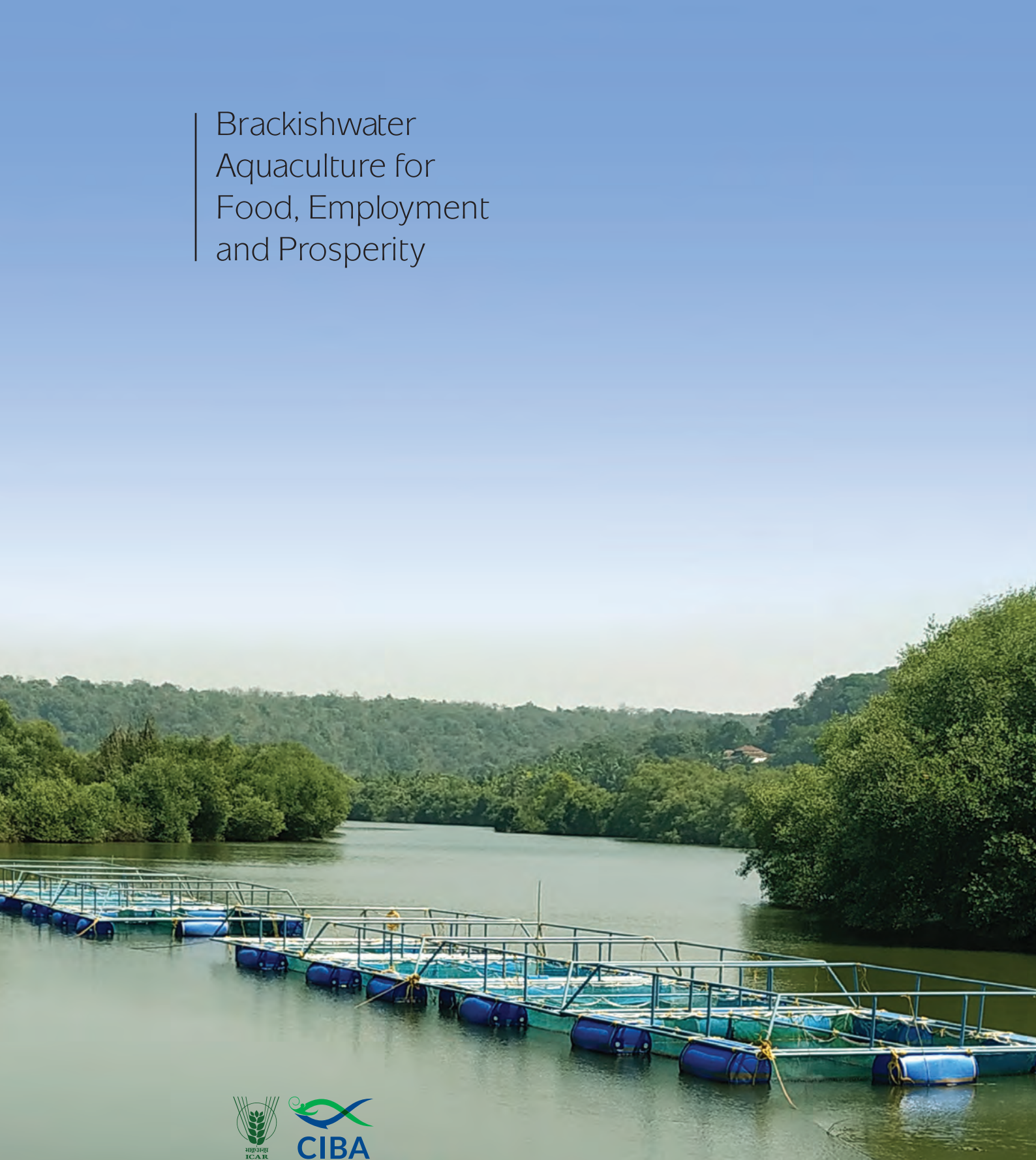
47. National Workshop on Brackishwater Aquaculture Resource Mapping for Sustainable Development during 14-15, March 2019 at ICAR-CIBA, Chennai – Dr. M. Muralidhar, Dr. R. Saraswathy, Dr. P. Kumararaja, Dr. Gouranga Biswas, Dr. Prem Kumar, Dr.R.Ananda Raja

48. Seminar on Climate Change, Demographic Pressures and Global Sustainability organized by MSSRF on 19 March 2019 at Chennai - Dr. M. Muralidhar

49. Meeting on Revival of domestication of tiger shrimp *Penaeus monodon* project (DTSP) in Andaman and Nicobar islands organized by Department of Commerce through joint venture with AQUALIMA-UNIMA, Madagascar on 28 March, 2019 – Dr. C. P. Balasubramanian

Glimpses from BRAQCON 2019

Brackishwater Aquaculture for Food, Employment and Prosperity



ICAR-Central Institute of Brackishwater Aquaculture
ISO 9001:2015
(Indian Council of Agricultural Research)
#75, Santhome High Road, MRC Nagar, RA Puram,
Chennai, Tamil Nadu - 600 028.

Phone : +91 44 24618817, 24616948, 24610565
Fax : +91 44 24610311
Web : www .ciba.res.in
Email : dir ector.ciba@icar.gov.in /director@ciba.res.in

follow us on: / icarciba

ISSN 09765536
9 770976 553602