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ICAR - CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE

भा.कृ.अनु.प. - केन्द्रीय खारा जलजीव अनुसंधान संस्थान

ANNUAL REPORT 2017-18

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भाकृअनुप ICAR

CIBA

Muttukadu backwater

Brackishwater experimental research station of CIBA

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Brackishwater ornamental fishes: Ornamental fish industry is an emerging aquaculture sector. Brackishwater aquariculture is elegant with potential species such as Green chomide, Spotted scat, Mono angel, Orange chromide, Tiger perch etc. ICAR-CIBA is conducting research and development programs to promote this emerging industry with technologies in seed, feed and health aspects.

भाकृअनुप
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वार्षिक प्रतिवेदन

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(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, Chennai - 600028, Tamil Nadu, India.

Published by

Dr. K.K. Vijayan
Director

ISSN 0976-5536

Citation : CIBA-2018. Annual Report 2017-18.
Central Institute of Brackishwater Aquaculture,
Chennai, Tamil Nadu, India.

Graphic design by: Erazp Dut, Santhome,Chennai-4

Farmed Indian white shrimp

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Preface

For mainstreaming the brackishwater aquaculture at the broader context of social development, landless and underemployed fishers should be brought to the aquaculture sector. CIBA has successfully demonstrated cage farming of Asian seabass in the open brackishwater ecosystem with the active participation of coastal fisher.

The year 2017-18 was a momentous year for ICAR-Central Institute of Brackishwater Aquaculture as it marked thirty years of useful research and development in brackishwater aquaculture sector. Our research focuses on crucial questions to develop strategies and technologies for sustainable aquaculture, aquatic food security and how to translate the research outputs for the benefit of the society and support rural livelihood. Since the introduction of specific pathogen free stock of exotic shrimp *Penaeus vannamei* with united efforts of CIBA along with other national agencies in 2010, India had an ever time high production of 0.6 million tons of farmed shrimp during the current year. This high production masks the several crucial weakness and challenges of the industry, for example: low survival, emerging disease problems, the high cost of production, and issues in marketing. Therefore ICAR-CIBA has an enormous task in steering the brackishwater aquaculture industry towards sustainability, contributing towards food security and livelihood. We continued to work with our stakeholders to translate our mission into reality.

When the Indian shrimp farming sector, almost depend on a single exotic species of American shrimp shipped from overseas, it is only an imperative endeavour to find a *'desi'* option, to compliment vannamei, to free the industry from a risky single species dependence. Therefore, development of a native *Penaeus* species, which has the potential for selective breeding and genetic improvement, has been one of the high priority area of brackishwater aquaculture in India, and for CIBA. Thus, *Penaeus indicus* has been identified as a national priority species for specific pathogen free and genetically improved stock. In order to generate real farm level performance of this species, twenty-one culture trials were carried out at identified stations all along the Indian coast including eight shrimp producing states with the participation of farmers. The production performance of the native species, without any stock improvement, indicates that the production levels are similar or even better to the exotic Vannamei of pre-genetic selection phase, up to a size of around 20 g, within 90-120 days farming period. It is a clear evidence of this species for its potential for domestication and selective breeding. The most importantly, the absence of emerging diseases such as EHP and running mortality syndrome during this demonstration trials, is found to be not affecting this species.

Kuruma shrimp, *Penaeus japonicus,* is reportedly the highest valued penaeid shrimp, because of its outrageously high price in Japan. Incidentally, we have this species available on the coast of Chennai and Maharashtra, and the studies conducted by CIBA suggested the organoleptic qualities are similar to the Japanese kuruma shrimp, with prospects of farming here and live export to japan as a high value product. Further, the molecular signature of Indian japonicus proved that Indian strain is a cryptic species of *Penaeus japonicus* group, and the genetic distance between Indian species and *P, japonicus* and *P. pulchircaudatus,* qualifies and confirms a new species status for Indian taxa.

For mainstreaming the brackishwater aquaculture at the broader context of social development, landless and under employed fishers should be brought to the aquaculture sector. Aquaculture of brackishwater fishes, in locally crafted

brackishwater cage units (BCU) suitable for estuaries, creeks, are an emerging innovative and viable technology. CIBA has successfully demonstrated cage farming of Asian seabass fish (*Lates calcarifer*) in the Buckingham canal waters at the Vennangupattu coastal village (Kancheepuram District, Tamil Nadu). This is a novel three tier model comprising nursery rearing, pre-grow out and grow out cages, were able to generate income at each stage, proving BCU as a successful livelihood support enterprise, which is becoming popular due to the economic benefits.

Aquaculture feed and his nutrition has been the major thrust area of the Institute since its establishment. Asian seabass, *Lates calcarifer*, has been the focus of diversification of brackishwater aquaculture in India. Low volume cage culture in coastal waters, particularly in estuaries and open brackishwater bodies is emerging aquaculture in many coastal states of India. The feed is the major critical input for the success of aquaculture. The institute has formulated, tested and successfully developed functional and grow-out quality feed for seabass, *Lates calcarifer*, under the brand name Seabass plus for broodstock, larvae, nursery and grow-out which is a cost-effective import substitute.

In order to achieve greater efficiency and sustainability in aquaculture, it is required to formulate a holistic research practice with inter and intra disciplinary cooperation. Research program with the proper merging of basic and applied research is needed to resolve the current research issues and planning for the future. We are developing our research program on an interdisciplinary mode. The white spot syndrome virus, WSSV, is the major pathogen of shrimp aquaculture, which has been devastating the shrimp farming industry since its emergence in the early nineties. For the first time, the complete de novo genome of an Indian isolates of this virus has been deciphered using Illumina and Nanopore sequencing technologies. The genome has 280,591 bp with 442 predicted coding genes. The availability of this genome provides a valuable information providing a better understanding on the viral architecture, which would help in developing novel strategies in the management of this serious pathogen affecting the shrimp aquaculture industry.

A model organism is crucial in biological studies, particularly for developmental biology, animal health and genetic research. Studies using the model organism revolutionized the scientific application of basic research, for example, studies on Zebra fish provided reproductive biological methods for breeding of aquaculture species, while a saline tolerant model is not available. Such a brackishwater fish model (*Oryzias javanicus)*, with a wide range of salinity tolerance has been identified, evaluated and selected, and bred, as a first step.

High quality research work carried out by our scientists enhanced our reputation. During the current year the Institute released 209 publications with 79 papers published in high quality peer reviewed journals, an increase of 41% over the last year. Generating new knowledge and developing new product and process are crucial for achieving our mission. During the current year, we have generated ₹ 2.5 million on technology transfer, and have made 18 commercial agreements with various public and private stakeholders.

I am honoured to present the annual report of ICAR-CIBA that reports the highlights of research and development during the period 2017-18. I am extremely grateful to ICAR in the first place, and our all funding agencies and stakeholders for their valuable support. Newly emerging challenges and possibilities keep research organizations such as ICAR-CIBA at the central position, where we are expected to deliver the needs and aspirations of the vibrant brackishwater farming sector. I have no doubt that the team CIBA with its scientific resource is in the pursuit of meeting these challenges.

As I complete my fourth year as Director of this prestigious Institute, I place on record my personnel gratitude to all our stakeholders who supported us, and their faith in our mission enables our effort. We are immensely grateful to Dr Trilochan Mohapatra, the Director General ICAR, without his professional support all these research performance and achievements would not have been possible. We are deeply indebted to Dr J. K. Jena, Deputy Director General (Fisheries) for his keen support, enthusiasm and timely help. I thank all my colleagues for their commitment and support for the fulfilment of the mandate of the Institute.

Thank you all for joining with us on this journey, the achievements provided here are only highlights, and I invite readers to go through the detailed report

Dr K.K.Vijayan
Director

कार्यकारी सारांश

यद्यपि कई दशकों से भारत में खारे पानी की जलकृषि किया जा रहा है, परन्तु आधुनिक जलकृषि विशेष रूप से झींगा खेती १९८० के दशक के मध्य में शुरू हुई थी। पिछले तीन दशकों से खारे पानी के जलीय कृषि की वृद्धि शानदार रही है भा.कृ.अनु.प. -सीबा उद्योग को आकार देने, जलीय कृषि में मुद्दों को हल करने और नीतियों को तैयार करने में सहायता करने में एक महत्वपूर्ण भूमिका निभा रहा है। देश के सबसे प्रमुख अनुसंधान संगठनों में से एक होने के नाते, संस्थान द्वारा किए गए शोध कार्य खारे पानी जलीय कृषि के क्षेत्र के लिए महत्वपूर्ण हैं। वर्ष 2017-18 वैज्ञानिक योगदान, और इस क्षेत्र पर प्रभाव के संदर्भ में भा.कृ.अनु.प. -सीबा का एक सफल वर्ष था। 29 आन्तरिक और बाहरी वित्त पोषित परियोजनाओं के कारण और तकनीकी जानकारियों और गतिविधियों को प्रचलित करने के लिए संस्थान खारा पानी जलीय कृषि के विज्ञान क्षेत्र में उल्लेखनीय योगदान प्रदान करने में सक्षम रहा । वर्तमान वर्ष में सिबा ने 31 MOU किये, जिसकी वजह से 2.5 मिलियन राजस्व उत्पन्न किया गया । इस साल संस्थान ने उच्च प्रभाव पत्रिकाओं में ७९, वैज्ञानिक पत्रों सहित २०९ प्रकाशन जारी किए। वर्ष २०१७-१८ के दौरान संस्थान द्वारा किए गए शोध की मुख्य विशेषताएं नीचे दी गई हैं ।

पीनीयस इंडिकस प्रदर्शन परीक्षण

भारत में झींगा खेती, जो विदेशी पीनीयस वनामेई पर आधारित है, उभरती बीमारियों, कम अस्तित्व, उत्पादन की लागत में वृद्धि, और हाल ही में कीमतों में गिरावट के कारण एक चुनौती पर है । इस समय मूल प्रजातियों के विकास झींगा खेती की स्थिरता सुनिश्चित करने के लिए एक विकल्प है । भारतीय सफेद झींगा, पी. इंडिकस घरेलू और आनुवांशिक सुधार के लिए उपयुक्त उम्मीदवार प्रजातियों के रूप में पहचाना गया है। खेत के स्तर के प्रदर्शन का मूल्यांकन करने के लिए, 21 प्रदर्शन परीक्षण भारतीय तट के साथ सभी पहचाने गए स्टेशन पर किए गए थे। उत्पादन 15 से 45 पीएल/एम^2 के स्टॉकिंग घनत्व पर ६.५-२ मीटर/हेक्टेयर के बीच था, और जीवित अवलोकन 80 से 98% के बीच था। एफसीआर 1.4 से 1.65 तक था। ईएचपी और रनिंग मोर्टेलिटी सिंड्रोम जैसी उभरती बीमारियों की अनुपस्थिति पी. इंडिकस की एक महत्वपूर्ण विशेषता है।

दक्षिण पश्चिमी पंजाब में अंतर्देशीय कम नमकीन झींगा खेती के माध्यम से किसानों की आय को दोगुना करना: सीबा की पहल

पंजाब के दक्षिण पश्चिमी क्षेत्र में 3 से 15 पीपीटी तक की लवण वाली अंतर्देशीय खारे भूजल के संसाधन हैं। दक्षिण पश्चिमी पंजाब में सीबा के

झींगा खेती तकनीकी पैकेज का उपयोग कर वनामेई खेती से किसानों ने चार महीने की अवधी में 2.0 लाख/एकड़ लाभ की प्राप्ति हुई। झींगा खेती के लिए उपलब्ध उच्च तकनीक गुणवत्ता वाले बीज और कम लागत की देसी फ़ीड का उपयोग नमकीन भूजल वाले भाग में पंजाब के किसानों की आय को गुणात्मक बृद्धि का एक महत्वपूर्ण जरिया बन सकता है।

उत्पादन प्रणाली विविधीकरण: एकीकृत बहु-ट्राफिक जलकृषि (आईएमटीए) का विकास

उत्पादन प्रणाली सुधारना और पालित प्रजातियों का विविधीकरण जलकृषि अनुसंधान की प्रमुख प्राथमिकताएं हैं । आईएमटीए दो या दो से अधिक पूरक प्रजातियों की खेती है जहां एक प्रजाति का अपशिष्ट अन्य प्रजाति के लिए इनपुट फीड या उर्वरक के रूप में कार्य करता है। इस प्रकार, तटीय जलकृषि से संबंधित पर्यावरणीय मुद्दों को हल किया जा सकता है, और विभिन्न फसलों की खेती आर्थिक रिटर्न को अनुकूलित करती है। महाराष्ट्र के सिंधुदुर्ग जिले के गाद नदी में एक खुला पानी आईएमटीए विकसित किया गया था। एक 32 एम³ पिंजरे में सीबास और ग्रीन मसल को एक साथ में पालन किया गया । नौ महीने के पालन के बाद, सीबास 909.1 ग्राम के औसत आकार के साथ ३६० किलो के कुल उत्पादन और 63% जीवित अवलोकन तक प्राप्त हुआ। किसानों को नौ महीने के 120000 की कुल लागत के लिए 162000 का राजस्व प्राप्त हुआ।

बायोफ्लोक आधारित कल्चर प्रणालियां

सीमित या बिना जल विनिमय वाले उच्च-घनत्व जलकृषि प्रणालियों के परिणामस्वरूप सूक्ष्मजीव, ऑटोट्रोफिक और हेटरोट्रोफिक बैक्टीरिया सहित फ्लोक्यूलेटेड जैविक कणों की बड़ी मात्रा में उत्पादन होता है। ये, अद्वितीय बायोफ्लोक प्रणाली, खेती की प्रजातियों के लिए कई फायदेमंद प्रभाव प्रदान करती है।

मिल्कफिश : विभिन्न कार्बन स्रोतों (गुड़, गेहूं और मकई) का उपयोग करके बायोफ्लोक आधारित नर्सरी पालन प्रणाली में मिल्कफिश, (चैनोस चैनोस) का 60 दिनों का प्रयोग और मूल्यांकन किया गया। नतीजे बताते हैं कि गेहूं आधारित बायोफ्लोक प्रणाली में मिल्कफिश ने बेहतर विकास प्रदर्शन दिखाया । हालांकि बायोफ्लोक में पानी की गुणवत्ता विशेषताओं जैसे अमोनिया, नाइट्रेट और नाइट्रेट काफी अधिक थे , ये सभी पैरामीटर मिल्कफिश विकास के लिए अनुकूल पाया गया ।

पीनीयस वनामेई: जलकृषि के पानी के सी/एन अनुपात में पानी की गुणवत्ता और बायोफ्लोक बायोमास उत्पादन पर महत्वपूर्ण प्रभाव पड़ता है। पी. वनामेई के विकास और उत्तरजीविता के लिए सी/एन अनुपात 15:1 अनुकूल पाया गया ।

तालाब में भारतीय शाद, हिल्सा ब्रूड स्टॉक का पालन

कैप्टिव ब्रूडस्टॉक का विकास किसी भी जलकृषि प्रजातियों के बड़े पैमाने पर पालन के लिए प्रोटोकॉल विकसित करने के लिए आवश्यक है। हिल्सा का के ब्रूडस्टॉक्स सीबा के काकद्वीप शोध केंद्र में हिलसा प्लस खाद्य का इस्तेमाल करके ग्रो-आउट उत्पादन प्रणाली में विकसित किया गयाकिए गए । तालाब प्रणाली में प्रजनन परिपक्वता प्राकृतिक प्रजनन चक्र के साथ सिंक्रनाइज़ पाया गया ।

पॉलीकल्चर

पॉलीकल्चर एक या दो अधीनस्थ प्रणाली का जोड़ है, और यह उत्पादकता में वृद्धि और आर्थिक रिटर्न को अनुकूलित करने के कुशल तरीकों में से एक है। शेलफिश और फिनफिश सहित पॉलीकल्चर विकास और उत्पादन प्रदर्शन का मूल्यांकन करने के लिए कई प्रयोग किए गए। एक प्रयोग में, मिस्टस गुलिओ, चैनोस चैनोस, एट्रोप्लस सूरतेंसिस, ओरेक्रोमिस नीलोटिकस और पीनीयस मोनोडन के विकास प्रदर्शन का अध्ययन किया गया । पॉलीप्लस खाद्य का उपयोग कर किये गए प्रयोगात्मक परीक्षण पॉलीकल्चर खेती में विभिन्न फिनफिश और शेलफिश के विकास के संदर्भ में आशाजनक परिणाम दर्शाते हैं ।

'डेकन हिल्सा' के रूप में मिल्कफिश खेती का पश्चिम बंगाल में लोकप्रियकरण

एक सतत टिकाऊ जलीय कृषि का उचित और कुशल विपणन आवश्यक है। पश्चिम बंगाल में मिल्कफिश मछली का नाम 'डीकन हिल्सा' रखा गया है। इस कार्यक्रम के एक हिस्से के रूप में, एक निजी उद्यमी के साथ एक सहयोगी अनुसंधान कार्य किया गया था, और 225 ग्राम के औसत शरीर के वजन के साथ 2 टन मिल्कफिश मछली का कुल उत्पादन पाया गया ।

कर्नाटक में युवाओं के लिए आजीविका विकल्प के रूप में सीबास की खेती

सीबा ने कर्नाटक के कासरगोड में किसानों के लिए आजीविका विकल्प प्रदान करने के लिए सीबास कार्यक्रम शुरू किया। सीबा द्वारा उपलब्ध कराई गई हैचरी बीज के साथ, किसान 10 महीने की अवधि में 0.2 हेक्टेयर तालाब से 512 किलोग्राम सीबास फसल करने में सक्षम थे।

ब्रैकिशवाटर समुद्री शैवाल: ग्रासिलैरीआ

ग्रसिलैरीआ महत्वपूर्ण जलकृषि संसाधनों में से एक है, और यह व्यापक रूप से जलकृषि निर्वहन और अगार उत्पादन के लिए प्रयोग किया जाता है। उत्पादन तकनीक का मूल्यांकन करने के लिए कई प्रयोग किए गए। रस्सी खेती में उत्पादन नेट बैग की तुलना में अधिक था। समुद्री शैवाल आधारित बायोफिल्टर की संभावना को प्रभावकारिता के लिए विकसित और परीक्षण किया गया है।

वायु दक्षता

अर्ध-गहन और गहन झींगा खेती तालाबों में मैकेनिकल वायु का प्रयोग आवश्यक है। पानी की लवणता का स्तर डीओ निर्धारित करने का प्रमुख कारक है। विभिन्न लवणता स्तरों पर ऑक्सीजन की आवश्यकता विभिन्न एयररेटर्स जैसे पैडल व्हील, पनडुब्बी, सर्पिल, जेट और इंपेलर एयररेटर्स का उपयोग करके निर्धारित की गई ।

भारत में पीनीयस जैपोनिकस की क्रिप्टिक प्रजातियां

सीबा द्वारा आयोजित कुरुमा झींगा, पी. जैपोनिकस पर पिछले अध्ययनों ने जैव विज्ञान संदर्भ और इसके गुणों में अन्य देशों की तुलना में भिन्न होने का सुझाव दिया। इस प्रजाति के आणविक हस्ताक्षर, भारत में अपनी वितरण सीमा के साथ प्राप्त नमूनों का 16 एस आरआरएनए जीन और सीओ 1 जीन का उपयोग करके मूल्यांकन किया गया । 16 एस और सीओ 1 के आणविक फाईलोजेनेटिक विश्लेषण ने दर्शाया कि भारत में रिपोर्ट की गई प्रजातियां पी. जैपोनिकस समूह की एक अप्रकट प्रजाति है। भारतीय प्रजातियों पी. जैपोनिकस और पी. पुल्चिर्काडाटस के बीच अनुवांशिक दूरी एक नई प्रजाति की स्थिति की पुष्टि करती है।

मोल्ट के चरणों के संबंध में नर पीनीयस इंडिकस (भारतीय सफेद झींगा) की प्रजनन गुणवत्ता

झींगा हैचरि में नर का प्रजनन प्रबंधन और प्रजनन प्रदर्शन, बीज स्टॉक उत्पादन को अनुकूलित करने में महत्वपूर्ण है। मोल्ट चरणों के संबंध में पीनीयस इंडिकस के नर शुक्राणुरोधी गुणवत्ता का मूल्यांकन किया गया था, औसत शुक्राणुओं की गणना अंतराल चरण में अंतर मोल्ट चरण की तुलना में काफी अधिक थी, हालांकि मोल्ट चक्र के दो चरणों के बीच लाइव या सामान्य शुक्राणु के प्रतिशत में कोई अंतर नहीं था।

कृत्रिम गर्भाधान (एआई)

एआई मादा प्रजनन पथ में शुक्राणु का समाविष्ट करना है, और यह कैप्टिव प्रजनन कार्यक्रम का महत्वपूर्ण घटक है। एआई के कई परीक्षण पीनियस मोनोडन, पी. इंडिकस और पी. वनामेई में किए गए हैं। वनामेई में सफलता दर पी. मोनोडन और पी. इंडिकस से अधिक है, संभवतया इसमें अंतर प्रजनन आकृति के कारण है।

पीनीयस मोनोडन में इन विट्रो निषेचन (आईवीएफ) का विकास

झींगा जलीय कृषि में इन विट्रो निषेचन में झींगा के विकास जीवविज्ञान का अध्ययन करने के लिए महत्वपूर्ण साधनों में से एक है जो कैप्टिव प्रजनन में मुद्दों को हल करता है। इसके अलावा, प्रजातियों की संकरण क्षमता का मूल्यांकन करना महत्वपूर्ण है, जैसे कि इन विवो संकरण अक्सर निषेचन प्रक्रिया में शामिल समस्याओं को समझने में विफल रहता है। एक नया आईवीएफ प्रोटोकॉल में पी. वनामेई और पी. इंडिकस के साथ पी. मोनोडन अंडे की संकरण क्षमता का विकास और परीक्षण किया गया । पी. मोनोडन और पी. इंडिकस की तुलना में पी. मोनोडन और पी. वनामेई के बीच निषेचन का उच्च प्रतिशत हासिल किया गया।

अंतर्देशीय लवण पारिस्थितिक तंत्र के विशेष संदर्भ के साथ पीनीयस वनामेई और पी. इंडिकस के अस्तित्व, विकास और ऑस्मोरेगुलेटरी क्षमता पर लवणता का प्रभाव

हाल ही में, समुद्री झींगा खेती कम नमकीन तटीय क्षेत्रों और अंतर्देशीय खारे पानी के क्षेत्रों तक बढ़ी है, जहां परंपरागत रूप से झींगा खेती का अभ्यास नहीं किया जाता था। कम नमकीन और अंतर्देशीय खारे पानी में ऑस्मोरेगुलेशन शरीर विज्ञान को समझना कम नमकीन झींगा खेती प्रौद्योगिकी के आगे परिष्करण के लिए महत्वपूर्ण है। कम समुद्री जल के तहत पी. इंडिकस और पी. वनामेई की वृद्धि, उत्तरजीविता और ऑस्मोरेगुलेटरी क्षमता का मूल्यांकन करने के लिए प्रयोग किया गया । पी. इंडिकस का उत्तरजीविता समुद्र के 10 पीपीटी पर काफी अधिक था, जबकि पुनर्गठित अंतर्देशीय खारे पानी में 10 और 15 पीपीटी पर अधिक था।

मिट्टी केकड़ा स्काइला सेरेटा की, विभिन्न फीडिंग शेड्यूल द्वारा जीवित रहने की दर में सुधार

सिल्ला सेरेटा में ज़ोए की उच्च मृत्यु दर मिट्टी केकड़ा लार्वा पालन के शुरुआती चरण (जेड 1 से ज़ेड 3) में बड़ी बाधा रही है। केकड़ा लार्वा की पौष्टिक स्थिति इस चरण में कम जीवित रहने की दर अधिकतर जिम्मेदार है, जो फ़ीड की गुणवत्ता और मात्रा पर निर्भर करती है। रोटिफर थलसीओसिरा, क्लोरेला और टेट्रासेलमिस सहित फ़ीड के उपयोग से बेहतर उत्तरजीविता प्राप्त हुआ ।

ग्रे मैलेट मुगिल सेफलस के विकास और प्रजनन पैरामीटर- दो कैप्टिव स्टॉक की विविधताएं

जैविक मानकों में बदलाव मछली में स्टॉक विविधताओं के संकेतक के रूप में कार्य कर सकते हैं। पूर्व और पश्चिमी तट से प्राप्त मुगिल सेफलस की आबादी के विकास और प्रजनन प्रदर्शन का मूल्यांकन इस तरह की पर्यावरणीय परिस्थितियों में तीन वर्षों के पालन के बाद किया गया । दोनों आबादी विकास और प्रजनन विशेषताओं में काफी भिन्न पाया गया जो स्टॉक की विविधता को इंगित करते हैं।

सीबास हैचरी के स्टार्ट-अप कार्यक्रम

सीबास हैचरी की स्थापना को बढ़ावा देने के लिए, एक निजी उद्यमी को सीबा हैचरी में सुविधाओं का उपयोग करने की अनुमति थी। उद्यमी को बीज और तकनीकी जानकारियां प्रदान की गई। उद्यमियों को कुल 9, 60,000 स्पॉन आपूर्ति की गई, और उन्होंने 20-दिनों में 3,27,500 फ्राई उत्पादन किया । यह उत्पाद किसानों को 6,88,625 / - की राशि के लिए बेचा गया था

। एक ज्ञान भागीदार के रूप में सीबा को 250000 / की राशि मिली।

लिज़ा पार्सिया के कैप्टिव परिपक्वता और ओवुलेशन

खारे पानी जलकृषि के लिए क्षेत्रीय रूप से महत्वपूर्ण छोटी मछलियों का विकास तटीय ग्रामीण इलाकों में खाद्य सुरक्षा और आजीविका विविधीकरण की रणनीतियों में से एक है। गोल्ड स्पॉट, मलेट, लिज़ा पार्सिया भारत के कुछ राज्यों में एक मूल्यवान खाद्य मछली है। लिज़ा पार्सिया की प्रेरित परिपक्वता के लिए एक प्रजनन प्रोटोकॉल विकसित किया गया । प्रेरित प्रजनन के लिए, दो चरण पालन की आवश्यकता है: प्रजनन परिपक्वता के लिए कम नमकीन पानी में मछलियों को पालन किया जाना चाहिए और अंतिम डिम्बाणु परिपक्वता और स्पानिंग के लिए मछलियों को समुद्री जल में स्थानांतरित किया जाना चाहिए।

कैद के तहत मिल्कफिश का विस्तारित प्रजनन

प्रजनन तकनीक को और परिष्कृत कर कैप्टिव में प्रजनन अवधि को आठ महीने तक बढ़ा दी गई है। तेरह स्पॉन्गिं से कुल 1.39 मिलियन उर्वरित अंडे प्राप्त किए गए । यह देखा गया है कि मिल्कफिश स्पॉन्गिंग लवणता की तुलना में पानी के तापमान में वृद्धि के साथ अधिक संबंधित है। केरल, गोवा, गुजरात, तमिलनाडु, आंध्र प्रदेश और पश्चिम बंगाल के किसानों के बीच कुल 75000 प्रारंभिक मिल्कफ़िश वितरित किया गया, जिसमें 2.5 लाख उर्वरित अंडे सैटेलाइट नर्सरी पालन के लिए निजी उद्यमी को वितरित किए गए थे। बीज बिक्री से उत्पन्न कुल राजस्व 97500 था। आठ महीने तक मिल्कफिश का एकाधिक स्पॉन्गिंग प्रजनन की चुनौतियों को दूर करने की संभावना देते हैं।

क्रिसेंट पर्च, टेरापोन जर्बो का प्रजनन

एक्वैरियम मछली, क्रिसेंट पर्च के लिए एल.एच.आर.एच. हॉर्मोन का उपयोग कर सफल बीज उत्पादन प्रोटोकॉल को मानकीकृत किया गया है। तदोपरांत नैनोक्लोरोपसिस एसीय्यूलेट और रोटिफर जैसे लार्वा शैवाल का उपयोग करके लगभग 50000 लार्वा उत्पादित किए गए।

साइक्लोपीड कॉपीपोड की खेती

साइक्लोपीड कॉपीपोड उभरते हुए जीवित खाद्य जीव हैं, सिबा ने कॉपीपोड का बड़े पैमाने पर पालन के लिए प्रक्रिया विकसित की । नैनोक्लोरोपसीस, ईसोक्राइसिस, कीटोसेरोस, चावल के पाउडर और बेकर खमीर द्वारा संयोजित आहार का उपयोग करके कॉपीपोड पालन किया गया । इससे 14 दिनों के भीतर 1500 से 4500 नंबर कॉपीपोड प्राप्त हुए ।

व्हाइट स्पॉट और माइक्रोस्कोपोइडोसिस का झींगा खेती में उच्च प्रसार

तीन तटीय राज्यों (तमिलनाडु, आंध्र प्रदेश और पश्चिम बंगाल) के 420 झींगा खेतों में 2015-2018 के दौरान रोग निगरानी ने खुलासा किया कि एंटरोसाइटोज़ून हेपेटोपनेई (ईएचपी) के कारण झींगा हेपेटोपैंक्रेटिक माइक्रोस्कोपीडियोसिस 2015 में 43% का उच्चतम प्रसार था, और २०१७-१८ के दौरान इसके प्रसार में 21% की कमी हुई। इसी साल के दौरान सफेद स्पॉट बीमारी (डब्लू.एस.डी.) का प्रसार 37% और 11% था। संक्रमण हाइपोडर्मल और हेमेटोपोएटिक नेक्रोसिस (आईएचएनएन) का प्रसार भी पिछले तीन वर्षों के दौरान 6 से 3 % तक कम हो गया है। अन्य बीमारी सिंड्रोम, जैसे स्टंटेड ग्रोथ, व्हाइट फीकल सिंड्रोम (डब्लू.एफ.एस.), रनिंग मोर्टेलिटी सिंड्रोम (आरएमएस), ढीले खोल सिंड्रोम (एल.एस.एस.) और ब्लैक गिल 27, 12, 4, 6% और 5% दर्ज किए गए। भारत में 2017-18 के दौरान ओ.आई.ई. सूचीबद्ध बीमारियों जैसे टॉरा सिंड्रोम (टी.एस.), पीला सिर रोग (वाईएचडी), तीव्र हेपेटोपैंक्रेटिक नेक्रोसिस बीमारी (एएचपीएनडी) और नेत्रोटिंग हेपेटोपैंक्राइटिस (एनएचपी) से 2017-18 के दौरान मुक्त थी। हालांकि फरवरी-मार्च 2017 के दौरान आंध्र प्रदेश और तमिलनाडु में दो पी. वानामी खेतों में संक्रामक मायनेक्रोसिस (आईएमएन) का पता चला था।

भारतीय मायनेक्रोसिस वायरस स्ट्रेन ने इंडोनेशियन स्ट्रेन से उच्चतम समानता दिखायी

आंध्र प्रदेश के भीमवाम में 2017 में संक्रामक मायनेक्रोसिस वायरस (आई.एम.एन.वी.) का पता चला । बायोऐसे अध्ययन ने पी. वनामेई में बीमारी का पुनरुत्पादन कर 80% मृत्यु दर दर्ज हुई। प्रभावित झींगा की मांसपेशियों में फाइब्रोसिस और वैक्यूलेशन जैसे अल्ट्रास्ट्रक्चरल बदलाव थे। भारतीय आईएमएनवी के जीनोम अनुक्रमण ने इंडोनेशियन आईएमएनवी केएफ 836757.1 के साथ अधिकतम समानता दिखायी।

भारत में तिलापिआ लेक वायरस (टी.आई.एल.वी.) को गिफ्ट तिलापिआ में पहली बार पता चला

आंध्र प्रदेश और तमिलनाडु के गिफ्ट तिलपिया के नमूनों में पहली बार तिलपिया लेक वायरस (टी.आई.एल.वी.) का पता चला। प्रभावित मछली के त्वचा में अल्सरेटिव घाव, शरीर पर रक्तस्राव और कौडल पंख और आंखों के लेंस में अस्पष्टता थी। इस रोग को प्रयोगात्मक बायोऐसे द्वारा तिलपिया में पुनः उत्पन्न किया गया जिसके परिणामस्वरूप 86.67% मृत्यु दर दर्ज हुई। टी.आई.एल.वी. को तिलपिया मस्तिष्क प्राथमिक सेल कल्चर में अनुकूलित किया गया ।

खारे पानी के मछली में परजीवी प्रोफाइलिंग

पांच उम्मीदवार प्रजातियों (लेट्स कैलकारिफर, मुगिल सेफलस, चैनोस चैनोस, स्काटोफैगस आरगस और एट्रिप्लुस

पुरतेन्सिस) की लगभग 600 मछलियों में परजीवी प्रोफाइलिंग ने इंगित किया कि आरगुलस और कैलीगस खारे पानी के मछली को प्रभावित करने वाले सबसे आम परजीवी थे। आरगुलस का एल कैल्केरिफर में 10.5% संक्रमण, एम. सेफलस में 6.3%, एस आरगस में 7.5% और पर्ल स्पोत में 5.0% संक्रमण देखा गया । कैलिगस स्पीशीज संक्रमण स्काटोफैगस आरगस और पर्ल स्पॉट तक सीमित था। दिलचस्प बात यह है कि चैनोस चैनोस में कोई परजीवी संक्रमण दर्ज नहीं किया गया।

ईएचपी और सफेद मल प्रभावित तालाब की माइक्रोबियल विविधता

ईएचपी और सफेद मल सिंड्रोम (डब्लू.एफ.एस.) से प्रभावित तालाब के माइक्रोबियल विविधता का अध्ययन मेटाजेनोमिक्स का उपयोग करके किया गया। प्रमुख बैक्टीरियल परिवारों में स्यूडोल्टरोमोनाडेसी (17.44%), इडियोओरिनिएसे (11.12%), फ्लैवोबैक्टेरिएसी (7.71%), स्यूडोमोनाडेसी (5.58%) और रोडोबैरेसी (5.03%) शामिल थे। प्रमुख जीवाणु जीनस स्यूडोल्टरोमोनास (16.54%), इडियोमोरीना (10.9 9%) और स्यूडोमोनास (5.45%) था। कुल परिचालन टैक्सोनोमिक इकाइयों (ओटीयू) का केवल 0.12% विब्रियो से संबंधित था।

बैक्टीरियल उत्पाद 'सिबामॉक्स' की माइक्रोबियल प्रोफाइलिंग

सिबामॉक्स एक माइक्रोबियल कंसोर्टियम है जिसमें अमोनिया ऑक्सीडाइजिंग बैक्टीरिया (ए.ओ.बी.), नाइट्राइट ऑक्सीडाइजिंग बैक्टीरिया (एन. ओ. बी.) और डेनिट्रिफाइंग बैक्टीरिया (डी.एन.बी.) शामिल है। डीजीजीई-पीसीआर द्वारा माइक्रोबियल प्रोफाइलिंग - ने 2 डीएनबी, 8 एओबी और 11 एनओबी समूहों की उपस्थिति की पुष्टि की। मेटाजेनोमिक विश्लेषण ने 199 ओटीयू को पुनर्प्रास किया जिसमें अल्फाप्रोटेबैक्टेरिया (32.4%), गामाप्रोटेबैक्टेरिया (28.6%), बीटाप्रोटेबैक्टेरिया (1.0%) और डेल्टाप्रोटेबैक्टेरिया (0.7%) शामिल हैं।

लाइसोजेनिक फिलामेंटस फेज हार्वेई क्लेड की प्रजातियों में व्यापक रूप से वितरित

विब्रियो कैंपबेलि और विब्रियो हार्वेई समेत हरवेई क्लेड बैक्टीरिया के 60 आइसोलेट्स (एनसीबीआई डेटाबेस) के बायोइनफॉर्मेटिक विश्लेषण से संकेत मिलता है कि लगभग 50% हरवेई क्लेड बैक्टीरिया, फिलामेंटस लाइसोजेनिक फेज को रखते हैं और इन बैक्टीरिया के विरुलेन्स में एक महत्वपूर्ण भूमिका निभाते हैं। विशेष रूप से डिज़ाइन किए गए प्राइमरों का उपयोग करके, सीआईबीए के विब्रियो कैंपबेलि के 33% आइसोलेट्स में इसकी उपस्थिति की पुष्टि हुई।

एंटरोसाइटोज़ून हेपेटोपनेई (ईएचपी) के लिए बेहतर डायग्नोस्टिक किट का विकास

ईएचपी के तेज़ और विशिष्ट पहचान के लिए एक नेस्टेड पीसीआर किट विकसित किया गया। कुल 486 बीपी (पहले चरण) और 349 बीपी (नेस्टेड) पीसीआर उत्पादों को अनुकूलित एम्पलीफिकेशन द्वारा उत्पन्न किया गया । किट में न्यूक्लिक एसिड निष्कर्षण सुनिश्चित करने के लिए बीटा एक्टीन हाउस-कीपिंग जीन भी शामिल है। यह किट प्रयोगात्मक संक्रमित पी. वनामेई में ईएचपी का पता लगाने में 100% सटीक था इस किट की पहचान सीमा 20 कॉपी है ।

एशियाई सीबास को प्रभावित करने वाले नर्वस नेक्रोसिस वायरस के खिलाफ टीका विकसित

किशोर एशियाई सीबास में नर्वस नेक्रोसिस वायरस (एनएनवी) संक्रमण को नियंत्रित करने के लिए निष्क्रिय वायरल टीका विकसित की गई । एनएनवी वायरस को एस.एस.एन.-1 सेल लाइन में बृद्धि कराकर बाइनरी एथिलेनिमाइन का उपयोग करके निष्क्रिय किया गया । मोंटानाइड एस्साई जीआर 01 पीआर और मौंटानाइड आईएमएस 1312 वीजी एनपीआर सहायक के साथ निष्क्रिय आयल एडजुवन्ट टीका का उत्पादन किया गया । टीकाकृत मछली ने विरुलेन्ट वायरस के द्वारा चुनौती किये जाने पर 60% सापेक्ष जीवितता (आरपीएस) दर्ज किया।

फेज थेरेपी वाणिज्यिक झींगा हैचरि में लुमिनेसेन्ट विब्रोसिस को नियंत्रित करने में प्रभावी

फेज थेरेपी द्वारा लुमेनसेंट विब्रिओसिस को नियंत्रित करने के लिए चार वाणिज्यिक झींगा हैचरियों में परीक्षण किया गया । चार फेज़ेज़ का कंसोर्टियम विकसित किया गया । दो वाणिज्यिक हैचरि लुमिनेसेन्ट विब्रिओसिस से गंभीर रूप से प्रभावित थे । फेज़ कंसोर्टियम के इस्तेमाल से इन हैचरियों में 35- 53% पोस्टलार्वा में जीवितता दर्ज हुआ, जबकि इलाज न किए गए समूह में 100% मृत्यु दर देखि गयी । अन्य दो हैचरियों जिसमें विब्रिओसिस का कोई रिकॉर्ड नहीं था, इसमें फेज को प्रोफेलेक्टिक के रूप में उपयोग करने से, 15 - 17% तक पोस्टलार्वा जीवितता में सुधार देखने को मिला ।

ऑक्सीटेट्रासाइक्लिन का अवक्रमण लवणता और तापमान पर निर्भर है

ऑक्सीटेट्रासाइक्लिन के अवक्रमण पर अध्ययनों ने लवणता, तापमान और फोटोपॉरिओड का सकारात्मक प्रभाव दर्शाया। कम लवणता और उच्च तापमान पर गिरावट की दर तेज थी। कुल मिलाकर 36 डिग्री सेल्सियस पर 2 दिन और 25°C पर 5 दिन में 98% ऑक्सीटेट्रासाइक्लिन निष्क्रिय हो जाती है ।

एक्वाफेड्स में उपयोग के लिए नए फ़ीड सामग्री का मूल्यांकन

चावल ग्लूटेन के प्रयोग से संकेत मिलता है कि इसे वनामी फ़ीड में 20% तक इस्तेमाल किया जा सकता है। इथेनॉल उत्पादन से निकलनेवाले उप-उत्पाद, घुलनशील डिस्टिलर का उपयोग 25% मछली, 30% सूरजमुखी केक और 11.25% सरसों केक को

पॉलीकल्चर फ़ीड में प्रतिस्थापित कर सकता हैं। पी. इंडिकस फीड में कच्चे रैपसीड (2.5%) की तुलना में 7.5% तक किण्वित करने के उपरान्त शामिल किया जा सकता है । इसी प्रकार, सोयाबीन, मूंगफली, रैपसीड और सूरजमुखी के किण्वित भोजन के संयोजन झींगा फ़ीड में 70% तक प्रतिस्थापित करने में सक्षम थे। इसी प्रकार पोली कल्चर फीड में फिश साइलेज ५०% फिश मील २०% सूरज मुखी केक और ५% सरसों केक को प्रतिस्थापित करने में सछम है।

सीआईबीए द्वारा विकसित फ़ीड का किसान के तालाब में प्रदर्शन

वनामेई झींगा, सीबास और केकड़ा के लिए विकसित फ़ीड जैसे वैनामीप्लस, सीबास नर्सरी प्लस, सीबासप्लस और सिल्लाप्लस फ़ीड को किसानों के तलाव में प्रदर्शन करके सफल उत्पादन किया गया । श्रिम्प्स ने 72 दिनों में 24.5 ग्राम औसत वजन के साथ 550 किग्रा उत्पादन प्राप्त किया। इसकी तुलना में सीबास ने 90 दिनों में 95% उत्तरजीविता के साथ 90 से 200 ग्राम औसत वजन मिला। पिंजरों में 6 महीने ग्रो- आउट के उपरान्त, सीबास ने 900 ग्राम - 1.25 किलोग्राम वजन, 460 किग्रा उत्पादन और 1.85: 1 फ़ीड रूपांतरण अनुपात (एफसीआर) हासिल किया। चार हफ्तों के बाद, 93% केकड़ों की उत्तरजीविता के साथ 22% केकड़ों में मोल्टिंग देखने को मिली ।

शेलफिश और फिनफिश मछलियों के लिए आवश्यक पोषक तत्वों का अनुकूलन

सीबास लार्वा आहार में 0.5% टॉरिन पूरक था। हिल्सा (फ्राई) में लाइसिन और मेथियोनीन की आवश्यकता फ़ीड में क्रमसः 3.54% और 1.64% (सूखे आधार) पाई गयी । हिलसा के बेहतर वृद्धि दर के लिए २५% जीवित खाद्य और ७५% निर्मित खाद्य का संयोजन सर्वाधिक उप्युक्त पाया गया । मिल्कफिश लार्वा के विकास के लिए विटामिन सी की आवश्यकता 183-204 मिलीग्राम एस्कॉर्बिक एसिड प्रति किलोग्राम फ़ीड पाई गयी । जबकि 25% प्रोटीन और 6% वसा मिस्टस गुलिओ के ग्रो-आउट आहार में अनुकूलतम है।

फ़ीड प्रबंधन विकल्प

फ़ीड के बेहतर उपयोग और अच्छे एफसीआर के लिए किशोर पर्ल स्पॉट में 5% की दर से दैनिक राशन अनुकूल पाया गया । प्रयोगों से संकेत मिलता है कि मिल्कफिश किशोरों द्वारा पेरिफाईटन का बेहतर उपयोग किया जा सकता है और यह मोनोकल्चर में 46% तक एफसीआर को कम कर सकता है।

लाइव फीड्स

विभिन्न सूक्ष्म शैवाल के विकास गतिशीलता (growth kinetics) अध्ययन से पता चला है कि टेट्रासेलमिस 12 दिन तक तीव्र वृद्धि दिखा रहा था। फाइकोसाइनिन पिग्मेंट को आर्थोस्पिरा मैक्सिमा से निष्कर्षण किया गया, इसकी शुद्धता वाणिज्यिक रूप से उपलब्ध स्पिरुलिना (स्पाइरुलिना प्लैटेंसिस) के बराबर थी। झींगा के लार्वा पालन में उच्चतम अस्तित्व, विकास और तेज़ रूपांतरण थैलासिओसाइरा : टेट्रासेलमिस (1: 1) के संयोजन से प्राप्त हुई। इसके बाद यह गुणधर्म थल्सिसिसोरा: चाइटोसेरोस और थालासिओसाइरा
से प्राप्त हुई।

डब्ल्यूएसएसवी पूर्ण जीनोम अनुक्रम

पहली बार, वाइट स्पॉट सिंड्रोम वायरस (डब्लू.एस.एस.वी.) के भारतीय आइसोलेट का पूर्ण जीनोम अनुक्रम किया गया है। इसका डी नोवो अनुक्रम नैनो पोर और एलुमिना प्लेटफॉर्म पर किया गया। अध्ययन से पता चला की इसके जीनोम में कुल 280,591 bp और 442 कोडिंग जीन है।

पैनेअस इंडिकस जीनोम का अनुक्रम

पहली बार पैनेअस इंडिकस जीनोम का अनुक्रम सिबा द्वारा किया जा रहा है। केनमेर सिद्धांत के आधार पर पैनेअस इंडिकस जीनोम की लंबाई 1.57 से 1.87 जीबी और दोहराव 62.7 से 82.5% के बीच होने का अनुमान है। इसके साथ ही साथ अधययन से पता चला की पैनेअस इंडिकस जीनोम को छोटे इलुमिना के साथ इकट्ठा नहीं किया जा सकता है क्योंकि इससे जीनोम कई टुकड़ों में टूट जाता है।

उम्मीदवार प्रजातियों के जीनोम आकार

उम्मीदवार मछली और शेलफिश प्रजातियों का जीनोम आकार फ्लो साइटोमीटर का उपयोग करके अनुमान लगाया गया था। झींगा में, जीनोम आकार लिंग के बीच काफी भिन्न था।

नई मॉडल मछली प्रजातियां

चावल मछली (ओरीज़ियास) का प्रजनन केज कल्चर में पहली बार हासिल किया गया है। इस मछली को खारे पानी की मछलियों में अध्ययन के लिए मॉडल जीव के रूप में अपनाने की क्षमता है।

पर्ल स्पोत, ग्रे मलेट और चैनोस चैनोस की जेनेटिक विविधता

माइटोकॉन्ड्रियल एटीपीऐज 6/8 जीन के विश्लेषण के आधार पर पर्ल स्पॉट में उच्च आनुवंशिक विविधता देखी गई। मुगील सेफलस में, माइटोकॉन्ड्रियल एटीपीऐज 6/8 जीन ने तीन अलग आनुवांशिक स्टॉक जैसे गोवा स्टॉक, कर्नाटक स्टॉक और तीसरा केरल, तमिलनाडु, आंध्र और ओडिशा के स्टॉक होने का संकेत दिया। चैनोस चैनोस में यह अधययन गोवा और केरल के स्टॉक के बीच महत्वपूर्ण अनुवांशिक विचलन देखा गया ।

अंतर्देशीय खारे पानी की खेती के लिए उपयुक्त साइट

राजस्थान के अंतर्देशीय खारे क्षेत्रों में जलीय कृषि खेती के लिए मिट्टी और सतह / जमीन नमकीन स्रोत जल गुणवत्ता और उपयुक्तता मानदंडों के आधार पर, कृषि स्थलों (जयपुर, अजमेर, जोधपुर, पाली और जलोरे के जिलों) की पहचान की गई।

मृदा और जल प्रबधन

पेरासिटिक एसिड (10 पीपीएम) लुमेनसेंट विब्रियो और दूसरे बैक्टीरिया को नियंत्रित करने में सछम है। इसके अतिरिक्त ब्लीचिंग पाउडर और सोडियम हाइपोक्लोराइट (72 घंटे) की तुलना में पेरासिटिक एसिड का अवशिष्ट प्रभाव मात्र 48 घंटे के बाद शून्य हो गया। इससे पता चलता है कि पेरासिटिक एसिड को एक वैकल्पिक कीटाणुशोधक के रूप में इस्तेमाल किया जा सकता है।

ऑक्सीजन रिहाई यौगिक

प्रोटोटाइप ऑक्सीजन रिलीजिंग यौगिक (ओ.आर.सी.) को आपातकालीन स्थिति में पूरक के रूप में उपयोग किया जा सकता है। कैल्शियम पेरोक्साइड और ओआरसी को स्रोत जल के साथ-साथ सीओडी समृद्ध निर्वहन पानी के उपचार के लिए किया जा सकता है।

झींगा पालन तालाबों की खनिज डेटाबेस

आंध्र प्रदेश, तमिलनाडु और गुजरात के झींगा पालन तालाबों और स्रोत जलों के बीच कैल्शियम, पोटैशियम, मैग्नेसियम, जिंक और कॉपर के परिमाण में कोई महत्वपूर्ण अंतर नहीं देखा गया। हालाँकि सोडियम, क्लोरीन, आयरन, और मैंगनीज़ की उच्च सांद्रता 16-20 वर्ष पुराने तालाबों में देखी गई। विभिन्न स्थानों के क्रीक और बोर पानी कि खनिज संरचना और आयनिक अनुपात भिन्न होती है।

पेनीअस वानामी में लवणता अनुकूलन

पेनीअस वानामी में लवणता अनुकूलन (0, 16 और 32 पीपीटी) अध्ययन से पता चला की पानी की ओस्मोलालिटी (21, 419 और 909 एमओएसएमओएल / किग्रा) लवणता में वृद्धि के साथ बढ़ जाती है। जबकि सीरम ओस्मोलालिटी (614, 713 और 888 एमओएसओल / किग्रा) इसकी तुलना में कम वृद्धि देखने को मिली। यह वानामी के अनुकूलन क्षमता को इंगित करता है। इसके अलावा पी. वानामी 24 घंटे के अंतराल में खनिज मात्रा में तीव्र परिवर्तन के अनुकूलित हो जाती है।

मेटाजेनोमिक्स द्वारा झींगा तालाबों में जीवाणु विविधता की पहचान

पेनीअस वानामी तालाब के सेडीमेंट-पानी इंटरफेस (एस.डब्ल्यू.आई) पर जीवाणु समुदायों की विविधता का अध्ययन विभिन्न लवणता पर किया गया। शुरुआती दिनों की तुलना में अंत समय में माइक्रोबियल समुदायों में अधिक विविधता देखि गयी। नमकीन और उच्च नमकीन तालाबों में एक्टिनोबैक्टेरिया 30 डी.ओ.सी और प्रोटेबैक्टेरिया 60 और 9 0 डी.ओ.सी पर जयादा संख्या में पाए गए, जबकि कम नमकीन तालाव में पूरे काल के दौरान प्रोटेबैक्टेरिया प्रभावी था। सल्फर-रेडूसिंग जीवाणुओं की आबादी कम नमकीन तालाबों में 60 डी.ओ.सी., नमकीन में 90 डी.ओ.सी. और उच्च नमकीन तालाव में पुरे फसल की अवधि के दौरान देखि गयी। इससे तलाव में हो रहे सल्फाइड निर्माण का संकेत मिलता है।

पर्यावरण प्रभाव आकलन

सिंधुदुर्ग जिले में पानी और मिट्टी की गुणवत्ता की निगरानी, स्रोत पानी, केकड़ा तालाब, और जल निकायों में किया गया। अध्ययन में केकड़ा खेती का कोई नकारात्मक प्रभाव पर्यावरण पर नहीं देखा गया। जिले में जल निकायों के क्षमता का विश्लेषण केकड़ा खेती क्षेत्र में वृद्धि की संभावना को दर्शाता है।

जलकृषि किसानों को मृदा-जल स्वास्थ्य कार्ड

सिबा ने नेल्लोर जिले में तीन निजी प्रयोगशालाओं और मत्स्यपालन कॉलेज के सहयोग से मिट्टी और जल स्वास्थ्य कार्ड तैयार किए। संस्थान द्वारा विकसित पोर्टेबल जल विश्लेषण किट बाजार में उपलब्ध समकक्ष किट की तुलना में अधिक सटीक साबित हुए।

ग्रीन हाउस गैस उत्सर्जन, पशु चयापचय और उत्तरजीविता पर जलवायु परिवर्तन का अध्ययन

कार्बन डाइऑक्साइड का उत्सर्जन तालाव सुखाने की प्रक्रिया के दौरान जबकि मीथेन का उत्सर्जन कल्चर अवधि के दौरान उच्च था। नाइट्रस ऑक्साइड उत्सर्जन में इस प्रकार के कोई प्रवृति नहीं देखि गयी। थर्मल तनाव प्रयोग के अधययन के लिए इन सीटू पर्यावरण इकाई विकसित की गयी। अधययन से पता चला की सीबास फ्राई 30 डिग्री सेल्सियस पानी के तापमान को 72 घंटे तक आसानी से सहन कर सकता है, जबकि 32 डिग्री सेल्सियस और उससे अधिक तापमान पर उच्च मृत्यु दर पाई गयी। वानामी किशोरों के हेपेटोपैनक्रियास में में 31 और 33 डिग्री सेल्सियस पर अधिक लिपिड और फैटी एसिड पायी गयी। इसी प्रकार फैटी एसिड जैव संश्लेषण, पैंटोज फॉस्फेट पाथवे और बायोटिन चयापचय 35 डिग्री की तुलना में 31 और 33 डिग्री सेल्सियस पर पर अधिक था।

एक्वास्टैट इंडिया 2017 - खारापानी जलकृषि क्षेत्र के लिए व्यापक डेटाबेस

एक्वास्टैट इंडिया 2017 - वैश्विक और भारतीय परिदृश्य पर ब्रैकिशवाटर जलकृषि छेत्र के लिए व्यापक डेटाबेस तैयार किया गया। इस डेटाबेस में जलकृषि के संसाधन, उत्पादन और व्यापार आंकड़े शामिल हैं और इसमें खारापानी के जलकृषि से सम्बंधित

तकनीकी पहलुओं और उनके आर्थिक प्रभाव की जानकारी भी शामिल है।

खारापानी जलकृषि प्रौद्योगिकियों का प्रभाव विश्लेषण

सन 2002-16 की अवधि के लिए इनपुट-आउटपुट विश्लेषण से संकेत मिलता है कि खारापानी जलकृषि छेत्र की तीन प्रौद्योगिकियों जैसे डब्लू एस एस वी किट (2002-2009), पेनीअस वानामी का भारत में जलकृषि (2009-2016) और सिबास्टीम (2012-2016) से राष्ट्रीय खजाने को कुल मिलाकर 34,413 करोड़ रुपये आर्थिक लाभ अर्जित हुआ।

ब्रैकिशवॉटर एक्वाकल्चर- किसान की आमदनी को दोगुना करने के लिए संभावित क्षेत्र

झींगा और फिनफिश का वैज्ञानिक उत्पादन और प्रबंधन छोटी अवधि के भीतर किसानों को उच्च आय प्रदान करती है, जो परंपरागत तरीकों की तुलना में चार गुना अधिक है। सफेद झींगा (पेनीअस वानामी; 7 लाख / हेक्टेयर), मिल्क फिश (चैनोस चैनोस; 2.40 लाख/हेक्टेयर), एशियाई सीबास (लेट्स कैलकारिफर; 4.00 लाख/हेक्टेयर), और पर्ल स्पॉट (एट्रोप्लस सूरतेंसिस; 2 लाख/हेक्टेयर) सुध लाभ अर्जित करने में सछम है।

सीबास का तीन स्तरीय मॉडल के तहत पिंजरे में जलपालन

सिबा ने एन.आई.ओ.टी. चेन्नई और फिशर युवा समूह के साथ मिलकर कांचीपुरम जिले के वेलंगुपट्टू गांव में सीबास का पिंजरे में जलपालन का प्रदर्शन किया। इसके तहत नर्सरी पालन, पूर्व-विकास (प्री-ग्रो आउट) एवं विकास (ग्रो-आउट) का प्रदर्शन ओपन ब्रेकिशवॉटर में प्रौद्योगिकी पैकेज के रूप में सम्पन्न हुआ। एशियाई सीबास (लेट्स कैलकारिफर) मछली को इसकी विकास क्षमता, बीज और फ़ीड की उपलब्धता, और उच्च बाजार मूल्य के कारण प्रदर्शन के लिए चुना गया। उत्पादन लागत 190 रुपये प्रति किलोग्राम की तुलना में बिक्री मूल्य 380 रुपये प्रति किलो प्राप्त हुआ।

अतिरिक्त मॉड्यूल के साथ वानामी श्रिंप ऍप का उन्नयन

वानामी श्रिंपैप झींगा खेती पर दुनिया भर में पहला मोबाइल ऐप है। इसे 7500 से अधिक स्टेकहोल्डर्स के द्वारा दुनिया के अनेक देशो में (भारत, इंडोनेशिया, वियतनाम, ब्राजील, पेरू, मेक्सिको, इक्वाडोर और संयुक्त राज्य अमेरिका) नियमित रूप से उपयोग किया जाता है। ऐप को प्रबंधन मॉड्यूल, इनपुट कैलक्यूलेटर, रोग निदान, झींगा फार्म जोखिम आकलन, सरकारी विनियम, एफ.ए.क्यू. मॉड्यूल, एक प्रश्न पोस्ट करें, आदि के साथ व्यापक अपग्रेड किया गया है।

जलकृषि क्षेत्र में पारिवारिक भागीदारी की मूल्य श्रृंखला

पारिवारिक भागीदारी के मूल्य श्रृंखला तंत्र के सेगा विश्लेषण से संकेत मिलता है कि 20% परिवारों ने मछली पालन में नई तकनीकों को अपनाया है और नए बाजारों में प्रवेश किया है। पुरुष और महिलाएं मिलकर जलकृषि और मत्स्य मूल्य श्रृंखला में निर्णय लेती है।

खारापानी जलकृषि में शामिल जनजातीय किसानों का सामाजिक स्थिति विश्लेषण

तमिलनाडु के तटीय आदिवासी गांवों में 50 जनजातीय परिवारों की सामाजिक स्थिति के अधययन से पता चला कि उनका आयु समूह (पुरुष और महिला दोनों) 20 से 40 वर्ष (60%), 40 से 60 साल (20%), और 60 वर्ष और उससे अधिक (20%) के बीच थे। उनमें से 90% अशिक्षित थे। मत्स्य पालन, वाइल्ड झींगा संग्रह और केकड़ा संग्रह उनका प्रमुख व्यवसाय (90%) है। इनकी मासिक आय Rs. 1000-4000 /- (20%), 4001-10,000 /- (70%) और 10,001-15,000 /- (10%) थी। वे चावल मिल और कृषि क्षेत्रों में मजदूर के रूप में भी काम करते हैं जो उनका माध्यमिक व्यवसाय (10%) है।

आजीविका गतिविधि के रूप में एशियाई सीबास (लेट्स कैलकारिफर) का नर्सरी पालन

सी.आई.बी.ए. ने नर्सरी पालन के लिए 10 हापा (2x1x1m) में 500 नंबर प्रति हैपा कि दर से सीबास फिश फ्राई (1.2-1.8 सेमी) स्टॉक किया। 57 दिनों के भीतर 35.80% कि जीवितता दर से 1820 फिंगरलिंग्स (3-9.5 सेमी) प्राप्त हुआ। इससे किसान को प्रति चक्र में 28000/- शुद्ध आय प्राप्त हुआ।

अड्यार क्रीक में मिट्टी केकड़ा कल्चर का प्रदर्शन

ग्रामीणों के लिए जल निकाय का उपयोग कर आजीविका का जलकृषि मॉडल विकसित किया गया। इसके तहत दो प्रदर्शन परीक्षण आयोजित किए गए। नदी में 100 m^2 का पेन लगाकर मिट्टी केकड़ों को 40 दिनों तक रखा गया। इससे जलकृषि किसानों को 16000 सुद्ध आय कि आमदनी हुई।

युवाओं को एक्वाकल्चर व्यबसाय में आकर्षित करना

चेन्नई के आसपास के स्कूल और कॉलेज के छात्रों ने (पंद्रह बैच) सी. आई. बी. ए. मुख्यालय और एम.ई.एस. मुथुकादु का दौरा किया। उन्हें खारे पानी के जलकृषि के बारे में जानने और सी. आई. बी. ए. मुख्यालय और एम.ई.एस. मुथुकादु की आधारभूत सुविधाओं का निरीक्षण किया। इसके अतिरिक्त सात सप्ताह के लिए ब्रैकिशवॉटर जलकृषि पर छात्र परियोजना मॉड्यूल सितंबर-अक्टूबर 2017 के दौरान आयोजित किया गया, इसके तहत केन्द्रीय विद्यालय, चेन्नई के नौ छात्र समूह को अल्पकालिक परियोजनाएं दी गई।

ब्रैकिशवॉटर जलकृषि में वेब-आधारित ज्ञान केंद्र

ब्रैकिशवॉटर जलकृषि में वेब-आधारित ज्ञान केंद्र को डिज़ाइन,

डेवलपमेंट, कार्यान्वयन और मूल्यांकन सहित निर्देशक सिस्टम डिज़ाइन (आईएसडी) के ADDIE मॉडल को विकसित किया गया। कुल 110 स्टेकहोल्डर्स की आवश्यकताओं के आकलन के आधार पर आवश्यक जानकारी को आठ श्रेणियों में विभाजित की गई, जैसे, ब्रैकिशवॉटर जलकृषि का अवलोकन, झींगा विवरण, मछली विवरण, केकड़ा विवरण, मत्स्य संस्थान, एक्वाकल्चर आंकड़े, मत्स्य पालन नीतियां, आईसीटी उपकरण और महत्वपूर्ण लिंक।

जलकृषि के लिए अड्यार क्रीक और एस्टूरी सूचना तंत्र (ए.सी.ई.आई.एस.-एक्वा)

जल निकायों में जलकृषि के विकास के लिए MySQL डेटाबेस प्रबंधन प्रणाली और PHP स्क्रिप्टिंग भाषा का उपयोग करके अड्यार क्रीक और एस्टूरी सूचना प्रणाली (ए.सी.ई.आई.एस.-एक्वा) को विकसित किया गया। यह वेब-आधारित सिस्टम उपयोगकर्ताओं को ब्रैकिशवॉटर जलकृषि से सम्बंधित आंकड़े प्रदान करता है।

Shrimp farmer monitors the check trays in pond

Aerial view of CIBA hatchery complex at Muttukadu

Executive Summary

Although brackishwater aquaculture has been practiced in India for several decades, the modern brackishwater aquaculture particularly shrimp farming started in mid 1980s. The growth of brackishwater aquaculture for the last three decades has been spectacular. ICAR-CIBA has been playing a pivotal role in shaping the industry, resolving the issues in aquaculture and assisting in framing the policies. Being one of the foremost research organizations in the country, the research works carried out by the Institute lead to outcomes that are crucial to the brackishwater farming sector. The year 2016-17 was a rewarding and fulfilling year of CIBA in terms of scientific contributions, and impacts on the sector. With a twenty nine in-house and external funded projects and out reaching activities the Institute was able to provide remarkable contribution for the science of brackishwater aquaculture that leads to the technological know-hows. The current year CIBA had 31 MoUs, and that generated a revenue of 2.5 million, During this year the Institute released 209 publications including 79 peer-reviewed scientific papers in high impact journals. Presented below are some of the highlights of the research and development that accomplished by the Institute during 2017-18

Penaeus indicus demonstration trials

Shrimp farming in India, which is based on exotic *Penaeus vannamei*, is at a cross road due to the emerging diseases, reduced survival, increase in the cost of production, and recent falls in prices. At this juncture development of native species is a viable option to ensure the sustainability of shrimp farming. Indian white shrimp, *P. indicus,* has been identified as a suitable candidate species for domestication and genetic improvement. In order to evaluate the farm level performance, 21 demonstration trials were carried out at identified stations all along the Indian coast. The production ranged between 2- 6.5 mt/ha at stocking density of 15 to 45 PL/m^2, with a survival Salient observation is absence rate ranging between 80 and 98%. The FCR ranged from 1.4 to 1.65. The absence of emerging diseases such as EHP and

running mortality syndrome, is found to be an important characteristic of *P. indicus*.

Doubling of farmers income through inland low saline shrimp farming in south western Punjab: Initiative of CIBA

South Western region of Punjab possesses abundant resources of inland saline groundwater with salinities ranging from 3 to 15 ppt. Vannamei farming in this area leads to a success story in South Western Punjab, where farmers obtained an income of Rs. 2.0 lakh/acre from a four-month long crop, using the technological package for shrimp farming from CIBA. The technology of shrimp farming using saline groundwater with high-quality seed and cost-effective *desi* feed has become an income multiplier for farmers in Punjab.

Production system diversification: development of integrated multi-trophic aquaculture (IMTA):

Diversifying and improving the performance of production system and species cultured are the major priorities of aquaculture research. IMTA is the cultivation of two or more complementary crops where waste of one crop serve as input (feed or fertilizer) for other crops. Thus, environmental issues related to the coastal aquaculture could be solved to greater extend, and further cultivation of different crop optimize the economic returns. An open water IMTA was developed in Gad River, Sindhudurg district, Maharashtra. Seabass was reared in a 32 m^2 cage along with green mussel as an extractive crop. After nine month of rearing, sea bass has grown to an average size of 990.1 g with a total production of 360 kg and survival of 63%. Farmers received revenue of 162000/ for a total cost of 120000/ for nine months

Biofloc based culture systems:

High-density culture systems with limited or no water exchange result in the production of large volumes of suspended flocculated organic particles including microalgae, autotrophic and heterotrophic bacteria. These, unique system, biofloc system, provides several beneficial effects to farmed species.

Chanos chanos: A 60 days experiment was carried out and evaluated growth performance of milkfish, *Chanos chanos* in biofloc based nursery rearing system using different carbon sources (Molasses, Wheat & Corn). The results revealed that milkfish fry reared in wheat based biofloc system showed significantly better growth performance. Although water quality characteristics such as ammonia, nitrate and nitrite were significantly higher in biofloc system, all these parameters found to be favorable for milkfish growth

Penaeus vannamei: The C/N ratio of the culture water can have extremely significant impact on water quality and biofloc biomass production. The effect of different C/N ration on production performance of *P. vannamei* was evaluated. C/N ratio up to 15: 1 is favourable for growth and survival of *P. vannamei*.

Pond reared brood stock for Indian shad, Hilsa

Development of captive broodstock is the essential pre requisite for developing protocol for mass rearing of any farmed species. Broodstocks of Hilsa were developed in the grow-out production system in Kakdwip research centre of CIBA. Reproductive maturation in pond system is found to be synchronized with natural breeding cycle.

Polyculture

Polyculture is the addition of two or more subordinate species, and it is one of the efficient ways of increasing productivity and optimizing the economic returns. Several experiments were carried out to evaluate the growth and production performance of polyculture including shellfish and finfishes. In one experiment, growth performance of *Mystus gulio*, *Chanos chanos*, *Etroplus suratensis*, *Oreochromis niloticus* and *Penaeus monodon* was studied. The experimental trials demonstrates promising results in terms of growth of various finfishes and shellfishes in the polyculture farming

Popularization of milkfish farming as 'Decan Hilsa' in West Bengal:

Proper and efficient marketing is the essential component of a sustainable aquaculture. Milk fish has been marketed in West Bengal under the name,'*Decan Hilsa*'. As a part of this program, a collaborative research work with a private entrepreneur was carried out, and 2 mt of milkfish with an average body weight of 225 g was harvested

Seabass farming as a livelihood option for youth in Karnataka

CIBA started a seabass farming program to provide livelihood option for young farmers in

Kasargoda village in Karnataka. With the hatchery reared seed provided by CIBA, farmers were able to harvest 512 kg of seabass from 0.2 ha pond for a period of 10 months.

Brackishwater seaweed, *Gracilaria spp*.

Gracilaria spp is one of the most important aquaculture resources, and it has been widely used for the production of agar and treatment of aquaculture discharges. Several experiments were carried out to evaluate the production technique and farming environment: for example pond and open lagoon. Production performance was higher in rope culture compares to net bags. The potential of seaweed as biofilter has been tested and seaweed based biofilter has been developed and tested for the efficacy.

Aeration efficiency

Mechanical aeration has been the general practice in feed based aquaculture system particularly in semi-intensive and intensive shrimp culture ponds. The efficiency of aeration is extremely important to optimize the economics of the culture system as well as to optimize the DO levels in the aquaculture ponds. Salinity levels in the water have been the major deciding factor that determines the DO levels. The oxygen requirement at different salinity levels were determined using different aerators such as paddle wheel, submersible, spiral, jet and impeller aerators.

Cryptic species of *Penaeus japonicus* from India

Previous studies on kuruma shrimp, *P. japonicus*, conducted by CIBA suggested the difference in the biology and in the aquaculture traits with reference to *P. japonicus* reported from other countries. Molecular signature of this species, using specimens obtained all along its distributional range in India, was evaluated using 16S rRNA gene and CO1 gene. Molecular phylogenetic analysis of 16S and CO1 demonstrated that the species reported in India is a cryptic species of *P. japonicus* group. The genetic distance among Indian species, and *P, japonicus* and *P. pulchircaudatus* confirms a new species status for Indian taxon.

Reproductive quality of male *Penaeus indicus* (Indian white shrimp) in relation to molting stages

Reproductive management of males in shrimp hatchery is crucial in optimizing reproductive performance and seed stock production. The male spermatophore quality of *Penaeus indicus* was evaluated in relation to the molt stages, the average sperm count was significantly higher in premolt stage compare to inter molt stage although no difference in percentage of live or normal sperm between the two phases of molt cycles.

Artificial insemination (AI)

AI is a deliberate introduction of sperm into the female reproductive tract, and which is the crucial component of captive breeding program. Several trials of AI have been carried out in *Penaeus monodon, P. indicus* and *P. vannamei*. Success rate in *P. vannamei* is found to be higher than the *P. monodon* and *P. indicus*, presumably due to the difference in the reproductive morphology.

Development of In vitro fertilization (IVF) of *Penaeus monodon*

In vitro fertilization in shrimp aquaculture is one of the important tools to study the developmental biology of shrimp that resolve the issues in captive reproduction. Further, it is important to evaluate the hybridization potential of the species, as *in vivo* hybridization often fails to understand the problems involved in the fertilization process. A novel IVF protocol is developed and tested the hybridization potential of *P. monodon* eggs with *P. vannamei* and *P. indicus*. High percentage of fertilization was achieved between *P. monodon* and *P. vannamei* compared to *P. monodon* and *P. indicus*.

Effect of salinity on survival, growth and osmoregulatory capacity of *Penaeus vannamei* and *P. indicus* with special reference to the inland saline ecosystem

Recently, marine shrimp farming is extended to low saline coastal areas and inland brackishwater areas, where traditionally shrimp farming was not practised. Understanding the physiology of osmoregulation in low saline and inland brackishwater is vital for further refinement of low saline shrimp farming technology. Experiments were carried out to evaluate the growth, survival and osmoregulatory capacity of *P. indicus* and *P. vannamei* under reduced seawater salinities and reconstituted inland salinities. Survival of *P. indicus*

whereas survival was significantly higher at 10 and 15 ppt in the reconstituted inland saline waters.

Improving the survival rate of mud crab, *Scylla serrata*, by different feeding schedule

High mortality rate of *Scylla serrata* zoea has been the major bottleneck in the initial phase (Z1 to Z3) of mud crab larval rearing. The poor survival rate at this phase is mostly attributed to the nutritional status of the crab larvae, which in turns depends on the feed quality and quantity. Rotifer fed on *Thalassiosira* and combination feed including *Chlorella* and *Tetraselmis* produced better survival.

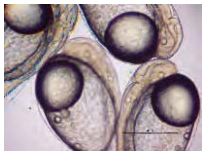
Growth and reproductive parameters of grey mullet *Mugil cephalus*- variations of two captive stocks

Variations in biological parameters may serve as indicators of stock variations in fish. Growth and reproductive performance of the populations of *M. cephalus* obtained from east and west coast were evaluated, after rearing three years at similar environmental conditions. It was found that both stocks are significantly different in growth and reproductive characteistics indicating the variability of the stock.

Start-up program of seabass hatchery

In order to promote establishment of seabass hatchery, a private entrepreneur was allowed to use the facilities in CIBA hatchery. Seeds and technical knowhow were provided to entrepreneur. A total of 9,60,000 spawn supplied to entrepreneur, and he produced old 3,27,500 20-day old fry. The produce was sold to farmers for an amount of 6,88,625/- .. As a knowledge partner CIBA was shared an amount of 250000/.

Captive maturation and ovulation of *Liza parsia*



Development of regionally important small fishes for brackishwater aquaculture is one of the strategies for food security and livelihood diversification in coastal rural areas. Gold spot mullet, *L. parsia* is a high valued food fish in some states of the country. A breeding protocol has been developed for the induced maturation of *L. parsia*. For induced breeding, two phase rearing is required: fishes should be reared in low saline water for reproductive maturation, and for final oocyte maturation and spawning fishes should be transferred to full strength seawater.

Larval development and rearing procedure of *Hilsa ilisha*

Larval development and detail ontogeny of larvae were studied and documented. Hilsa larvae were reared in tanks for fifteen days using live feed such as *Chlorella*, copepod and *Artemia* nauplii. Subsequently the larvae were transferred to earthen pond for further rearing.

Extended breeding of milkfish under captivity

Milkfish breeding technology has further refined, and breeding period under captivity has been extended for eight months. A total of 1.4 million fertilized eggs were obtained from thirteen spawning. It has been observed that milkfish spawning is more correlated with increasing water temperature than salinity. A total of 75000 early milkfish fry were distributed among farmers from Kerala, Goa, Gujarat, Tamil Nadu, Andhra Pradesh and West Bengal along with 2.5 lakh fertilized eggs to the private entrepreneur for satellite nursery rearing. Total revenue generated was 97500 from seed sale. Multiple spawning of milkfish extended for eight months gives the possibility to overcome challenges of year round breeding

Breeding of crescent perch, *Terapon jarbua*

Seed production protocol for the aquarium fish, crescent perch, has been standardized. Induced breeding protocol using LHRHa was successful, and larvae were reared using algae, *Nanochloropsis aculeate* and Rotifer. About 50000 larvae were produced during the experiment.

Culture of cyclopoid copepod

Cyclopoid copepods are emerging live food organism, and procedure for mass rearing of a novel cyclopoid copepod was developed. Mass culture of copepod using a combination diet of *Nannochloropsis* sp and *Isochrysis* sp, *Chaetoceros* sp, rice bran powder and baker's yeast resulted 1500 to 4500 no/L within 14 days.

White spot disease and microsporidosis continue to haunt shrimp farming

Disease surveillance during 2015-2018 in 420 shrimp farms in three coastal states:Tamil Nadu, Andhra Pradesh and West Bengal revealed that the shrimp hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP) had the

highest prevalence of 43% in 2015, and during the last year, the prevalence decreased to 21%. The prevalence of white spot disease (WSD) was 37% and 11% during the corresponding years. The prevalence of infection hypodermal and haematopoietic necrosis (IHHN) also decreased from 6 to 3-% during the last three years. The other disease syndromes, such as stunted growth, white feces syndrome (WFS), running mortality syndrome (RMS), loose shell syndrome (LSS) and black gills were recorded in 27, 12, 4, 6% and 5% of the farms respectively during the year 2017-18. The shrimp culture in India was free from OIE listed diseases such as Taura syndrome (TS), yellow head disease (YHD), acute hepatopancreatic necrosis disease (AHPND) and necrotising hepatopancreatitis (NHP) during 2017-18. However, infectious myonecrosis (IMN) was detected in two *P. vannamei* farms in AP and TN during February- March 2017.

The Indian strain of Infectious myonecrosis virus (IMNV) showed highest sequence similarity to the Indonesian strain

Infectious myonecrosis virus (IMNV) was detected from some farms in Bhimavam in AP in 2017. The bioassay study reproduced the disease in *P. vannamei* and caused up to 80% mortality. The muscle of affected shrimp had ultrastructural changes such as fibrosis and vacuolation. The whole genome sequencing of this IMNV strain showed maximum identity with Indonesian IMNV strain KF836757.1.

Tilapia Lake Virus (TiLV) detected for the first time in GIFT Tilapia in India

Tilapia Lake Virus (TiLV) was detected for the first time in GIFT Tilapia samples of Andhra Pradesh and Tamil Nadu. The affected fish had ulcerative lesion in the skin, haemorrhages on body and caudal fins, and opacity of the eye lens. The disease was reproduced in tilapia by experimental bioassay resulting in 86.7% mortality. The TiLV was adapted in primary culture of tilapia brain.

Parasitic profiling in brackishwater finfishes

Parasitic profiling of nearly 600 fishes of five candidate species (*Lates calcarifer*, *Mugil cephalus*, *Chanos chanos*, *Scatophagus argus* and *Etroplus suratensis*) indicated that *Argulus* and *Caligus* were the most common parasites affecting these brackishwater finfishes. *Argulus* spp. infection was observed in 10.5% of *L. calcarifer*, 6.3% of *M. cephalus*, 7.5% of *S. argus* and 5.0% of *E. suratensis*. *Caligus* spp. infection was restricted to *S. argus* and *E. suratensis*. Interestingly, no parasitic infection was recorded in milk fish, *C. chanos*.

Microbial diversity of EHP and white feces affected pond

The microbial diversity study of EHP and white fecal syndrome (WFS) affected pond was carried out using metagenomics. The dominant bacterial families included Pseudoalteromonadaceae (17.4%), Idiomarinaceae (11.1%), Flavobacteriaceae (7.7%), Pseudomonadaceae (5.6%) and Rhodobacteraceae (5.0%). The dominant bacterial genus was *Pseudoalteromonas* (16.5%), *Idiomarina* (11.0%) and *Pseudomonas* (5.45%). Only 0.1% of the total operational taxonomic units (OTUs) belonged to *Vibrio* spp.

Microbial profiling of nitrifying and denitrifying bacterial product 'CIBAMOX'

CIBAMOX is a microbial consortium containing ammonia oxidising bacteria (AOB), nitrite oxidising bacteria (NOB) and denitrifying bacteria (DNB). The microbial profiling by PCR-DGGE confirmed the presence of 2 DNB, 8 AOB and 11 NOB groups. Metagenomic analysis recovered 199 (OTUs) covering Alphaproteobacteria (32.4%), Gammaproteobacteria (28.6%), Betaproteobacteria (1.0%) and Deltaproteobacteria (0.7%).

Lysogenic filamentous phages are widely distributed among species of harveyi clade

Bioinformatic analysis of 60 isolates (NCBI database) of harveyi clade bacteria including *V. campbellii* and *V. harveyi* indicated that almost 50% of isolates possessed filamentous lysogenic phage and appeared to play an important role the in virulence of these bacteria. Using specifically designed primers, its presence was confirmed in 33% of *V. campbellii* isolates at CIBA.

Improved diagnostic kits developed for *Enterocytozoon hepatopenaei* (EHP)

A nested PCR kit targeting spore wall protein gene was developed for rapid and specific diagnosis of EHP in shrimp. The PCR products of 486 bp (first step) and 349 bp (nested) were generated by an optimized amplification cycle. The kit also includes -

actin house-keeping gene to ensure nucleic acid extraction. The detection of EHP was 100% accurate in experimentally infected *P. vannamei* and had detection limit of 20 copies.

Inactivated vaccine was developed against nervous necrosis virus affecting Asian seabass

Inactivated viral vaccine was developed to control nervous necrosis virus (NNV) infection in juvenile Asian seabass. The SSN-1 cell line propagated NNV virus was inactivated using binary ethylenimine. An oil adjuvant vaccine was produced by mixing inactivated cell culture supernatant with Montanide Essai GR01 PR and Montanide IMS 1312 VG NPR adjuvants. The vaccinated fish recorded 60% relative percentage survival (RPS) on challenge with virulent virus.

Phage therapy was effective in controlling luminescent vibriosis in commercial shrimp hatchery

The efficacy of phage therapy was tested in four commercial shrimp hatcheries to control luminescent vibriosis. A consortium of four phages improved the survival of postlarvae by 35 – 53% compared to 100% mortality in untreated group in two commercial hatcheries severely affected with luminescent vibriosis. As a prophylactic measure, phage application improved the larval survival by 15 - 17% in two hatcheries having no record of vibriosis.

Degradation of oxytetracycline is dependent on salinity and temperature

Studies on the degradation of oxytetracycline indicated a positive influence of salinity, temperature and photoperiod. The rate of degradation was faster at lower salinity and higher temperature. Overall, 98% oxytetracycline was degraded with in 2 days at 36°C compared to 5 days at 25°C.

Evaluation of newer feed ingredients for use in aquafeeds

Experiment on use of rice gluten indicated that it could be used up to 20% in the vannamei feed. Dried distiller's grains with solubles, a by-product from ethanol production can replace 25% of the fish meal, 30 % sunflower cake and 11.25 % mustard cake in fish polyculture feed. Fermented rapeseed meal can be included up to 7.5% in *P. indicus* feed compared to 2.5% with a raw meal. Similarly, combinations of fermented meals of soybean, groundnut, rapeseed and sunflower were able to replace up to 70% of fishmeal in shrimp feeds.

In situ demonstration of practical feeds developed by CIBA

Cost effective feeds developed for farmed species: vannamei, seabass, and crab such as Vanami^{Plus}, Seebass Nursery ^{Plus}, Seebass^{Plus} and Scylla^{Plus} respectively were successfully demonstrated in farmers pond. The shrimps attained an average body weight of 24.5 g within 72 days with a production of 550 kg. Seabass fry got a survival of 95% final average body weight ranged from from 50 to 200 g in 90 days. In grow-out farming in cages, seabass obtained the size of 900 g - 1.25 kg in 6 months with a production of 460 kg and feed conversion ratio (FCR) of 1.85:1. After four weeks, 22% of the crabs molted, and 93 % of the crabs survived.

Optimization of nutrient requirements for farmed fishes and shellfish

In seabass larval diet 0.5 % taurine supplementation was found to be optimum. Optimum lysine and methionine requirement of hilsa fry were found to be 3.54 % and 1.64 % of feed on a dry matter basis. The dietary vitamin C requirement for the growth of *Chanos chanos* larvae was estimated to be in the range of 183–204 mg ascorbic acid per kg of feed. The growth and survival of milkfish were positively related to the dietary PL concentration. It was found that 6% dietary fat with 25 % protein is optimum for *M. gulio* in its grow-out diet.

Feed management options

In juvenile pearlspot, the daily ration of 5% feed of average body was found to be optimum for better utilization of feed and good FCR. Experiments have indicated that periphyton can be better utilized by milkfish juveniles and it can reduce the FCR up to 46% in monoculture.

Live feeds

The growth kinetics of different micro algae showed The *Tetraselmis* sp extended exponential growth (>12 days) in its growth cycle. Extraction of bioactive pigment phycocyanin standardised for *Arthrospira maxima*, and the purity of crude extract of was on par with commercially available spirulina (*Spirulina*

platensis). Micro algal suitability for larval rearing of shrimp showed that the highest survival, growth and fast conversion with a combination of *Thalassiosira*: *Tetraselmis* (1:1) followed by *Thalssisosira* : *Chaetoceros* and *Thalassiosira*.

WSSV complete genome sequence

For the first time, complete genome sequence of an Indian isolate of white spot syndrome virus (WSSV) has been deciphered. The length and repeat content of *Penaeus indicus* genome were estimated to vary between 1.57 to 1.87 Gb and 62.7 to 82.5 % respectively based on k-mer principle.

Genome size of candidate species

The genome size of candidate fish and shellfish species was estimated using flow cytometer. In shrimp, the genome size varied significantly between sexes

New model fish species

Breeding of Rice fish, *Oryzias* sp. has been achieved for the first time in captivity. The fish has the potential to be considered as a model organism for studies in brackishwater fishes

Genetic diversity of pearlspot and grey mullet

High genetic diversity was observed among the stocks of *Etroplus suratensis* based on an analysis using mitochondrial ATPase6/8 gene, as most of the stocks studied exhibited significant divergence from other stocks. In *Mugil cephalus*, mitochondrial ATPase6/8 gene indicated three distinct genetic stocks viz., Goa stock, Karnataka stock and the stocks from Kerala, Tamil Nadu, Andhra and Odisha

Genetic diversity in *Chanos chanos*

Significant genetic divergence was observed between Goa and Kerala stocks of *Chanos chanos* based on mitochondrial ATPase6//8 gene

Suitable site for inland brackishwater farming

Based on the soil and surface/ground saline source waters quality and suitability criteria, farming sites (districts of Jaipur, Ajmer,Jodhpur, Pali and Jalore) were identified for aquaculture farming in the inland saline regions of Rajasthan.

Soil and water management

Peracetic acid of 10 ppm was effective in reducing bacterial count and inhibiting growth of luminescent *Vibrio* sp. and can be used as an alternative disinfectant. The residual effect of PAA reduced to zero after 48 hrs of application at 10 ppm conc compared to bleaching powder and sodium hypochlorite, which lasted upto 72 hrs.

Oxygen releasing compound

The prototype oxygen releasing compound (ORC) could be utilised as supplement to mechanical aeration under emergency condition rather than a replacement. Calcium peroxide and ORC could be utilized for the treatment of COD rich discharge water as well as source water.

Database on mineral status of shrimp culture ponds

Minerals status of shrimp culture ponds and source waters from Andhra Pradesh, Tamil Nadu and Gujarat showed no significant change for Ca, K, Mg, Zn and Cu with pond age and high concentration of available Na, Cl, Fe and Mn were observed in 16-20 year aged ponds. Creek and bore well waters from different locations, even with similar salinity varied in their mineral composition and ionic ratios.

Adaptation of *P. vannamei* under various salinities

Study of *P. vannamei* under 0, 16 and 32 ppt salinities throughout the culture revealed that the mean water osmolality varied from 21, 419 and 909 mOsmol/kg under 0, 16 and 32 ppt salinity respectively. However, there was not much change in serum osmolality (614, 713 and 888 mOsmol/kg at 0, 16 and 32 ppt), indicating that *P. vannamei* adapts well to varying salinities. Moreover *P. vannamei* rapidly adapts to drastic changes in the mineral content of water, even as quickly as every 24-hours interval.

Identification of bacterial diversity in shrimp culture ponds by metagenomics

The study was conducted to understand the diversity of the bacterial communities at sediment-water interface (SWI) in *P. vannnamei* culture ponds of various salinities. It was found that more diverse microbial communities toward the end compared to early days of culture in all salinities. Actinobacteria were dominant at 30 DOC and Proteobacteria at 60 and 90 DOC in saline and high saline culture ponds, whereas in low saline Proteobacteria was dominant during the whole culture period. The predominance of populations of sulfur-reducing bacteria starts from 60 DOC in low saline, throughout the cropping period in high saline, and at 90 DOC in saline culture ponds indicates the

possibility of build-up of sulphide and reduced condition in the pond.

Environmental impact assessment

Monitoring of water and soil quality from source water, crab culture pens and ponds, and receiving water bodies in Sindhudurg District showed no negative environmental impacts of crab farming on the receiving water bodies. Carrying capacity assessment of the water bodies in the district revealed the scope of increasing the area for crab farming.

Soil water health cards to aquaculture farmers

Soil and Water Health cards were prepared in PPP mode by the Institute in collaboration with three private laboratories and Fisheries College in Nellore District. Portable water analysis kits developed were refined and proved to be more accurate than the counterpart kits available in the market.

Climate change on GHG emission, animal metabolism and survival

The pond bottom emitted higher amount of CO_2 during the drying process compared to the emission during culture period, whereas CH_4 emission was high during culture period, and N_2O emission trend was not significant. In situ environment manipulation unit for conducting thermal stress experiments was fabricated. Seabass fry can tolerate acute temperature stress for a period of 72 h till 30°C with minimum mortality. Beyond 32 C water temperature, mortality was high and is not advisable for seabass nursery rearing. Temperature stress in *P. vannamei* juveniles showed increase in total lipid and fatty acid content in hepatopancreas, and increased fatty acid biosynthesis, pentose phoshphate pathway and biotin metabolism in shrimp reared at 31 and 33 but not at 35°C.

Aquastat India 2017 - brackishwater aquaculture sector

A comprehensive database, Aquastat India 2017-brackishwater aquaculture sector, on the global and Indian scenario of brackishwater aquaculture is being developed. The compendium consists of resources, production, and trade statistics of aquaculture and also includes information on technical aspects of the brackishwater aquaculture and their economic impact.

Impact analysis of brackishwater aquaculture technologies

Analysis based on Input-Output time series intervention model for the period 2002-16 indicated that the total economic benefits accrued to the national exchequer cumulatively from the three brackishwater aquaculture technologies viz., WSSV kit (2002-2009), Introduction of *Penaeus vannamei* (2009-2016) and the product CIBASTIM (2012-2016) were to the tune of Rs. 34,413 crores.

Brackishwater Aquaculture- the prospective sector for doubling farmer's income

Scientific production and management of shrimp and finfishes yield high income to the farmers within a short span of time, which are four-fold increase than the traditional practices. Production of shrimp species like white shrimp (*Penaeus vannamei*; net return of Rs.7 lakh/ha), milkfish (*Chanos chanos*; 2.40 lakh/ha), Asian Seabass (*Lates calcarifer*; 4.00 lakh/ha), and pearlspot (*Etroplus suratensis*; 2 lakh/ha) would fetch higher income within 8 months)

Seabass rearing in a three-tier model of cage farming in brackishwater

The technology package for a three-tier model of cage farming of fishes in open brackishwater comprises of nursery rearing, pre-grow out and grow out phases was validated in partnership with the NIOT Chennai and fisher youth group at Vennangupattu village cluster in Kancheepuram district, Tamil Nadu. Asian seabass (*Lates calcarifer*) fish was chosen as culture species due to its growth potential, availability of seed and feed and higher market value. The production cost was worked out to be Rs.190 per kg of fish and sale price was Rs.380 per kg with a BCR of 2.0.

Upgradation of Vanami Shrimpapp with additional modules

Vanami Shrimpapp is the first mobile app on shrimp farming and has been regularly followed by more than 7500 stakeholders (farmers and extension workers) across the globe (India, Indonesia, Vietnam, Brazil, Peru, Mexico, Ecuador, and the USA). The app is comprehensive and upgraded with Best Management Practices Module, Input Calculator, Disease Diagnosis using probabilistic techniques, Shrimp Farm Risk Assessment Module, Update and Advisories, Government Regulations, FAQ Module, Post a Query, etc.

The value chain of family participation in aquaculture sectors

SEAGA analysis of value chain mechanism of family participation indicated that women and their

had supported the men in aquaculture sectors (50%). They have adopted new techniques in fish farming practices (20%), entered into new markets and more profitable enterprises (20%) and both men and women play a major role in the aquaculture and fishery value chain (60%) and decision-making practices (60%) in value chain of fish and shrimp farming.

Social status analysis of tribal farmers involved in brackishwater aquaculture

The social status of the 50 tribal families in the coastal tribal villages of Tamil Nadu indicted that their maximum age group (both men and women) were between 20 and 40 yrs. (60%) followed by 40 and 60 yrs. (20%), and 60 yrs and above (20%). Ninety percent of them were illiterate followed by primary level education. Fishing, wild shrimp collection, and crab collection was their major occupation (90%). The majority (70%) of the beneficiary's monthly income ranged from Rs.4001- 10,000/- followed by Rs.1000- 4000/- (20%) and Rs. 10,001 - 15,000/- (10%). They also work as wage labourers in rice mills and agriculture fields which is their secondary occupation (10%).

Nursery rearing of seabass (*Lates calcarifer*) as a livelihood activity

A nursery rearing unit comprised of 10 hapas (2x1x1m size) with a total volume of 120 m^2 was selected, and the seabass fish fry of size 1.2-1.8 cm provided by CIBA was stocked @ 500 no. per hapa was reared for 57 days. The realized production was 1820 fingerlings of size 3-9.5 cm. The net income per cycle was 28, 000 and the families got an income of 7000/- per head. The survival realized was 35.8% (in open waters).

Demonstration of mud crab culture in the open water system at Adyar creek

In order to utilize open water bodies for aquaculture as livelihood option for marginalized rural poor, an aquaculture model was developed. Two demonstration trials were conducted, to standardize the potential aquaculture models. A 100 m^2 pen was erected in the estuary and mud crabs are reared for 40 days. Farmers obtained 16000/ at the end of the culture .

Attracting and Retaining Youth in Aquaculture (ARYA)

Fifteen batches of schools and college students mainly in and around Chennai visited CIBA HQ and MES Muttukadu and were exposed to learn about brackishwater aquaculture farming and to observe infrastructural facilities of CIBA HQ and MES Muttukadu. Student project module on brackishwater aquaculture for seven weeks was conducted during September-October, 2017. A batch of nine higher secondary students from the Kendriya Vidyalaya, Island Ground, Chennai were given short-term projects to study the brackishwater resources for aquaculture. Totally 354 students from 4 universities and 6 colleges and 5 schools visited CIBA during this period.

Web-based knowledge centre in brackishwater aquaculture

Web-based knowledge centre in brackishwater aquaculture was designed based on the ADDIE model of Instructional System Design (ISD), including Analysis, Design, Development, Implementation, and Evaluation. Based on the needs assessment of 110 stakeholders, users of ICT projects of Village Knowledge Centre of MSSRF, Tamil Nadu, and Aquachoupal, Andhra Pradesh (50 nos); aqua/tribal farmers of Gujarat (50 nos.) and students (10 nos.). The required information was designed into eight categories viz., Overview of brackishwater aquaculture; Details of Shrimp; Details of fish; Details of Crab; Fisheries institutions; Aquaculture statistics; Fisheries policies; ICT tools and Important links.

Adyar Creek and Estuary Information System (ACEIS-Aqua) for aquaculture

Adyar Creek and Estuary Information System (ACEIS-Aqua) was developed using MySQL database management system and PHP scripting language for the development of aquaculture in the water bodies. This web-based system describes the database/search modules that permit end users fast and easy access to large amounts of analyzed data which are collected in different sample locations and details of cultural practices which are suitable for these water bodies for the development of brackishwater aquaculture.

Introduction

All over the world, the demand for seafood has increased as people started taking seafood as a part of regular diet due to its beneficial effect to fight against cardiovascular disease, cancer, Alzheimer's and many other major illnesses. On the other hand, supply of seafood from oceans is almost stable or declining. Therfore, aquaculture, which involves breeding, rearing and harvesting of aquatic species has been recognised as the most competent option to meet the growing demand for seafood. At present, aquaculture sector contributes around 50 per cent of all seafood produced for human consumption, and that contribution will continue to increase.

Although aquaculture practised in all kinds of water resources (freshwater, brackishwater and seawater), the pressure on freshwater resources due to multi-user demands and climate change related impacts constraint the future expansion, and, therefore, the future aquaculture development is expected to occur mostly in brackishwater. Further, aquaculture in brackishwater helps in minimising the carbon footprint of fish production in freshwater water. In India excluding the 1.2 million hectares of the coastal land area identified suitable for pond based brackishwater farming, about 3.9 million ha of open brackishwaters comprises estuaries, creeks, backwaters, and lagoons remain unutilized for fish production. Furthermore, brackishwater environments are rich in biodiversity and more productive ecosystems than the open marine waters, which are challenging to manoeuvre. Brackishwater resources are, therefore, perceived as ideal for aquaculture in the future. As an added advantage, high tolerance of brackishwater flora and fauna to the extremes of the water quality make them more appropriate for farming under controlled conditions. In addition to the food production, coastal aquaculture can generate substantial employment opportunities in diversified fields across coastal India.

India emerged as a fastest growing major economy in the world and the second largest producer of farmed fish and shellfish. Frozen shrimp produced from brackishwater sector continued to be the major valued item accounting for a share of 70% of the total export earnings (about US$ 6.5 billion). After playing a crucial role in the introduction of exotic *P. vannamei* to Indian shrimp farming, ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA) realizes the risk of complete dependence of the sector entirely on imported broodstock. As a futuristic alternate strategy, CIBA has identified native Indian white shrimp, *P. indicus* as native candidate species for research in the direction of stock improvement through selective breeding. Farming of seabass in customized open-water cages, and other fishes such as milkfish, hilsa, mullet and pearlspot gained a notable impetus and given confidence to the coastal farmers. CIBA as a nodal agency in brackishwater aquaculture development, not only developing technology for producing seeds of candidate species but also engaged in issues related to the environment, cost-effective feed production, farm and hatchery construction, disease diagnosis, monitoring and advocating remedies etc.. Besides production-oriented research, CIBA also researches to preserve the valuable natural resources like land, water and energy, to have more sustainable, eco- friendly and socio-economically viable brackishwater aquaculture in this country.

Out of total 3.9 million ha of the estuarine 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. The unutilized resource can be made highly productive for fish farming by proper planning and implementation of technological advancements.

At ICAR-CIBA, we support cutting-edge science and research to develop customized technologies suitable for different agro-climatic conditions that leads to 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 and research centre at West Bengal.

The headquarters with the administrative office-cum-laboratory is located on the banks of Adyar river creek in MRC Nagar, Chennai, since 2001. The Muttukadu Experimental Station (MES) is located about 30 km south of Chennai on the east coastal highway connecting Puducherry. The Kakdwip Research Centre (KRC) in West Bengal is situated about 100 km south from Kolkata close to the deltaic region called the Sundarban of Hooghly estuarine complex.

The research programs in CIBA are diverse. In the year 2017-18 the institute has handled 12in-house and 21 externally funded projects. Our research programs are prioritised according to the fixed mandates.

OUR VISION

CIBA envisages it role as one of the world's best 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

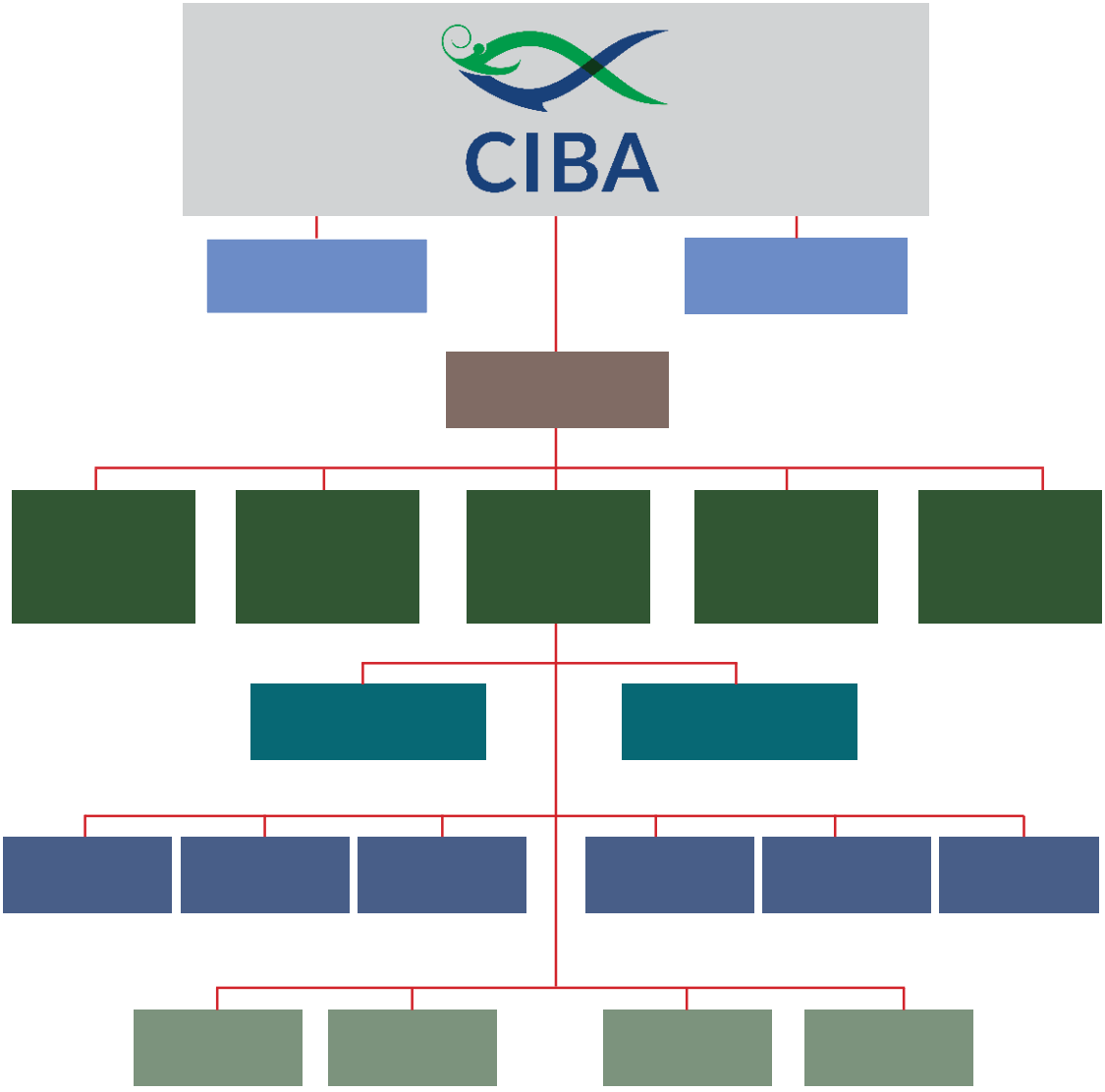
OUR MISSION

Our mission is to realize the 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 repository of information on brackishwater fishery resources with a systematic database.
- Human Resource Development, capacity building and skill development through training, education and extension.

Organisation Chart



Unified Budget of ICAR-CIBA - 2017-18
(Rupees in lakhs)

S.No.	Sub-Head	BE	RE	Actual expenditure during
	Grants for creation of CAPITAL ASSETS (Capital)			
1	Works - Office building	145.00	175.00	175.00
2	Equipments	70.00	75.00	75.00
3	Information Technonogy	20.00	20.00	20.00
4	Library Books and Journals	25.00	15.00	15.00
5	Furniture & Fixtures	20.00	25.00	25.00
	Sub-total (A)	280.00	310.00	310.00
	Grants in Aid - SALARIES (Revenue)			
1	Establishment Expenses (A) Salaries	1685.50	1741.00	1738.70
	(B) Loans & Advances	7.00	7.00	0.50
	Sub-total (B)	1692.50	1748.00	1739.20
	Grants in Aid - GENERAL (Revenue)			
1	Pension & Other Retirement Benefits	1430.00	2014.00	1827.46
2	Traveling Allowances	25.00	28.00	28.00
3	Research & Operational Expenses	166.00	178.00	178.00
4	Administrative Expenses	706.00	690.00	690.00
5	Miscellaneous Expenses (HRD & Others)	16.50	17.50	17.50
	Sub-total (C)	2343.50	2927.50	2740.96
	Tribal Sub-Plan (TSP)			
1	Capital	15.00	15.00	15.00
2	Revenue	12.00	12.00	12.00
	Sub-total (D)	27.00	27.00	27.00
	GRAND TOTAL	4343.00	5012.50	4817.16

Staff Position

Category	Sanctioned	Filled	Vacant
RMP/Director	1	1	0
HOD/Principal Scientist	5	2	3
Senior Scientist	10	6	4
Scientist	52	59	-7
Total	68	68	0
T-4	1	1	0
T-3	14	10	4
T-1	16	11	5
Total	31	24	7
Administrative Officer	1	1	0
Finance & Accounts officer	1	0	1
Deputy Director (OL)	1	0	1
Asst. Administrative Officer	3	3	0
Junior Accounts Officer	1	1	0
Private Secretary	1	0	1
Personal Assistant	2	2	0
Stenographer Grade - III	1	2*	*1 excess
Assistants	7	6	1
Upper Division Clerk	3	2	1
Lower Division Clerk	5	4	1
Total	26	20+1*	6
Skilled Support Staff	55	28	27
Grand Total	180	141	39

The details of sanctioned, filled and vacant position as on 31.03.2018

Official Language Implementation Programme

Official Language Implementation Committee meetings were held on 01.07.2017, 21.10.2017, 06.01.2018 and 08.05.2018 during the year 2017-18. Usage of Hindi in official correspondences, bilingual use of Hindi and English in files, publications in Hindi were reviewed in these meetings. Hindi Saptah (week) was celebrated at the Institute from 14.09.2017 to 20.09.2017. As part of the Hindi Saptah celebrations, Hindi Kavita Path, Hindi noting & drafting and Hindi Prasnothari competitions were organized. Hindi Day was celebrated on 20.09.2017. During the valedictory function, Sri. R. Sudarsan, All India Radio, Chennai has been invited for delivering lecture on Official Language implementation and thereafter the 1st, 2nd, 3rd and consolation prizes were given to the winners of Hindi competitions by the Director.

Sri. R. Sudarsan, All India Radio distributing prizes to winners of the Hindi competition

Hindi Week Celebration at KRC

Hindi week was celebrated at KRC, Kakdwip during 16-22 Sept. 2017 to promote the use of Hindi in Official and Scientific works. In this connection various competition such as singing, quiz, extempore were conducted among the KRC-staffs. Chief Guest of the valedictory function, Mr. Ramdayal Sharma (Hindi officer, NIRJAFT, Kolkata) delivered motivating talk on how to use Hindi in official and scientific works. He also encouraged the uses of Hindi in file noting.

On-Going Research Projects

Crustacean Culture Division

Institute Funded Projects

Sl. No.	Project Title	Funding	Project Team
1	**Technology upgradation and refinement for sustainable development of diversified systems and species of penaeid shrimp**	**ICAR**	**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, Dr. T.K. Ghoshal, Dr. M. Kumaran, Dr. K. Ambasankar, Dr. Sanjoy Das, Dr. R. Geetha, Mr. Jose Antony, Dr. N.S. Sudheer, Mr. I.F. Biju, Mr. R. Aravind, Dr. Suvana Sukumaran, Mr. Pankaj Amrut Patil, Dr. T.N. Vinay, Dr. S. Sivagnanam, Shri S. Rajamanickam
2	**Issues in biology, reproduction, larval rearing of candidate crustacean species for brackishwater aquaculture**	**ICAR**	**PI: Dr. C.P. Balasubramanian** **Co-PIs:** Dr. C. Gopal, Dr. M. Jayanthi, Dr. A. Panigrahi, Dr. P. Nila Rekha, Dr. P. Shyne Anand, Ms. L. Christina, Dr. N.S. Sudheer, Mr. Jose Antony, Mr. I.F. Biju, Mr. R. Aravind, Dr. T.N. Vinay

Sl. No.	Project Title	Funding	Project Team
3	**Demonstration of improved culture technologies in shell fish and finfish aquaculture and TSP programmes in Gujarat**	**ICAR**	**PI: OIC, Navsari** **Co-PIs:** Dr. M. Kailasam, Dr. M. Muralidhar, Dr. P.K. Patil, Dr. P. Mahalakshmi, Dr. T. Ravisankar, Dr. M. Jayanthi, Dr. A. Panigrahi, Dr. P. Shyne Anand, Dr. Aritra Bera, Dr. S. Sivagnanam, Shri R. Puthiyavan
4	**Development of inland saline aquaculture in Punjab, Haryana, Rajasthan, Gujarat & Maharashtra**	**ICAR**	**PI: Dr. K.K. Vijayan** **Co-PIs: Dr. M. Kailasam,** Dr. Aritra Bera, Mr. I.F. Biju, Mr. Jose Antony, Mr. R. Aravind, Mr. Pankaj Amrut Patil, Mr. Tanveer Hussain , Mr. Dani Thomas, Dr. K. Ambasankar, Dr. J. Syama Dayal, Dr. Debasis De, Dr. K.P. Kumaraguru Vasagam, Mr. K.P. Sandeep, Dr. M. Muralidhar, Dr. P.K. Patil, Dr. S. K. Otta, Dr. P. Kumararaja, Dr. Satheesha Avunje, Dr. N.S. Sudheer, Dr. Suvana Sukumaran, Dr. T. Ravisankar, Dr. C.V. Sairam, Dr. B. Shanthi, Dr. P. Nila Rekha
Externally Funded Projects			
5	**Upgradation of breeding and culture technology of Indian white shrimp *P. indicus* through stock evaluation and culture demonstrations**	**NFDB**	**PI: Dr. A. Panigrahi** **Co-PIs:** Dr. G. Gopikrishna, Dr. C. Gopal, Dr. S. Kannappan, Dr. K.P. Kumaraguru vasagam, Dr. P. Mahalakshmi, Dr. K. Vinaya Kumar, Dr. P. Shyne Anand, Ms. L. Christina

Sl. No.	Project Title	Funding	Project Team
6	Seaweeds for bioremediation in recirculatory aquaculture system	DST	**PI: Dr. P. Nila Rekha** **Co-PIs:** Dr. K. Ambasanka r, Dr. A. Panigrahi, Dr. K.P. Kumaraguru vasagam
7	Evaluation and refinement of indigenous automatic feeder for shrimp farming	NFDB	**PI: Dr. P. Nila Rekha** **Co-PIs:** Dr. K. Ambasanka r
8	Healthy Shrimp and 'GIFT' tilapia production through bio-floc based farming system: Development of technology and standard operating procedure	DBT	**PI: Dr. A. Panigrahi** **Co-PIs:** Dr. M. Shashi Shekhar, Dr. P. Nila Rekha, Dr. K.P. Kumaraguru vasagam
9	Optimization of aerators use to reduce production cost of shrimps under different brackishwater farming conditions		**PI: Dr. M. Jayanthi** **Co-PIs:** Dr. T. Ravisankar, Dr. M. Muralidhar, Dr. R. Saraswati, Dr. Aritra Bera **Technical Associates** Dr.S.Sivagnanam, Shri R. Puthiavan

Finfish Culture Division

Institute Funded Projects			
10	Evaluation of reproductive biology, breeding, larval biology and seed production of candidate finfish species for brackishwater aquaculture development	ICAR-CIBA	**PI: Dr. M. Kailasam** **Co-PIs:** Dr. M. Makesh, Dr. Satyanarayan Sethi, Dr. Krishna Sukumaran, Dr. G. Biswas, Dr. Prem Kumar, Dr. B. Sivamani , Dr. K.P. Kumaraguru vasagam , Dr. J. Raymond Jani Angel, Smt. M.U. Rekha, Mr. Pankaj Amrut Patil, Mr. Tanveer Hussain, Mr. Dani Thomas, Mr. T. Sivaramakrishnan, Mr. R. Subburaj

Sl. No.	Project Title	Funding	Project Team
11	**Development and refinement of finfish culture technologies for sustainable brackishwater aquaculture development**	**ICAR-CIBA**	**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, Mr. Tanveer Hussain, Mr. Dani Thomas, Mr. Pankaj Amrut Patil, Mr. T. Sivaramakrishnan, Mr. R. Subburaj

Aquatic Animal Health and Environmental Division

Institute Funded Projects			
12	**Invertebrate and finish diseases in brackishwater aquaculture and development of prophylactic and therapeutic strategies**	**ICAR-CIBA**	**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, Mrs. Mary Lini, Dr. Vidya Rajendran, Mr. T. Sathish Kumar, Mr. Joseph Sahaya R ajan Associates from other division Dr. M. Makesh, Dr.N. Lalitha, Dr.G. Biswas, Dr. Aritra Bera, Smt. M.U. Rekha
13	**Development of water and soil health card for environmental management of brackishwater aquaculture systems**	**ICAR-CIBA**	**PI: Dr. M. Muralidhar** **Co-PIs:** Dr. R. Saraswathy, Dr. N. Lalitha, Dr. P. Kumararaja, Dr. Satheesha, Dr. Suvana Sukumaran , Mr. Jose Antony, Dr. A. Nagavel

Externally Funded Projects			
Sl. No.	Project Title	Funding	Project Team
14	**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, Mr. T. Sathish Kumar, Dr. Vidya Rajendran
15	**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. Sanjoy Das, Dr. R. Ananda Raja, Dr. T. Bhuvaneswari, Dr. Satheesha , Dr. M. Makesh, Dr. R. Saraswathy, Dr. N. Lalitha, Dr. P. Kumararaja, Dr. C.V. Sairam, Dr. T. Ravisankar, Dr. R. Geetha
16	**Development of diagnostics and vaccines for sustainable aquaculture**	**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

Sl. No.	Project Title	Funding	Project Team
	c. Biocontrol of vibrios in shrimp hatcheries using bacteriophages		**PI: Dr. S.V. Alavandi** **Co-PIs:** Dr. Satheesha Avunje, Dr. Vidya Rajendran
	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, Mr. T. Sathish Kumar, Dr. Vidya Rajendran
17	**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 Day al, Dr. A. Panigrahi , Dr. M. Kumaran , Dr. R. Saraswathy , Dr. S.K. Otta, Mr. 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			
Sl. No.	Project Title	Funding	Project Team
18	**Biotechnological interventions and application of bioinformatic tools for improvement of brackishwater fish and shellfish**	**ICAR-CIBA**	**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
19	**Newer feed resources and feed additives for development and improvement of shrimp and fish feeds**	**ICAR-CIBA**	**PI: Dr. K. Ambasankar** **Co-PIs:** Dr. J. Syama Dayal, Dr. T.K. Ghoshal, Dr. Debasis De, Dr. K.P. Kumaraguru vasagam, Mr. K.P. Sandeep, Ms. Leesa Priyadarsani
Externally Funded Projects			
20	**Outreach activity on fish feed**	**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 Priyadarshini
21	**Outreach activity on nutrient profiling and evaluation of fish as a dietary component (Lead Centre: CIFRI, Barrackpore)**	**ICAR**	**PI: Dr. J. Syama Dayal** **Co-PIs:** Mr. K.P. Sandeep, Mr. Jose Antony, Mr. T. Sivaramakrishnan

Sl. No.	Project Title	Funding	Project Team
22	Outreach activity on fish genetic stocks (Lead Centre: NBFGR, Lucknow)	ICAR	**PI: Dr. G. Gopikrishna** **Co-PIs:** Dr. M. Shashi Shekhar, Dr. C.P. Balasubramanian, Dr. Sherly Tomy, Dr. J. Raymond Jani Angel, Dr. T.N. Vinay, Ms. Misha Soman
23	Whole genome sequencing of Indian white shrimp *Penaeus indicus*	ICAR	**PI: Dr. M. Shashi Shekhar** **Co-PIs:** Dr. G. Gopikrishna, Dr. K. Vinaya Kumar, Mr. J. Ashok Kumar, Dr. C. P. Balasubramanian, Dr. S.K. Otta,
24	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
25	Stock characterization, captive breeding, seed production and culture of hilsa (*Tenualosa ilisha*)	NASF	**PI: Dr. Debasis De** **Co-PIs:** Dr. Prem Kumar
Other Projects			
26	Agri-Business Incubation centre (ABI) at CIBA, Chennai	NAIF - ICAR	**PI: Dr. T. Ravisankar** **Co-PI :** Dr. P.K.Patil
27	Intellectual property Management and Transfer/ Commercialization of Agricultural Technology Scheme (Up-scaling of existing components i.e. Intellectual property Right (IPR)	NAIF - ICAR	**PI: Dr. T. Ravisankar** **Co-PI :** Dr. P.K.Patil

Social Sciences Division

Institute Funded Projects

Sl. No.	Project Title	Funding	Project Team
28	**Research and developmental interventions for sustainable brackishwater aquaculture**	**ICAR-CIBA**	**PI: Dr. C.V. Sairam** **Co-PIs:** Dr. V.S. Chandrasekaran, Dr. T. Ravisankar, Dr. B. Shanthi, Dr. D. Deboral Vimala, Dr. M. Kumaran, Dr. P. Mahalakshmi, Mr. J. Ashok Kumar, Dr. R. Geetha

Externally Funded Projects

29	**Investigations on pathogenic microorganisms of shrimp aquaculture using metagenomic and other bioinformatics approaches**	**ICAR-Network Project**	**PI: Mr. J. Ashok Kumar** **Co-PIs:** Dr. S.V. Alavandi, Dr. K. Vinaya Kumar, Mrs. Mary Lini, Dr. Satheesha Avunje, Dr. Monendra Grover

Kakdwip Research Centre

Institute Funded Projects

30	**Development of economically viable and sustainable brackishwater aquaculture practices with special reference to Sundarban Mangrove biosphere**	**ICAR-CIBA**	**PI: Dr. T.K. Ghoshal** **Co-PIs:** Dr. Debasis De, Dr. Sanjoy Das, Dr. G. Biswas, Dr. Prem Kumar, Ms. L. Christina, Ms. Leesa Priyadarsani

RESEARCH HIGHLIGHTS

BRACKISHWATER PRODUCTION SYSTEM AND RESEARCH

Brackishwater aquaculture production system has been one of the most dynamic food production systems globally. CIBA focuses on various strategies to develop a sustainable production system

Successful harvest of Integrated multi-trophic aquaculture in Sindhudurg district, Maharashtra

Brackishwater Production System and Research

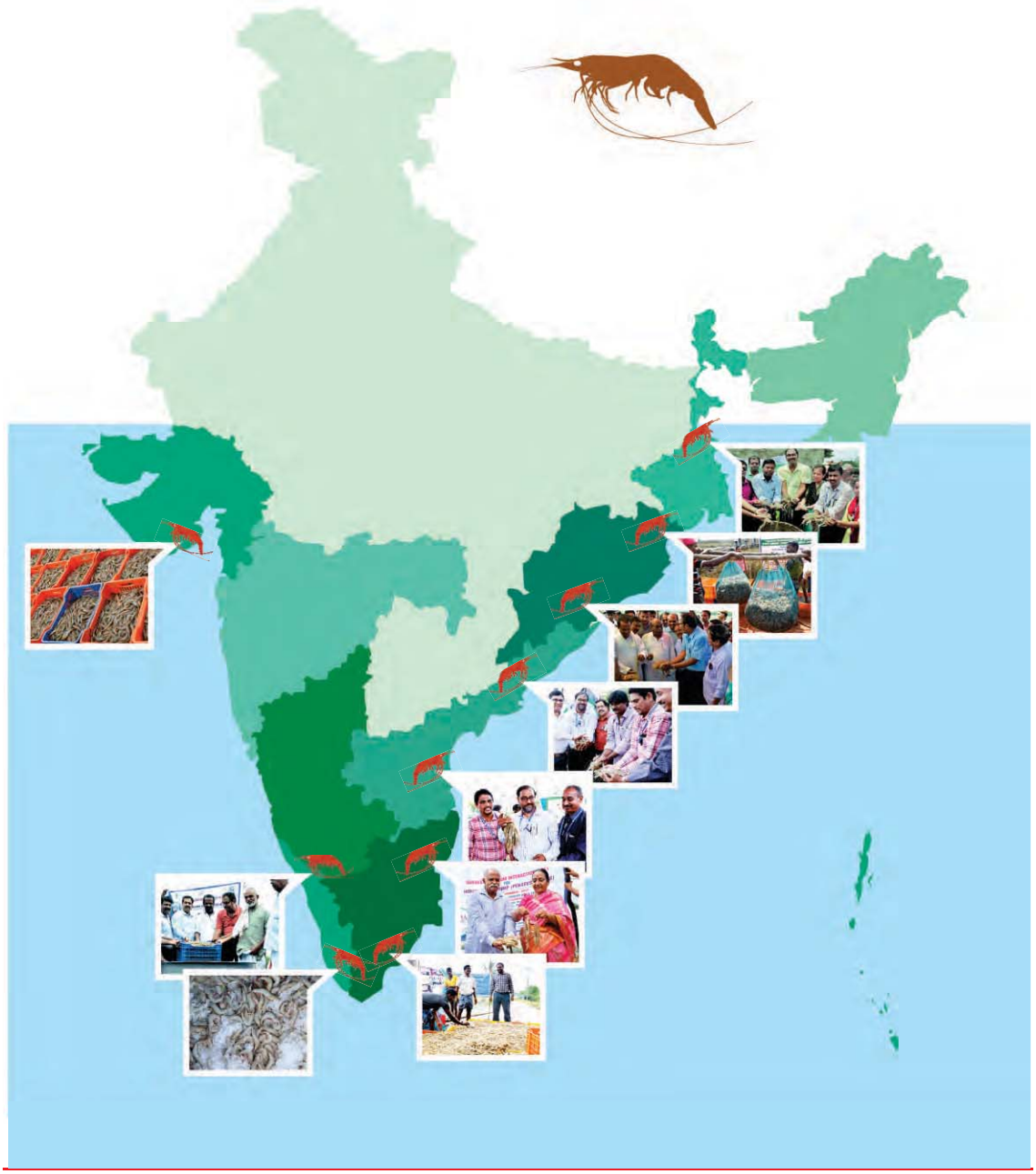
Brackishwater ecosystem, a subset of the coastal system, has traditionally been used for fisheries and aquaculture since several decades. These traditional aquaculture systems have transformed to modern high valued shrimp aquaculture system. The focus of brackishwater farming system research is the development of a sustainable production system. Presently brackishwater aquaculture in India is almost synonymous to farming of *Penaeus vannamei*, an exotic shrimp. The exclusive dependence on a single species culture is inherently unstable and therefore, diversification of species has been the major focus of the research

Penaeus indicus demonstration trials

Shrimp farming in India, which is based on exotic *Penaeus vannamei*, is at a crossroad due to the emerging diseases, reduced survival, increase in the cost of production, and recent falls in prices. At this juncture development of native species is a viable option to ensure the sustainability of shrimp farming. Indian white shrimp, *P. indicus*, has been identified as candidate species for domestication and genetic improvement, owing to its relative ease in captive breeding compared to other closed thelycum species. In order to evaluate the real world performance of this species, several culture demonstrations were conducted across different geographical locations. These participatory approaches enabled the farmers to make ensure the advantage of *P. indicus* farming. Multi-location culture demonstration of *Penaeus indicus* was carried out Nationwide in six coastal states: Odisha, West Bengal, Kerala, Andhra Pradesh, and. Gujarat. Demonstration trials were carried out at a stocking density of 15 to 45 individuals/m_2 in ponds of 0.2 to 1 ha ponds with a formulated feed developed by CIBA, 'Indicus^{Plus}' At the end of 100 -120 days of the culture period, a final body weight of 22-24 g with a survival up to 98% and a production ranging from 3 to 7 tons/ ha was obtained. The culture demonstration conducted across different salinities starting from 3 ppt to 60 ppt showed better growth could be observed in the range of 15 to 35‰ salinity. This species was cultured at very low salinity at Kattur village (Thiruvallur district, Tamil Nadu), and obtained a production of 3633/ha with 90 % survival. It is against the popular belief that *P. indicus* is not a suitable species for low saline culture

Grading of Indian white shrimp during harvest at farm site in Andhra Pradesh

Farming of Indian white shrimp (*Penaeus indicus*) was demonstrated across the coastal states of India as an complementary native species for exotic Pacific white shrimp (*Penaeus vannamei*)



Doubling farmers income through inland low saline shrimp farming in southwestern Punjab

South Western region of Punjab in India possesses abundant resources of inland saline groundwater with salinities ranging from 3 to 15 ppt. The districts of Bathinda, Muktsar, Fazilka, and parts of Mansa have regions with underlying low saline groundwater. Agricultural productivity in this region is lower compared to the rest of Punjab due to low soil fertility, poor irrigation network, the absence of major riverine systems and the presence of saline groundwater. To double the income of farmers in this region, farming of Pacific white shrimp, *Penaeus vannamei* was successfully demonstrated using amended inland low saline water at Sangat Kalan Village, Bathinda, Punjab with M/S Blancas Aqua, Bathinda in a partnership farming mode. The stocking of shrimp seed in the two 4000 m2 ponds was carried out in June 2017 using *P. vannamei* PL 13 (Avg. Length ~7.3mm, Avg. BW ~1.745±0.15 mg) sourced from a Coastal Aquaculture Authority (CAA) certified hatchery. The shrimp seed quality were assessed through PCR screening and stress tests at CIBA laboratory in Chennai before packing and transportation. Each of the 4000 m2 (1 acre) ponds were stocked with 1.2 lakh PL (Stocking density – 30 PL/m2) during the evening hours following standard acclimation procedure. The salinity and pH during the culture varied from 4.5 to 5.0 ppt and 8.1 to 8.9, respectively. The ionic profile of the culture medium was analysed once every week at CIBA based on which the mineral supplementation for potassium, magnesium and other trace elements were carried out. Mineral supplementation is a critical operation in inland shrimp farming as the ionic profile of inland saline groundwater varies significantly from the coastal saline waters. The shrimp attained a marketable size of 20 g (average body weight or ABW) within three months, and attained an ABW of 26.3 g within four months (36-40 count). The survival rate and feed conversion ratio (FCR) observed during the trial were 79.18 % and 1.2 respectively. At the end of 120 days of culture (DOC), a production of 2.5 tonnes was obtained from each of the 4000 m2 ponds resulting in a productivity of 6.25 tonnes/ha. The harvested shrimp realised a farm gate price of Rs. 320/Kg thus resulting in total revenue of Rs. 16 lakhs against an operating cost of Rs. 12 lakhs, creating a net profit of Rs. 4 lakhs, i.e., 2 lakhs/acre/crop.

The cost-effective white shrimp feed of CIBA, Vanami^{Plus} which was competitively priced at Rs. 60.0 as compared to vannamei shrimp feed marketed by MNCs (Rs. 74/Kg to Rs. 88/Kg) resulted in an additional 25 % reduction in the production cost on feed, thereby increasing the profit of the farmer. The harvest of the farmed shrimp was done on October 25, 2017, in the presence of Shri. Diprava Lakra, IAS, Deputy Commissioner, Bathinda, officials from State Fisheries Department, CIBA scientists, and farmers from nearby villages.

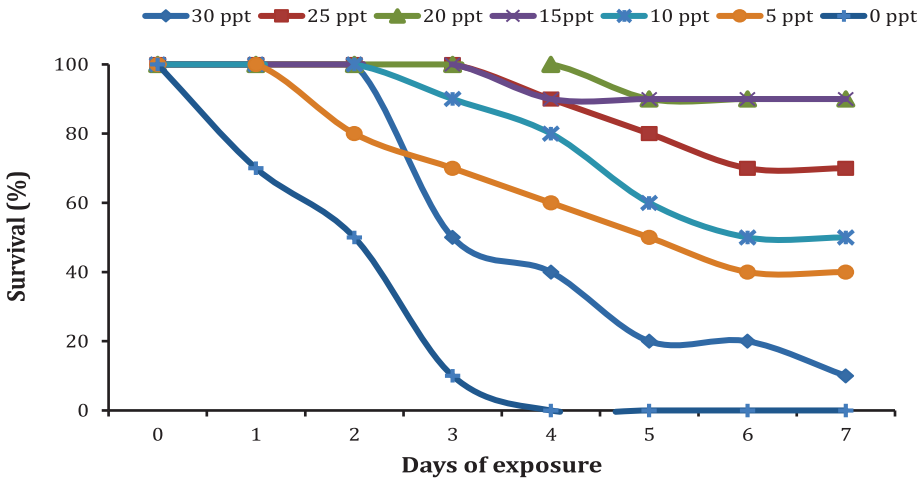
Production system diversification

Diversifying and improving the performance of the production system and species cultured are the major priorities of aquaculture research. Integrated multi-trophic aquaculture (IMTA) is the cultivation of two or more complementary crops where the waste of one crop serve as input (feed or fertilizer) for other crops. Thus, environmental issues related to the coastal aquaculture could be solved to a greater extent, and further cultivation of different crop optimize the economic returns. The purpose of this research was to evaluate and demonstrate an IMTA system in Sindhudurg district of Maharashtra. The cage was stocked with 800 sea bass nursery-reared fry (TL=120 mm; 19.5 g) that was transported to the culture site from Andhra Pradesh. As an extractive crop 50 ropes of green mussels, *Perna virdis,* also have been stocked as an extractive crop. Animals were fed with low valued fish bycatch initially at the rate of 15% of wet biomass and gradually reduced to 8%. After nine months of rearing, sea bass has grown to the average size of 990.1 g with a total production of 360 kg and survival of 63%. For nine months culture, revenue of ₹ 162000/ for a total cost of ₹ 120000/. As mortality occurred during monsoon season, culture period can be scheduled by excluding monsoon months.

Open water IMTA in Gad river Sindhudurg Maharashtra: Harvesting of sea bass

Salinity tolerance of estuarine oyster, *Crassostrea cuttackensis*, as a potential extractive species in IMTA

Bivalves are one of the most suitable extractive crops in IMTA systems. Edible estuarine oyster, *Crassostrea cuttackensisis,* is one of the most abundant bivalves in Sundarban, West Bengal. One of the most important biological traits to be considered while developing an IMTA system in a brackishwater ecosystem is: salinity tolerance limits of the species used for cultivation. An experiment was carried out to evaluate the salinity tolerance limit of *C. cuttackensisis.* After acclimation to 20 ppt, oysters were transferred directly to different salinity levels ranging from 0 to 30 (0, 5, 10, 15, 20, 25 and 30 ppt) in triplicate tanks (100 L). After 7 days, the highest survival (90%) was observed at 15 and 20 ppt and lowest survival were at 0 ppt. The results indicated that optimum salinity for this species is 15-20 ppt and it can be effectively used in the brackishwater IMTA systems after proper acclimatization.



Salinity tolerance of estuarine oyster, *Crassostrea cuttackensis*

High-density nursery rearing of milkfish

The recent breakthrough in captive breeding of milkfish would help to meet the increasing seed requirement for brackishwater culture system. In order to optimize the grow-out production of milkfish, high-density nursery rearing of milkfish in the earthen pond has been developed. After treatment of pond bottom with lime, it was filled to a depth of 30-40 cm and fertilized with mustard cake (200 kg/ha), urea (20 kg/ha) and single superphosphate (20 kg/ha), for the growth of benthic algal complex (*lab-lab*). After 10days of fertilization, ponds were stocked with milkfish fry (0.1 g/ 26.4 mm) at 200000 no./ha. Formulated powder feed prepared from locally available ingredients (mustard cake, rice bran, wheat flour, fishmeal etc.) was provided as supplementary feed @ 20 to 5% of body weight. Liming was done fortnightly with limestone powder at 250 kg/ha. After liming, ponds were fertilized fortnightly with the above mentioned fertilization dose. After 60 days of rearing, fingerlings were harvested and they attained 6-8 g body weight with 80% survival. A total of 3000 milkfish fingerlings were supplied to a farmer for grow-out culture demonstration. High-density farming of milkfish seed is advantageous over low-density rearing as the former is found to produce more number of fingerlings from the same water area.

Harvested milkfish fingerlings for stocking in grow-out pond

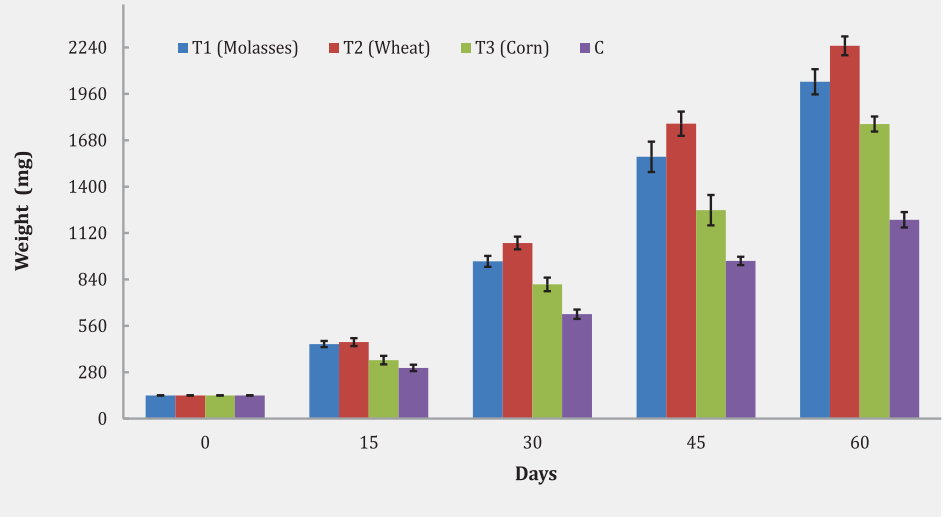
Nursery rearing of *Mystus gulio* in hapa

Brackishwater catfish, *Mystus gulio* is a small size indigenous fish species having high consumer preference. Homestead hatchery technology of this species has been developed and there is huge demand for seed among the farmers. To reduce the larval rearing time and operational expenditure at hatchery, a nursery rearing trial was conducted with 10-day old fry (0.01-0.02 g/ 8-11 mm) in net cages (hapa: 2×1×1 m) at three stocking densities, 500, 750 and 1000 nos/hapa. Fry was fed twice a day @ 4 to 10% of body weight with CIBA formulated larval diet (CP 30%, CF 6%; Price: ₹ 30/ kg). After 60 days rearing, fry attained significantly higher growth of 1.31±0.28 g and 1.35±0.37 g at 500 and 750 nos./hapa densities respectively compared to that (1.26±0.36g) of 1000 no./hapa group ($P<0.05$). However, survival was significantly higher(48.0±1.1%) at the lowest density with the lowest number of shooter emergence (3.8%). Therefore, the optimal stocking density for nursery rearing of *M. gulio* can be recommended @ 500 no /hapa

Harvested *Mystus gulio* fingerlings from hapa rearing system

Biofloc based nursery rearing of milkfish, *Chanos chanos* using different carbon sources

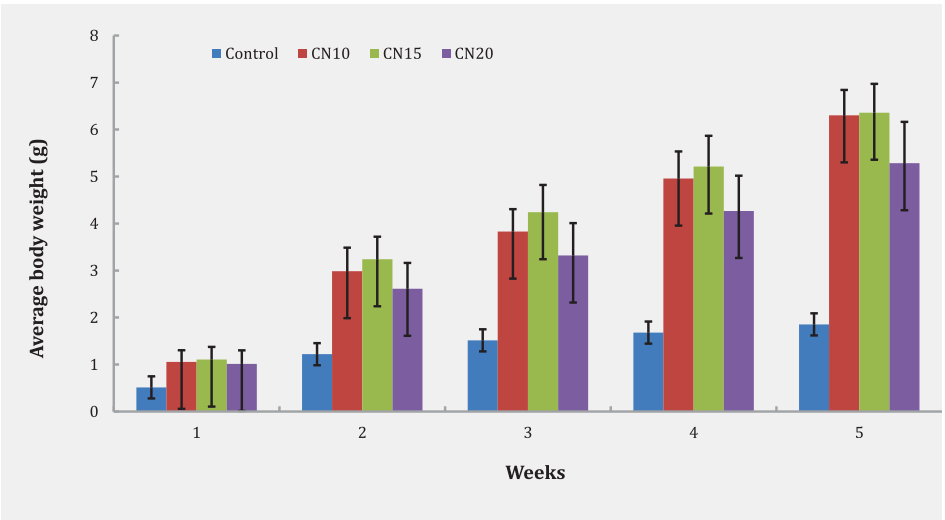
A 60 days experiment was carried out to evaluate growth performance of milkfish *Chanos chanos* in biofloc based nursery rearing system using different carbon sources (Molasses, Wheat & Corn). Each group consisted of triplicate tanks and each treatment was stocked with 20 days old *C. chanos* fry (1.78± 0.07 cm and 140± 0.09 mg) with a stocking density 70 fry/120 l. The results revealed that milkfish fry reared in wheat-based biofloc system showed significantly ($p<0.05$) higher growth performance, compared to molasses based and corn-based biofloc treatments and control. Growth, feed conversion ratio (FCR), feed efficiency ratio (FER), specific growth rate (SGR), the survival rate of milkfish fry reared in biofloc treatments were significantly better as compared to control. Proximate composition of biofloc showed a significant difference ($p<0.05$). Whereas, wheat-based biofloc showed highest crude protein(36.0± 1.18 %) and ether extract (2.06b ± 0.12 %). Mean water quality showed a significant difference ($p<0.05$), mean ammonia, nitrite and nitrate was recorded highest in biofloc treatments as compared to control. But all the water quality parameters in biofloc system found to be favourable for the culture of milkfish. Total settleable solids maintained in the range of 7 -12 ml/litre in all the biofloc treatments. From, the whole results, the study suggests that all the carbon sources are best for nursery rearing of milkfish fry in biofloc system. However, from the overall results, it was found that milkfish fry attains the fingerling stage in 30-40 days of rearing in wheat and molasses based biofloc system.



Growth performance of milkfish fry under different carbon sources in the biofloc based system for a period of 60 days

Effect of three C/N ratios on production performance of *Penaeus vannamei*

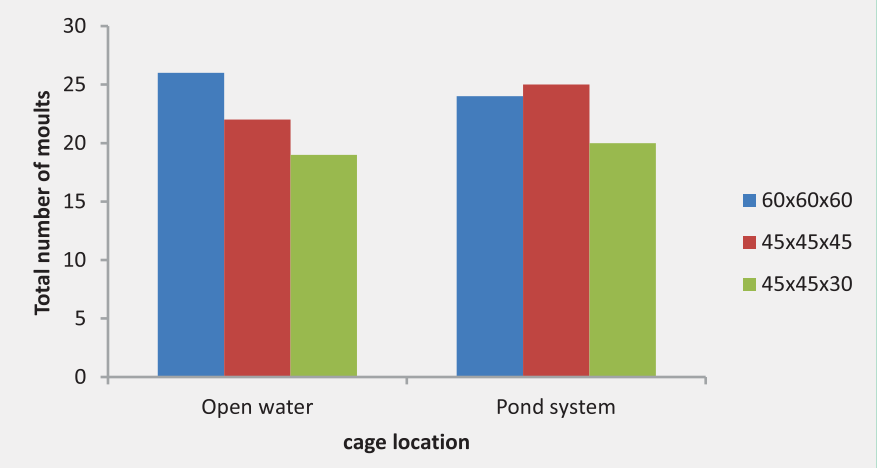
High-density shrimp culture systems with limited or no water exchange results in the production of large volumes of suspended flocculated organic particles including microalgae, autotrophic and heterotrophic bacteria. This unique biofloc system, provides several beneficial effects to shrimp farming. The C/N ratio of the culture water from feed or direct organic supplementations can have an extremely significant impact on water quality and biofloc biomass production. In order to evaluate the effect of various C /N ratio on production performance of *P. vannamei*, an experiment was conducted under a biofloc based system with a combinationthe of three carbon sources(molasses, rice and atta) with three C/N ratios 10:1, 15:1 and 20:1. The results showed that shrimps reared in CN:10 and CN:15 biofloc systems showed significantly (P=0.0229 and 0.0263) higher growth as compared to control and CN:20. All treatments showed survival rates above 91% with no significant differences between treatments. The total ammonia nitrogen, nitrite (NO_2) and nitrate (NO_3) in the water column were reduced significantly in the order of increasing the C/N ratio from 10 to 20 (P< 0.001).



Effect of different C/N ratio on growth performance of *P. vannamei*

Comparative growth performance of mud crabs, *Scylla serrata* using individual cages installed in open water and pond systems

Crab is a high-value seafood finds a good demand both international as well as in national markets. The culture trials in ponds have indicated lower survival due to the cannibalism and escape because of its burrowing habitat of *Scylla serrata*. Optimization of rearing system along with good feed and its management strategies specific to rearing system is very much required. We did a comparative grow out trials in ponds as well as in open waters using galvanised cages. In order to increase the survival, sixty galvanized cages were fabricated into three size groups viz., 60x60x60, 45x45x45 and 45x45x30 cm. Thirty cages were placed in open water Krishna River and other thirty cages were kept in adjacent brackishwater pond system in Nagayalanka. The initial average size of the stocked crabs was 200g. After 160 days of culture, 80% of crabs survived. The crabs which have moulted three times have attained >750g, i.e., XXL size which fetches a maximum price. The size of the cage is having significance ($P<0.05$) influence both on the number of moults and number XXL sized crabs harvested. In open water system, the cages having 60x60x60 cm had better performance whereas in the pond system the better performance was observed in 45x45x45 cm cages.



Effect of cage size on moulting in mud crab, *Scylla serrata*, reared in open water and pond system

Farmer feeding the crabs in cages using extended PVC pipes as his innovative feeding method

Effect of stocking density of *Penaeus vannamei* on its growth performances and immunological status under biofloc based rearing

In order to assess the growth performance, water quality, and immune status of *P. vannamei* post-larvae in a biofloc based system using different stocking densities. To achieve this, Pacific shrimp *P. vannamei* post-larvae (PL8) were cultured in the biofloc based system of 15:1 CN ratio in three different stocking densities: 3500, 7000 and 10000 post-larvae per m^3. The experiment was carried out for 5 weeks. Treatments consisted of three sources of organic carbon, atta, rice bran, and molasses at two rates of 2.5 g/L, 5 g/L, 10 g/L respectively. The immune status results revealed that shrimps cultured under three different densities with three different carbon sorces based biofloc system increased the total haemocyte cell count, lysozyme activity than those of control. Our findings proved that BFT is effective and highly potential technology for *P. vannamei* nursery culture in higher densities and would be the baseline for extrapolating this practice to field level to increase the production.

Microbial community in the culture system based on zero water exchange

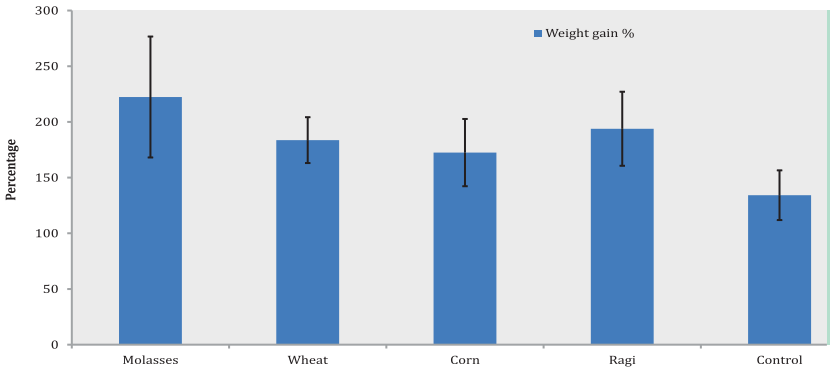
A study was conducted to evaluate the effects of four different ratios of Carbon and Nitrogen. The experiment was conducted with four different level of C:N ratio (5, 10, 15 and 20) and designated as C: N 5:1, C:N10:1, C:N15:1 and C:N 20:1. Molasses as carbohydrate source (200 ml), probiotics consortium (Bacillus strains (5.4 X 109 CFU/ml), were mixed in autoclaved seawater (10 L) and dissolved thoroughly and brewed for 24 h for fermentation. The fermented inoculum was applied in all the treatment tanks @ 50 ml/tank every day for five days to generate the heterotrophic bio-floc. Carbohydrate supplementation significantly increased the total heterotrophic bacterial (THB) count in increasing order from C:N5 to C:N20. As the culture proceeds, the increasing biomass had a significant effect ($P < 0.01$) over total microbial load with higher level recorded in C:N15 and C:N20. Similarly, carbohydrate supplementation had a significant effect on the reduction of Vibrio count (TVC) in water ($P < 0.01$). TVC levels were greatly reduced in C:N10, C:N15 and CN20 reared water (91.80 ± 0.3%) whereas in control it was highest followed by C:N5. The carbohydrate supplementation resulted in 71.7 ± 3.3% increase in TVC in water of BFT groups respectively. The proportion of Vibrio count to total heterotrophic bacterial count (V/T) was lower in the biofloc groups in decreasing order as we proceed from C:N5 to C:N20 compared to that of the control group. In spite of the increase in Vibrio load, the V/T ratio was non-significantly lower in the BFT groups with different C:N ratios. The bacterial diversity and the frequency distribution of bacterial phyla differed between the treatments. Both in control and C:N5 treated water, the Vibrio of 79% and 37% were the most dominant operational taxonomic unit respectively. In C:N10, Thauera (62%) was most represented taxa. In C:N15, Attheyaceae (56%) and Peridiniaceae (30%) were the most dominant phyla. In C:N20, the Psychrobacter (26%), Proteobacteria (25%) and Peridiniaceae (20%) phyla were found to be dominated phylum.

Biofloc based nursery and grow-out for Indian white shrimp, *Penaeus indicus*

Biofloc consortium and carbon sources and consortium with bacterial combinations were found to induce significantly higher growth and survival after six weeks of nursery rearing. Following this, a grow-out farming demonstration in farmer's facility successfully conducted with a high survival of 90.6 % with a final average body weight of 18 g and a total production of above 3.1 tons/ha from a low input low stocking of 15 nos/m2 in grow-out culture in 65 days.

Evaluation of growth performance of spotted scat, *Scatophagus argus* in a biofloc based system using different carbon sources

Spotted scat is an potential brackishwater ornamental fish, amenable for captive breeding. A thirty days experiment was carried out to study the growth performance of *Scatophagu argus* in a biofloc system using 4 different carbon sources: Molasses, Wheat flour, Corn flour & Ragi. Fifty-four days old scat fry (2.02±0.06 cm & 380±0.08) weight were stocked @ 30 nos /100 l in all the treatments. Fry was fed with 30 % crude protein feed at 5 % body weight. The results demonstrated that growth performance was significantly higher in the treatment where molasses used as carbon sources ($p<0.05$) in terms of final weight gain 1225±70.76 mg followed by the wheat flour based system (1116.7±60.09 mg) and lowest was observed in control (890.0±40.79 mg. Survival rate was found the maximum in T1 (88.33±2.30)followed by control (84.66±2.20) and lowest was indicated T3 (77.66±2.02). From the overall results, indicated that Molasses based biofloc system found to be the best for growth and survival of *Scatophagus argus*.



Growth performance of spotted scat fry under different carbon sources in the biofloc based system

Development of pond-reared broodstock of Indian shad

Maintaining broodstock under captive condition is critical and essential for breeding program of any fish. Brooders of Hilsa were maintained in brackishwater pond ecosystem at KRC of CIBA. For maintenance, periodical liming, fertilization and addition of photos and zooplankton at 30 days interval is carried out. To assess the maturity round the year monthly sampling was carried out. It is found that female attained the maximum average oocytes diameter of 510 µm in January, which is the natural breeding time of Hilsa in Ganges river.

Sampling of pond reared Hilsa broodstock for maturation status in ponds at KRC of CIBA

Comparative study of multi-tier farming and polyculture with different brackishwater species

Comparative growth performance of *Mystus gulio, Chanos chanos, Etroplus suratensis, Oreochromis niloticus* and *Penaeus monodon* was studied in two different rearing system: multi-tier farming and polyculture. In both the systems, *Mystus gulio* (average weight: 0.8 g; stocking density: 20 m^{-2}), *Chanos chanos:* average weight: 4.5 g; stocking density: 3 m^{-2}), *Etroplus suratens* (average weight: 0.40 g; stocking density: 5 m^{-2}), *Oreochromis niloticus* (average weight: 2.5 g; stocking density: 5 m^{-2}) and *Penaeus monodon* (average weight: 0.25 g; stocking density: 18 m^{-2}) were stocked. Fishes were fed with polyculture feed @ 5% of total biomass. Results of the study showed that after 5- months of culture, weight gain of cultured fishes were measured as 32 g, 79 g, 20g, 76 g and 21 g for gulio, milkfish, pearl spot, tilapia, and tiger shrimp respectively. The experimental trials pointed out the promising results in terms of growth of various finfishes and shellfishes in the polyculture farming.

Popularization of milkfish farming as *'Decan Hilsa'* in West Bengal

Proper and efficient marketing is the essential component of a sustainable aquaculture. Milk fish has been marketed in West Bengal under the name,*'Decan Hilsa'*. As a part of this program, a collaborative research work with a private entrepreneur is initiated. A total of 12000 hatchery produced fry was given for culture. Nursery rearing of milkfish was done for 45 days in 16 ppt salinity in pond condition. Survival during nursery rearing achieved 85% survival rate could be obtained with an average body weight of 20 g. Stocking was done in 1 ha pond for grow-out culture and around 2 t crop (average 220 g body weight) is expected to harvest from 1 ha pond (salinity > 7 ppt) with 90% survival at Joynagar, S-24 Pargana district

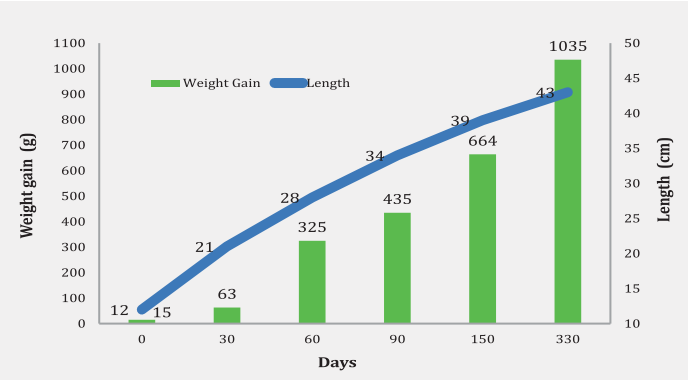
Milkfish monoculture demonstration in Kerala

As an initiative to promote milkfish farming in Kerala, CIBA supplied 6000 of hatchery produced milkfish seed to the farmer in Kollam district of Kerala. Seeds were stocked in 2 acre pond and feed on a formulated diet. In six month culture period the fishes attained a size range of 250 to 450 g. Framed fishes were sold on the basis of demand by partial harvesting (catching 10 to 30 kg by gill netting on a daily basis) and sold @ 350/kg for retail buyers and Rs. 220-250/kg to wholesale buyers.

Milkfish harvest mela and farmers interaction meet at Kollam district, Kerala: inaugurated by Dr K. K. Vijayan, Director ICAR-CIBA.

Farming of seabass in open water cages under public-private partnership model (PPP)

In order to promote seabass farming in Public Private Partnership mode (PPP), ICAR-CIBA has initiated a demonstration of cage farming of Asian Seabass (*Lates calcarifer*) in Kollam District, Kerala has been initiated. Seabass juveniles (7-8 g) were stocked @ 750 no/cage in grow out cages (4x4x2 m GI cage). Fishes were fed with CIBA's formulated indigenous feed (Seebass^{Plus}) @ 2 to 3% of their body weight. The fishes reached to the average size of 350gm within 6 months culture period.



Seabass, *Lates calcarifer*: growth rate in pond Kazargoda Village, Karnataka

Asian seabass a livelihood option for youths in Kazargoda village, Uttara Kannada, Karnataka

The institute has made its mark in Karnataka by popularizing brackishwater aquaculture as an alternative livelihood option for rural youths. A total of 600 no. of Asian seabass seed (average total length 13 cm & 15 g weight) were supplied to the farmers in Kasarkod, Uttarakannada district, Karnataka and stocked in the 0.18 ha pond, and cultured for 10 months Fishes were fed with trash fish (Sardine and Tilapia) @ 5 % body weight. Fishes attained a weight of 980 – 1050 g with a total production of 512 kg/0.18 ha. Farmers were able to sell the farmed seabass in the Goa market @ 450 Rs/kg.

A young farmer from Uttara Kannada, Karnataka with harvested seabass from his pond

Gracilaria - a potential brackishwater seaweed for farming in coastal saltwaters

Gracilaria spp, is one of the most important aquaculture resources, and it has been widely used for the production of agar and treatment of aquaculture discharges. In order to evaluate the brackishwater seaweed resources along the coast of Chennai, periodic surveys were carried out in Vennangupattu Lake (12°14'41" N, 79°58'58" E). The study revealed that the major species found in the lake is *Gracilaria sp.* (Rhodophyta). The species was identified morphologically and further confirmed by molecular methods as *Gracilaria tenuistipitata,* which was 100 % identical with the specimen identified previously from Muttukadu (Tamil Nadu) .Different methods of propagation of this species, net bag and rope method were tested in two different ecosystems: pond and lagoon ecosystem. Further the growth and production at different stocking density, g/m2) were also evaluated. The production and growth of seaweed were found to be higher in rope culture method compared to the net bag in the lagoon, however, net bag culture showed better production and growth in pond systems. Invariably in both the ecosystem, low-intensity culture provided better production and growth. both the ecosystem. Further, it is also showed that lower intensity gives a higher growth rate compared to higher biomass intensity.

Gracilaria farmed in Muttukadu backwaters using ropes and net bags

Seaweed based biofilter for RAS

Two porotypes of the filter has been fabricated and tested for its efficiency as a biofilter. Series of experimental trial on biofiltration potential of two models: M1 and M2. The efficiency was evaluated by observing the concentration of nutrients (NH_4-N and PO_4-P) at two hours interval. Nutrients concentration at control (without seaweed) was not significantly changed with time (R^2 was <<0.5) for both nutrients. Both filtration systems were efficiently removed N and P at a considerable level after 48 hours but removal efficiency was faster at M2 than M1 for both nutrients. Full experimental set up as depicted below for design 2.

Seaweed based biofilter developed at Muttukadu experimental station of CIBA

Assessment of aeration efficiency of different aerators in various salinities

Assessment of the oxygen transfer performance of the aerators was carried out in 50 mt plastic tanks having dia of 7.2 m and depth of 1.2 m. Evaluation trials have been carried out to deoxygenate the water. Then aerators were used to increase the dissolved oxygen (DO) concentrations at different salinities: 5‰, 20‰, 35‰ and 50‰. The DO deficit was computed for each time till saturation. The oxygen-transfer coefficient is adjusted to 20OC, used to estimate the standard oxygen-transfer rate (SOTR) of aerator based on American Society of Civil Engineers (ASCE) standard method for aerator evaluations. The standard aeration efficiency (SAE) of paddle wheel, submersible, spiral, jet and impeller aerators arrived from SOTR and the power consumed for different salinities to understand the performance efficiency.

It was found that SAE of commonly used paddle wheel aerators ranged from 1.545 to 0.423 kg O_2 / hr at a salinity range of 5 to 50 ppt. Spiral leaf aerators SAE ranged from 1.228 to 0.761 kg O_2 / hr; air jet aerators SAE ranged from 1.771 to 1.005 kg O_2 / hr; Submersible aerators SAE ranged from 0.504 to 0.226 kg O_2 / hr and Impeller aerator efficiency ranged from 2.319 to 1.549 kg O_2 / hr for a salinity range of 5 to 50 ppt. The varying aeration efficiency at different salinities indicated the varying requirement of aerators for the same stocking density and the possibility for saving the energy use and production cost.

Efficiency of aeration was evaluated in special experimental tank system built in Muttukadu Experimental Station

Mapping of coastal resources and identifying suitable areas for expanding integrated multi-trophic aquaculture (IMTA) in Maharashtra

A preliminary survey was conducted to identify the suitable creeks based on physical and chemical characteristics of water bodies. The creeks in Maharashtra have been mapped and water quality such as physicochemical and biological parameters was analyzed from five districts namely Palghar, Thane, Raigad, Ratnagiri and Sindhudurg) creeks and river waters of Maharashtra state. The water depth and current flow have been measured in all creeks. The resource mapping of land and water has been initiated. Two seasonal water characteristics have been analysed and the water quality is found to be optimum for the aquaculture. The sites are being identified based on the physical and chemical characteristics of creeks.

REPRODUCTION, BREEDING AND LARVAL REARING

Reproduction and larviculture are fundamental for developing sustainable aquaulture. The institute addresses the various issues on captive reproduction and larviculture of candidate species.

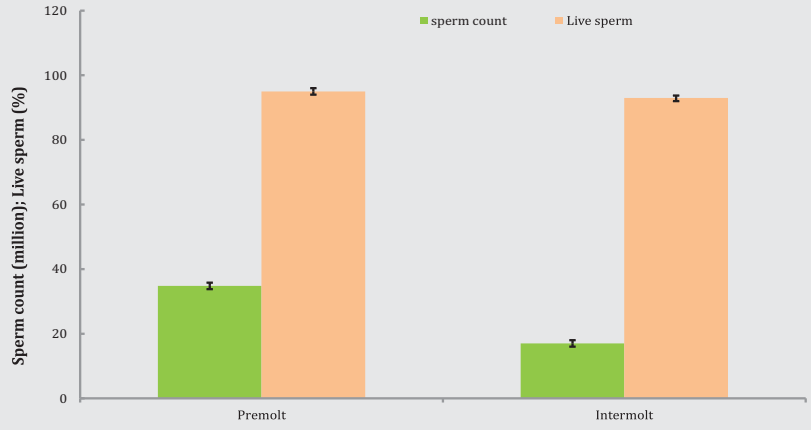
Newly hatched larvae of Spotted scat, *Scatopagus argus*

Reproduction, Breeding and Larval Rearing

Complete control over the reproduction of the farmed species is the most elusive goal of aquaculturists and scientists since the inception of modern aquaculture. Further, larviculture remains to be a bottleneck in the industrial farming particularly in the case of emerging species. We focus on various biological aspects of reproductive maturation, breeding and larviculture.

Reproductive quality of male *Penaeus indicus* (Indian white shrimp) in relation to molting stages

Reproductive management of males in shrimp hatchery is crucial in optimizing reproductive performance and seed stock production. The male spermatophore quality of *Penaeus indicus* was evaluated in relation to the molt stages. Setal morphology of the uropod was adopted to ascertain the molt stages. The average Spermatophore weight (g) observed was 0.12 ± 0.01 and 0.11 ± 0.01 in the premolt and intermolt stage respectively. The average sperm count observed was 34.8±4.57 X 10^6 and 16.98±1.25 X 10^6 no during the premolt stage and intermolt stages respectively and was significantly higher in the premolt stage. The average percentage live sperms and sperms with normal morphology were not significantly different in the intermolt and premolt stages.



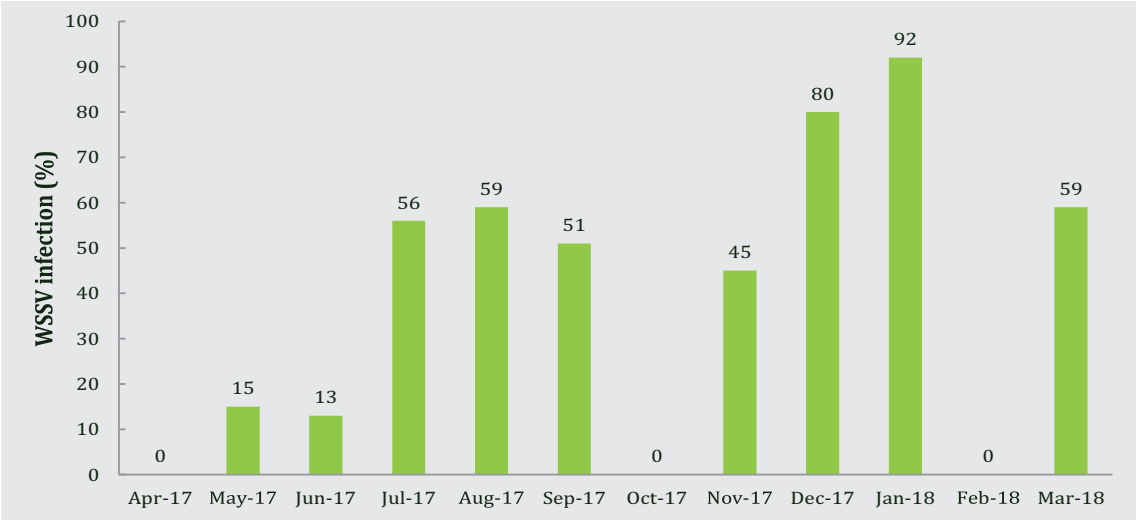
Reproductive management of males in shrimp hatcheries is crucial in optimising reproduction. The average sperm count in premolt animals were almost double of intermolt animals.

Penaeus indicus: Sperm count and live sperm (%) during different phases of molt cycle

Hatchery production of *Penaeus indicus* using wild caught broodstock

A total no. of 471 *P. indicus* adults was procured from the local fisherman during the period from May 2017 – January 2018. Out of the total broodstock procured 218 (46.2%) animals were found to be WSSV positive. Major WSSV infections were found during December and January, 78 and 90% respectively. Average fecundity was 3304 eggs/g body weight. A total of 10 spawning were realized from the WSSV free stock and a total of 0.2 million larvae were produced. In order to evaluate the effect of size on reproductive performance, various size groups of brooders (30-40, 40-50 & 50-60 g) were segregated, and reproductive performance was evaluated. The result showed that 40 – 50 g size group was performed significantly higher spawning, fecundity, hatching rate and larval conversion when compared to other groups. In order to resolve the issues in fertilization and further development of eggs, the detailed

knowledge of embryogenesis is extremely important. A comprehensive study of early embryogenesis of *P. indicus* was documented.



Incidence of WSSV in the wild caught broodstock of *Penaeus indicus* during different months, while screening for seed production in CIBA shrimp hatchery

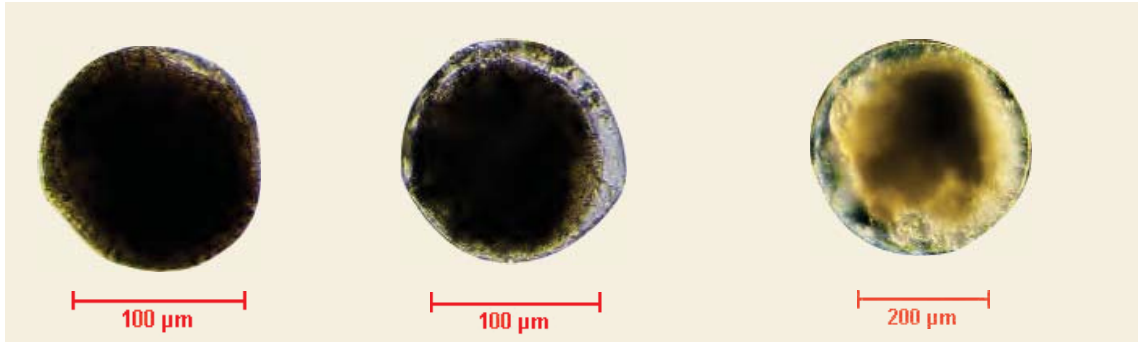
In order to resolve the issues in fertilization and further development of eggs, the detailed knowledge of embryogenesis is extremely important. A comprehensive study of early embryogenesis of *P. indicus* was documented.

***Penaeus indicus*-early developmental stages**

Artificial insemination (AI) in Penaeid shrimps

Deliberate introduction of sperm into the female reproductive tract is the crucial component of the captive breeding program, and that revolutionized breeding programs in livestock. Although AI techniques have been studied in penaeid shrimps, since the advent of shrimp farming, detailed documented evidence are limited particularly in the closed thelycum species. Detailed studies have been carried out on AI of *P. monodon* and *P. vannamei*. In *P. monodon* post molted females were inseminated with newly extruded spermatophore, and inseminated females were induced for maturation and spawning by eyestalk ablation. In *P. vannamei*, the post-molted female was ablated after 3 days, and inseminated in stage IV of maturation, whereas in *P. monodon*, only a few females reached reproductive phase (23%), In *P. vannamei*, 40% of artificially inseminated females produced fertilized eggs. The lower success rate in *P. monodon* may be due to the morphological differences of the external reproductive organ.

Artificial insemination in *Penaeus monodon*



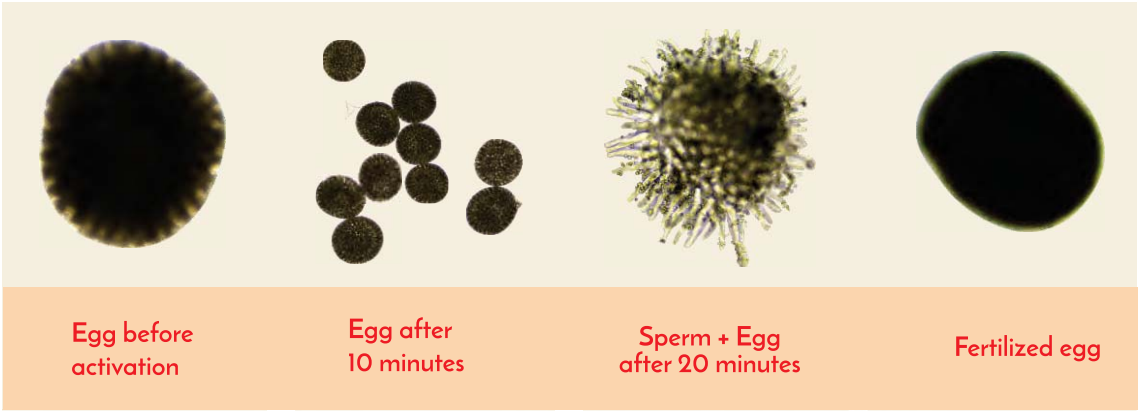
Fertilized egg of *P. vannamei* after artificial insemination

Fertilized egg of *P. vannamei*: stage 2

Fertilized egg of *P. vannamei*: final stage

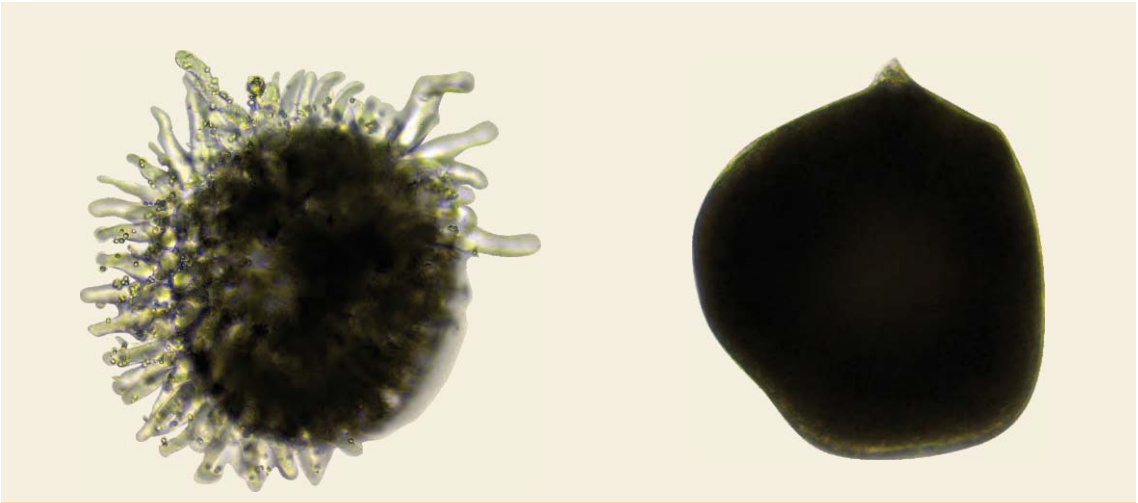
Development of In vitro fertilization of *Penaeus monodon*

The major objective of this work was to evaluate the feasibility of fertilizing preovulatory oocytes of *P. monodon* and to evaluate the potential hybridization of *P. monodon* oocyte with *P. vannamei* and *P. indicus* spermatozoa *in vitro*. Additionally, the events during the fertilization have been studied. Male spermatozoa of *P. vannamei* and *P. indicus* were removed using sterilized microforceps, and macerated in 1 ml filtered seawater, and counted. Females with ripe ovaries were dissected and kept at 4 °C for 5 minutes. Eighty thousand oocytes were mixed with 1 ml of sperm suspension (1 ml contains 34 million) in 2 L of filtered seawater for each treatment (Treatment 1: *P. monodon* X *P. monodon;* Treatment 2: *P. monodon* X *P. vannamei;* P. *monodon* X *P. indicus*). Fertilization and embryonic development were evaluated at every 15 minutes. Immediately after the contact with seawater cortical rods emerged from the eggs and cortical rod dissipated forming a jelly coat around the eggs. The thick hatching envelope was then developed. The study shows that preovulatory eggs are capable for egg activation and fertilization. Fertilizability of *P. monodon* eggs is found with both conspecific and interspecific spermatozoa. The fertilization ability was highest in the conspecific interaction (40%), and the minimum in the crossing between *P. monodon* and *P. indicus* (10%). Surprisingly moderately high percentage of fertilization was achieved between *P. monodon* and *P. vannamei*.



Appearance of egg during in-vitro fertilization of *Penaeus monodon* egg by sperms from same species

Appearance of egg during in-vitro fertilization of *Penaeus monodon* egg by sperm from *P. vannamei*



In vitro fertilization of *Penaeus monodon* egg with *P. indicus* sperm

A cryptic species in *P. japonicus* species complex

Kuruma shrimp, *Penaeus japonicus*, has been the most priced penaeid shrimps owing to the high demand of this species in Japan. It is widely distributed in the Indo Pacific region and believed to be the most successful migrant among penaeid shrimps. Aquaculture traits of *P. japonicus* in India are reported to be different from those reported from other countries. Therefore, the identity of this species was evaluated using morphological and molecular traits. In this section morphological characteristics are included whereas the molecular data is given in the section, Genetics and Biotechnology. Morphological and genetic study shows a new species status for Indian kuruma shrimp. This species is the third known species of genus/subgenus *Marsupenaeus*, and it is most closely resembles morphologically with *P. japonicus* (Spence Bate, 1888) and *P. pulchricaudatus* (Stebbing, 1914). However, the present species can at once be distinguished based on the characteristic features, such as, presence of: characteristic additional adrostral carina present at the level of epigastric tooth to fifth dorsal teeth; 6th segment with two prominent cicatrices, third almost insignificant; three pairs of lateral spines on telson,located towards distal part; the distal two segments of endopod of second maxilleped almost equal sized. Along with this morphological study with molecular data confirm a new species status for Indian taxon.

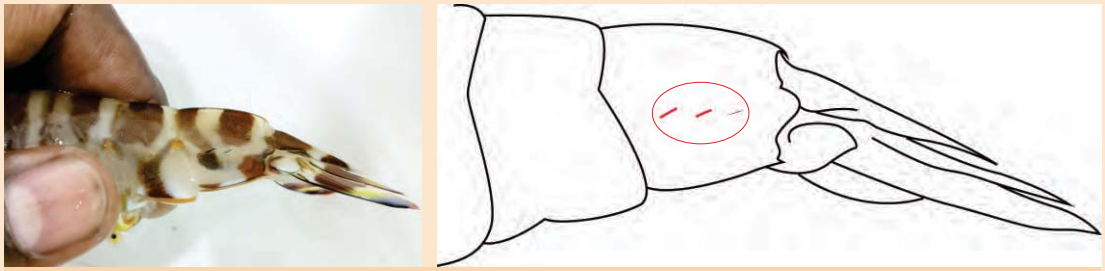
Adult Indian Kuruma Shrimp: a cryptic *Penaeus* sp.

Identification charecters of the cryptic *Penaeus* sp.

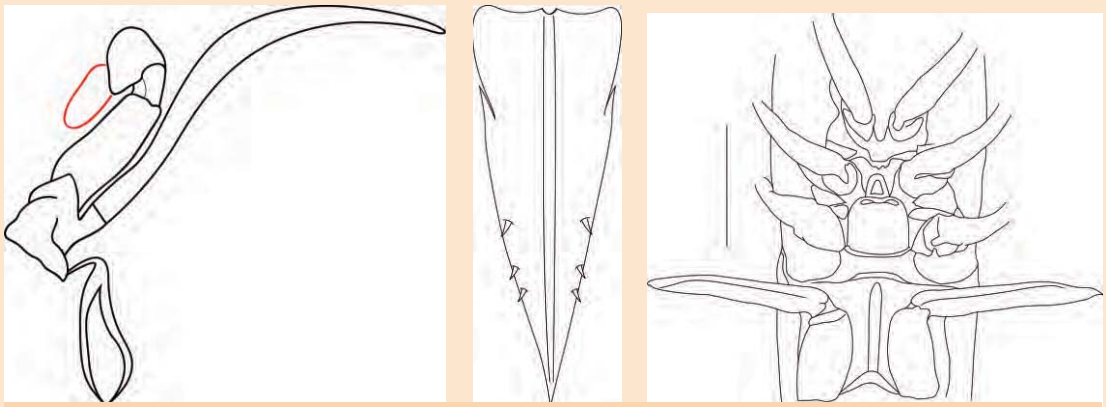
Classification

Kingdom:	Animalia
Phylum:	Arthropoda
Sub Phylum:	Crustacea
Order:	Decapoda
Super Family:	Penaeoidea
Family:	Penaeidae
Genus:	Penaeus
Species:	*Penaeus sp.*

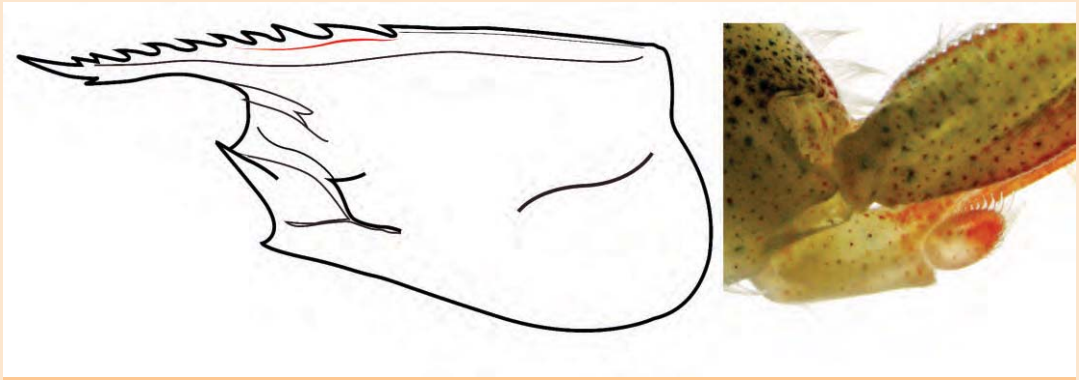
Petasma Thelycum



Cicatrix at 6th abdominal segment



2nd maxilleped Telson Thelycum



Appendix masculina

Seed production of Indian Kuruma shrimp

In order to refine the hatchery production of kururma shrimp, several hatchery runs were carried out. Brooders of kuruma shrimp were obtained from coastal fishers, and all the animals were screened for WSSV. WSSV negative broodstock were divided into two groups for the study: maturing and empty stage depending upon the ovarian maturity stage. After eyestalk ablation, the maturing group attained full maturity within 14 days was observed whereas females of spent group attained full maturation only after 25 days.. The average egg production per spawning was 30,000 no with a fecundity of 541.41 ± 31.01 eggs/gm body weight in the mature group and 486.71 ±19.16 in the empty group. There was no significant difference in the larval survival between the mature and empty group

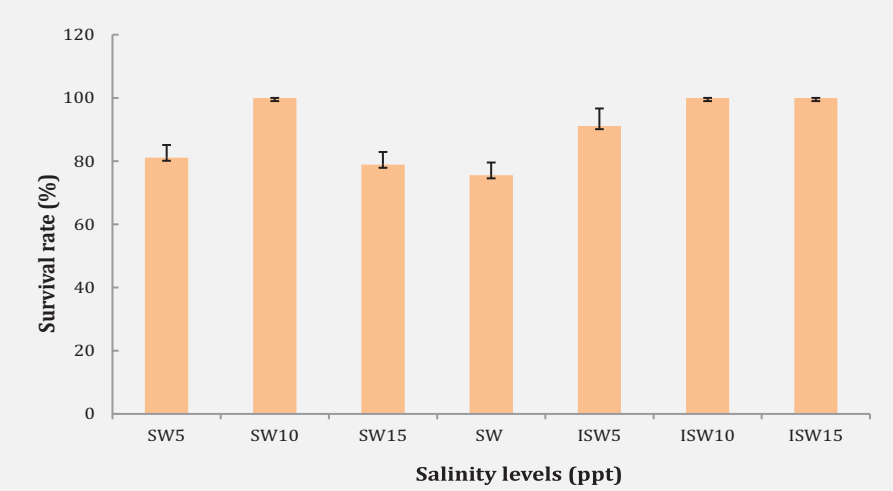
Reproductive performance of Indian Kuruma shrimp

Maturation stage	Body weight (g)	Latency period (days)	Fecundity	Relative Fecundity (no/g)	Hatching rate (%)
Maturing	59.6 ±5.1	14 ± 1.4	32320	541.9 ± 53.3	37.7 ± 2.7
Empty	56.1 ± 5.0	25 ±2.2	26986	486.71 ± 19.1	25.5 ± 3.5

Effect of different salinities, coastal and inland, on growth and osmoregulation of farmed penaeid shrimps

Indian white shrimp, *P. indicus*

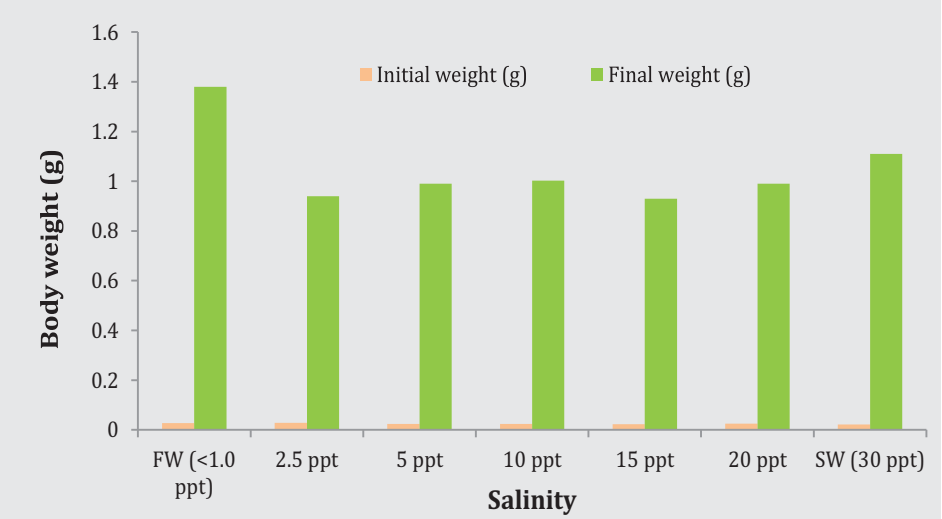
Recently, marine shrimp farming is extending to low saline coastal areas and inland brackishwater areas. Understanding the physiology of osmoregulation in low saline and inland brackishwater is vital for further refinement of low saline shrimp farming technology. In order to evaluate the physiological characteristics of *P. indicus* grown in these areas, a 45 days indoor trial was carried out. Inland saline groundwater of different salinities was prepared by mixing of different salts viz. NaCl, KCl, $MgCl_2.6H_2O$, $CaCl_2.H_2O$, $NaHCO_3$, $MgSO_4.7H_2O$ and KBr in various proportions with freshwater. The ionic profile of the artificial amended inland saline groundwater was formulated to match the ionic composition of saline groundwater used for shrimp aquaculture in North-western India with a Mg_2+/Ca_2+ ratio of 1.7:1 to 1.8:1 and a Na+/K+ ratio of 43:1 to 44:1 respectively. A total of thirty *P. indicus* juveniles (BW – 0.06924 ± 0.0023 g) were stocked into several 100 litre FRP tanks filled with seawater and inland saline water of different salinities in triplicate. The mean final individual weight of shrimp in all the treatment and control salinities did not vary significantly. However, the survival rate at the end of 45 days was significantly higher for shrimp reared in seawater of salinity 10 ppt (SW10) and amended saline groundwater of salinities 10 and 15 ppt (ISW10 and ISW15). The iso-osmotic point of juveniles reared in seawater and inland saline water has been determined as 793.80 mOsmol/kg and 774.05 mOsmol/Kg respectively. The serum osmolality of shrimp reared in inland saline groundwater was observed to be significantly lower compared to their counterparts reared in seawater of similar salinities. The study concludes that the farming of Indian White Shrimp using inland saline groundwater is technically and economically feasible.



Survival rate of *Penaeus indicus* at different salinities

Pacific white shrimp, *P. vannamei*

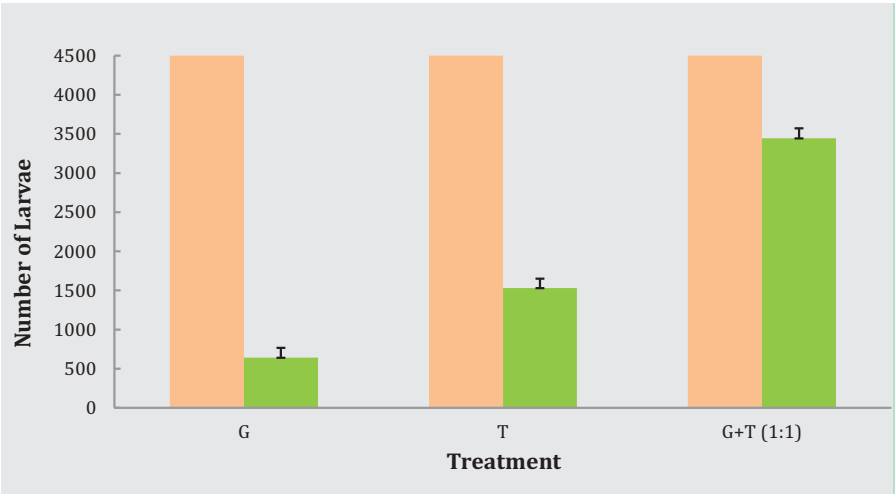
In another experiment, a 45-day indoor trial was conducted to study the growth, survival and osmoregulation of *P. vannamei* PL reared in freshwater and seawater diluted to different salinities. The present trial consisted of 6 treatment salinities: FW (0.7-0.8 ppt), 2.5 ppt, 5 ppt, 10 ppt, 15 ppt, 20 ppt and seawater of salinity (29-30) ppt served as the control group. The mean final individual weight was observed to be significantly higher for shrimp reared in freshwater (Salinity <1.0 ppt). Significantly lower survival rate was observed for shrimp reared in freshwater and SW respectively. The survival rate of shrimp in all the other treatment salinities ranging from 2.5 ppt to 20 ppt did not vary significantly. This indicates that the farming of *P. vannamei* can be carried out economically at salinities ranging from 2.5 to 20 ppt. The higher growth for shrimp reared in freshwater may be attributed to the lower survival rate in salinity resulting in larger sized shrimp. However, in the case of shrimp reared in fresh water, it was observed that the shrimp were growing at a faster rate and slow continuous mortality started setting in post 30 days of culture.



Growth of performance of *Penaeus vannamei* at different salinity levels

Micro algal suitability for zoea of mudcrab, *Scylla serrata*

Improving the survival rate of *Scylla serrata* zoea through use of rotifers reared on different algal species: High mortality rate of *Scylla serrata* zoea is observed during the initial phase (Z1 to Z3) of mud crab larval rearing. The poor survival rate at this phase is mostly attributed to the nutritional status of the crab larvae, which in turns depends on the feed quality and quantity. Two studies were conducted to evaluate the effect of feeding crab larvae with rotifers reared using different algal species and their combinations. In the first trial, five feeding treatments viz., rotifers grown on yeast (Y), rotifers grown on yeast and enriched on 1:1 mix of *Chlorella* sp. and *Tetraselmis* sp. for four hours (Y + G), rotifers grown on 1:1 mix of *Chlorella* sp. and *Tetraselmis* sp. (G), rotifers grown Thalassiosira sp.(T) and rotifers grown on yeast and enriched on Thalassiosira sp for four hours (Y + T) were evaluated for the effect on the survival rate of Zoea at the end of 10 days. The rotifer and algal density in the tanks were maintained at around 20 ind./ml and 1 lakh cells/ml respectively. At the end of 10 days the survival rate of larvae grown on treatments T (rotifers grown on *Thalassiosira* sp.) and G (rotifers grown on 1:1 combination of *Chlorella* sp. and *Tetraselmis* sp.) was significantly higher than the other treatments though there were no significant differences among them. Larvae reared on yeast fed rotifers resulted in 98 % mortality by day 5 and 100 % mortality by the end of the trial. The study indicate that rotifers grown on *Thalassiosira* sp. can be used as feed for the crab larvae and is a viable alternative to the traditional *Chlorella* sp. based rotifer production.



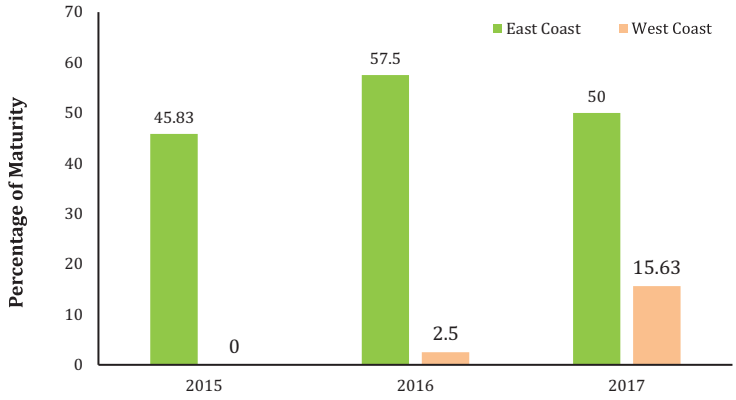
Survival rate of *Scylla serrata* at three different feeding regimes: *Chlorella* sp (G), *Thalassiosira* sp. (T), *Chlorella* sp+ *Thalassiosira* sp. (G+T)

Megalopa production in mud crab

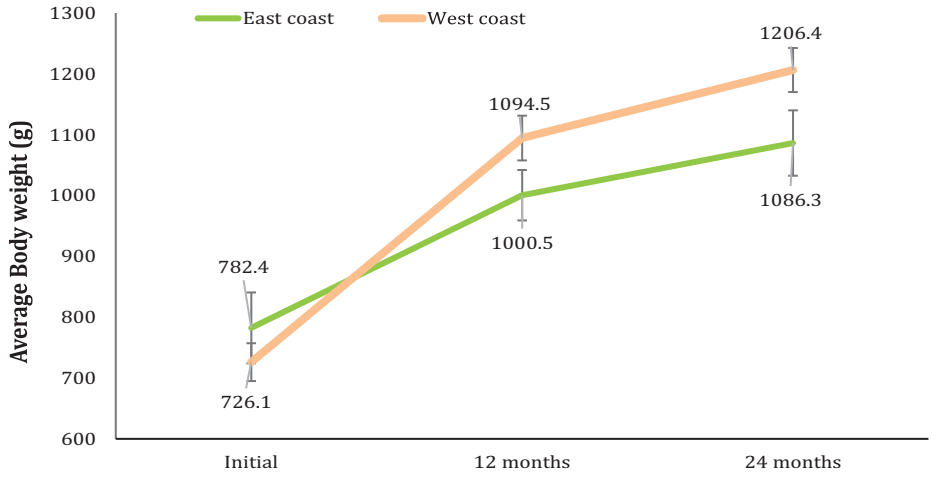
Megalopa stage in the mud crab, *S. serrata* larval cycle encounters high mortality during the nursery rearing phase due to intense cannibalistic behaviour, moult death syndrome resulting in poor survival to the crab stage. The survival rate of megalopa to crab instar can be improved through nutritional interventions and reduction in the stocking density. Four feeding treatments viz., artemia biomass (T1), clam meat (T2), crab larvae (T3) and artemia nauplii (T4) were evaluated for their effect on crab instar conversion. Megalopa (3 to 4 days old, Avg. BW – 5.05 ± 0.26 mg) produced in the hatchery were stocked in to FRP tanks at the rate of 1 megalopa/4 litres. The feeding treatments artemia biomass (T1) and clam meat (T2) resulted in significantly higher survival rate of 74.7 % and 72% respectively at the end of 8 days. Artemia nauplii (T4) resulted in poor survival rate of megalopa to crab stage. The study concludes that artemia biomass and clam meat are suitable nursery feeds for rearing of mud crab megalopa to crab instar stage.

Growth and reproductive parameters of grey mullet *Mugil cephalus*- variations of two captive stocks

Variations in biological parameters may serve as indicators of stock variations in fish. Grey mullets collected from two locations; East coast (Chennai, Tamil Nadu) and West coast (Ernakulam, Kerala) were maintained in 100 mt provided with continuous flow through of seawater for two years; feeding was done on formulated broodstock feed developed by CIBA (twice daily at 3-4%). After 12 and 24 months, the growth performance of grey mullet from the west coast was significantly ($P<0.05$) higher than fish from the east coast, Specific Growth Rate (SGR) of east coast stocks after 12 and 24 months were 0.18± 0.02 and 0.04±0.01 %/day and that of the west coast stocks were 0.45±0.12 and 0.06±0.01%/day. Variations were also recorded in the reproductive characteristics of captive grey mullet brooders from East coast and West coast; the average oocyte growth was 7.6±0.3 (7.1 to 8.3 µm/day) in the east coast stocks and 4.1±0.1 (4.0 to 5.2 µm/day) for the west coast stocks. The peak breeding season for captive east coast stocks was November and December for the captive west coast stocks. No milting males were observed in the west coast stocks. The percentage of captive maturity of east coast stocks was 45.83%, 57.5% and 50% in 2015, 2016 and 2017 respectively. The percentage of captive maturity of west coast stocks was 0, 2.5 and 15.63% in 2015, 2016 and 2017 respectively. The maximum oocyte size recorded in fish from the west coast stock was 564.33±21.56 µm, the maximum oocyte size recorded in fish from east coast stocks was 538.13±5.70 µm. These variations could be recorded as both the stocks were maintained in captivity under similar conditions at one location. The reproductive parameters may potentially indicate reproductive isolation of the two stocks of grey mullet.



Percentage maturity of *Mugil cephalus* in East and West coast during 2015 to 2017

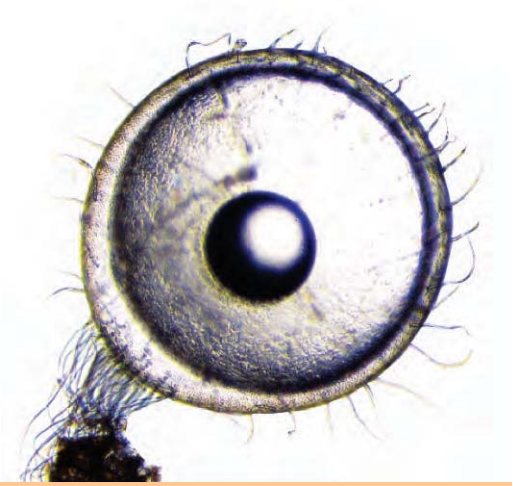


Average body weights of captive grey mullet broodstock from the East and West coast after 12 and 24 months culture period (G)

Succesful breeding of rice fish *Oryzias* sp in captivity

An unidentified rice fish, *Oryzias sp.* was collected from Muttukadu lagoon. They were found to be highly adaptable to brackishwater as well as seawater and could become a model organism for studies in brackishwater and marine fishes. Some of the rice fishes belonging to Adrianichthyidae and genus *Oryzias* are considered to be well-established experimental organisms for developmental biology, ecology, molecular biology and genetics. The fishes were reared in 250L circular tanks for a fortnight and were fed with commercial pellet feed. The sexes were distinct and mating appeared to be polygamous. Two males and three females (all mature) of 4-5 cm size were selected and reared together in 30 L tank at 30 ppt salinity. The fishes were fed twice daily with freeze-dried tubifex worms during the day and adult Artemia in the evening hours. The fish bred within ten days of rearing in captivity. Eggs were seen hanging in a cluster from the vent areas of the females, the eggs being highly adhesive with hard chorion possessing numerous short villi. The eggs after external fertilization by males were brushed off by the female which swam past fine-leaved plants that acted as a spawning mop. The fertilized eggs hatched by 10-14 days with 100% survival, the inconsistency in hatching could partly be attributed to the difference in water temperature. Some of the embryonic development stages have been documented.

Adult rice fish, *Oryzias* sp: could be a model organism for studies in brackishwater similar to Zebra fish in fresh water



Day 1

Day 5

Day 10

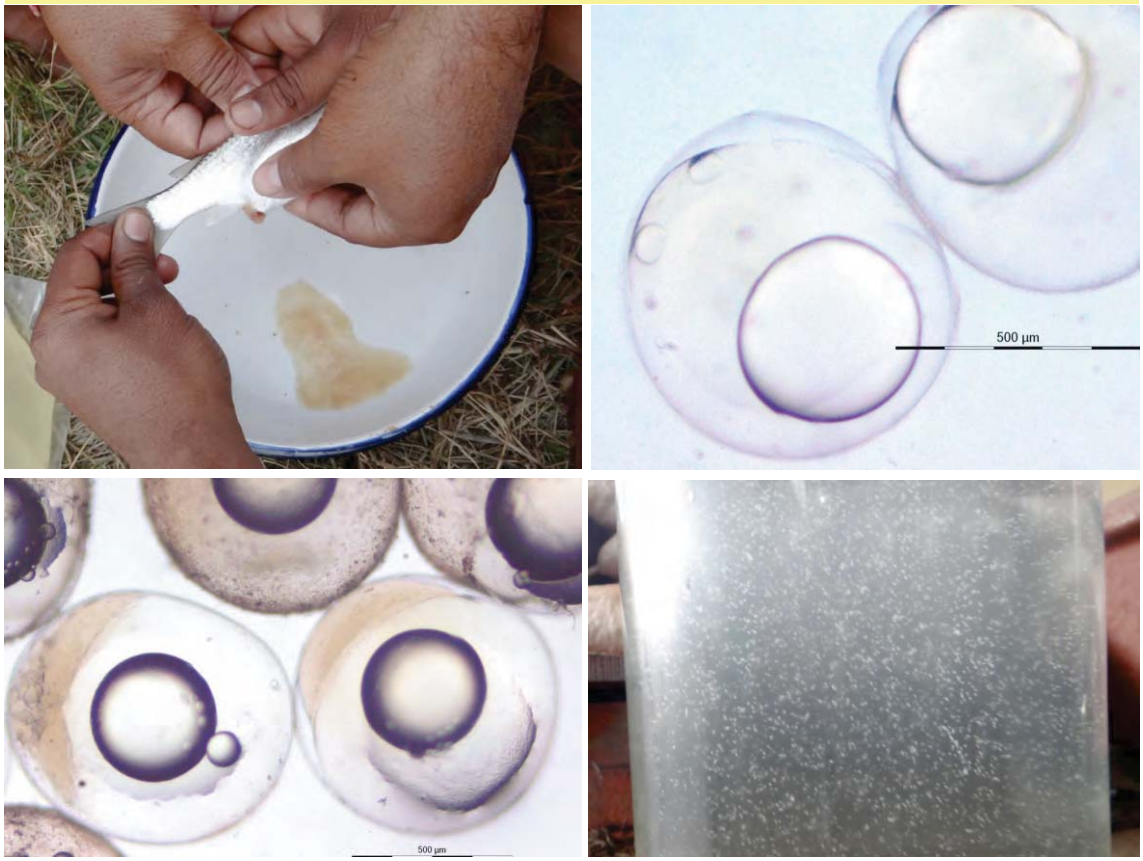
Newly Hatched out

Embryonic developmental stages of Rice fish

Induced maturation and spawning of *Liza parsia*

Gold spot mullet, *L. parsia* is a high valued catadromous food fish in India. Two separate brood stock holding RAS (10 mt) were maintained: brackishwater (7 to 8 ppt) and high saline water (30 ppt). In each RAS, 25 female and 50 male were stocked. To accelerate the captive maturation, all the brood stock in both systems were implanted during the month of November with cellulose-cholesterol LHRH, an implant (@ 30 µg/kg). In the case of brackishwater RAS, salinity was gradually increased to 30 ppt in 15 days. In the month of December, 100% oozing male and mature female having oocytes diameter of 560±20 µm were noticed in brackishwater RAS, whereas only 12% of female showed maturity in high saline water. With the standardized dose of inducing hormones (pituitary gland extract @ 20 mg/kg and human chorionic gonadotropin @20000 IU/kg) 20 breeding trials were conducted from brackishwater reared stock. Successful spawning was noticed in 15 cases; however, eggs failed to fertilize. From the study, it is concluded that, a primary dose of pituitary gland extract and a secondary dose of HCG for induced maturation and spawning of *L. parsia* in captivity are essential. Further, it is observed that for captive maturation brackishwater is required for initial maturation and high saline water is required for final maturation of *L. parsia*. Keeping only in high saline water may not suitable for captive maturation.

In captive maturation of *Liza parsia,* brackishwater is required for initially and sea water is required for final maturation. Keeping only in high saline water may not be suitable option for captive maturation.



Stripping of eggs from female, *Liza parsia* and its further development after fertilization

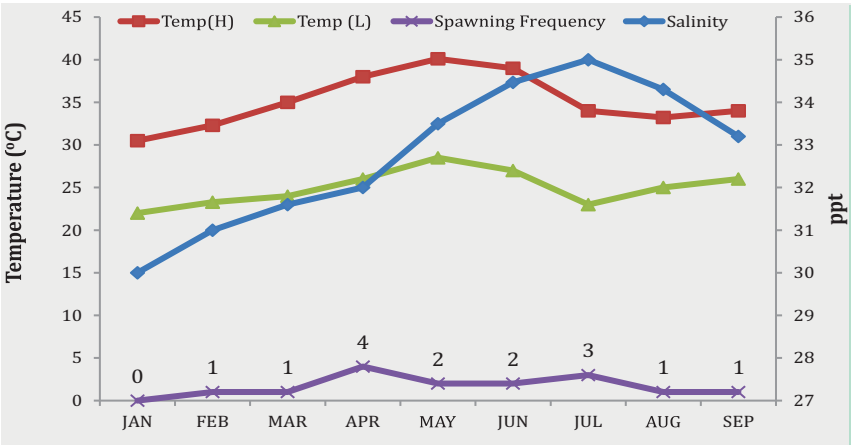
Captive broodstock development of mangrove red snapper (*Lutjanus argentimaculatus*) in land-based systems

A total of 47 fishes of mangrove red snapper is being maintained in 100-tonne capacity RCC tank and reached to the size range from 1.6 to 2.7 kg from the initial size of 40 g in 24 months period with the average size of 2110 g. Presence of oil globule noticed through biopsy examination during February 2018 and no matured fished observed in this stock. Maintenance of fishes is being continued.

Captively reared adult mangrove red snapper in broodstock tanks *at* Muttukadu fish hatchery

Extended breeding of milkfish under captivity

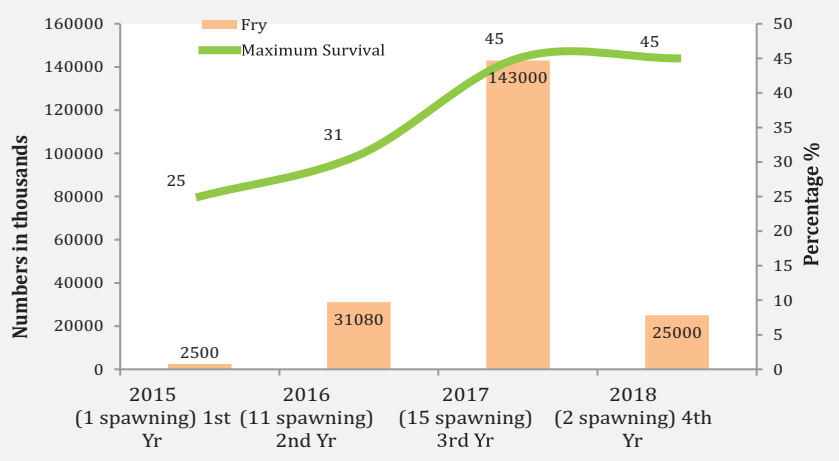
Milkfish breeding technology has further refined, and the active reproduction period has been extended for eight months (Feb-September) in captivity during 2017. A total of 1.39 million fertilized eggs were obtained from thirteen spawning. It has been observed that milkfish spawning is more correlated with increasing water temperature than salinity. Maximum spawning (four) was observed during April with increasing air temperature of 38°C and seawater salinity of 32 ppt. Lunar cycle found to positively influence milkfish spawning and the highest number of spawning occurred 4th day during new moon or full moon. Fry production enhanced by 4.6 times (total 1.43 lakh fry) compared to 2016 (total 31080 fry). The fry production activities carried out in following optimum live prey feeding schedule and introducing semi-outdoor yellow colour background tanks. A total of 75000 early milkfish frys were distributed among farmers from Kerala, Goa, Gujarat, Tamil Nadu, Andhra Pradesh and West Bengal along with 2.5 lakh fertilized eggs to the private entrepreneur for satellite nursery rearing. Total revenue generated was ₹97500 from seed sale. Multiple spawning of milkfish extended for eight months gives the possibility to overcome challenges of year-round breeding.



Relation of temperature and salinity on spawning frequency of milkfish under captivity

Yellow colour tanks with high prey visibility enhance the foraging, growth, and survival of young milkfish larvae

Mass mortality and variable survival have been major issues in milkfish larval rearing. Unlike other marine species, reports are scanty on use of different tank colour and strict feeding regime to improve milkfish larvae survival. An experiment was designed to understand the optimum background colour: white, blue and yellow under artificial and solar illumination improve foraging capacity, growth and survival. Fifteen RCC tanks (capacity, 8 t; water salinity, 32 ppt) with three different background colours, white, blue and yellow were divided into five (05) treatments groups with triplicates, i.e. indoor white (T1/C), blue (T2), yellow (T3) color tanks under artificial light and semi outdoor blue (T4), yellow (T5) colour tanks under sunlight. Newly hatched milkfish larvae (total length 3.4 mm) were stocked in the experimental tanks @ 10 no/l. Other factors such as feeding time, water exchange rate etc. were uniform in all the treatments. Phytoplankton, *Chlorella salina* @ 10^3 – 10^4 cells/ml were maintained from 2 dph to 20 dph; rotifer, *Brachionus plicatilis* (enriched with green algae paste Nannochloropsis oculata) were provided @ 20-30 no/ml from 3 dph to 14 dph depending on the larval density. Artemia nauplii @ 0.5– 1.0 no/ml was introduced from 15 dph. At the end of the experiment at 20 dph, highest ($p<0.05$) larval survival (42 %) was achieved in tanks providing yellow background colour (T5) compared to control and other treatments. Larval growth (total length, 18.7± 0.94 mm) was also found to be highest ($p< 0.05$) in T5. Survival and growth of milkfish larvae gradually decrease in the artificially illuminated yellow tank (T3), outdoor blue tank (T4), indoor blue tank (T2) and white tank (T1/C). The highest growth in T5 may be associated with a significantly higher ($p< 0.05$) larval gut rotifer and artemia content relative to other treatments. It was found that milkfish larvae being a day feeder does maximum foraging during 0700h to 1600h. Experimental data suggest that yellow background tank (T5) may be enhancing visibility and contrast of prey for milkfish larvae. Visibility enhancement during the said period may be linked to enhanced foraging evident from higher gut rotifer content. Milkfish seed production in the yellow colour tank may be useful for mass scale seed production.

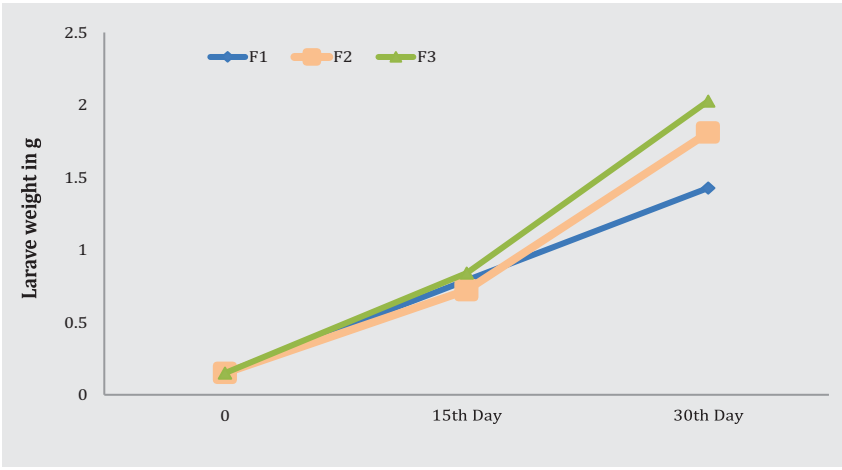


Year wise milkfish seed production in CIBA finfish hatchery

Growth performance, feed utilization efficiency and body indices of milkfish, *Chanos chanos* larvae fed with different micro-particulate feeds

A suitable micro-particulate feed is critical for attaining optimal growth and survival after weaning finfish larvae from live feeds. A 30 day feeding experiment was conducted for testing two indigenous larval micro-diets (F1 and F2) and commercial larval feed (F3) for milkfish larval rearing. The nutritional composition of two experimental larval feeds was crude protein (CP) and crude lipid (CL); 42% and 9%, 38% and 7% respectively; the CP content of commercial larval feed was 45%. The experiment was conducted in nine circular mesh basket floated inside outdoor FRP tank (capacity, 1tonne). Milkfish larvae, 18 dph (0.15±0.05 g) stocked at a density of 100 larvae/ basket were fed at 10% body weight twice daily. At the end the feeding trial, the survival rate estimated between 90 and 95% in all the treatments.

The highest final avg. body wt., total length and specific growth rate in F3 were 1.87±0.21g, 7.5±1.2 cm, 8.67±0.36 respectively, followed by F2and F1. Feed efficiency (FE) and protein efficiency ratio (PER) were similar among the different treatments. The feed conversion ratio (FCR) showed significant effects ($P < 0.05$) in relation to the feed treatments. A better FCR (0.78) was observed in F1 which had 38% protein and it was higher (1.1) in feed F1 which had 42% protein. The hepatosomatic index (HSI) and visceral somatic index (VSI) values increased with the decreasing dietary protein and lipid level. Significantly higher ($P<0.05$) crude lipid content (13.4%) was observed in the milkfish fry that were fed with F3 diet than that of other treatments. Although, a higher feed conversion was obtained with the commercial feed (F3) as compared to indigenous larval feeds (F1 and F2), the overall growth performance was observed superior with indigenous micro-particulate feeds. The relatively lower feed cost and higher growth performance observed in indigenous larval feeds indicate that it is a potential alternative to commercial feed for larval rearing of milkfish.



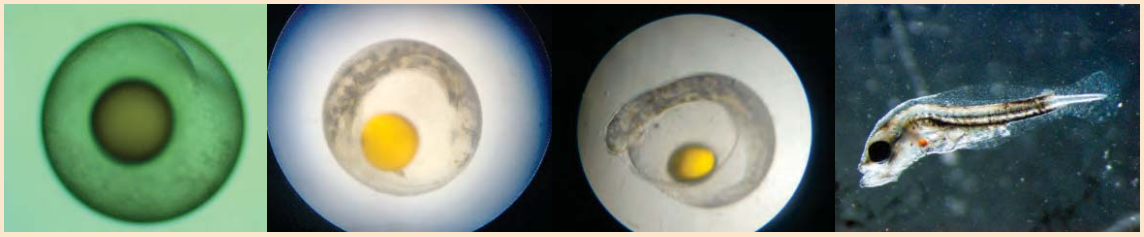
Growth of milkfish larvae fed different micro-particulated feeds

Induced breeding and seed production of crescent perch, *Terapon jarbua*

Mature male and female fishes were collected from Bay of Bengal, Ennore, Chennai and acclimatized to captive condition for 6 months under the flow-through system. To assess the maturity, female fishes were cannulated and the male was gently pressed near the vent. Female having the oocyte diameter more than 460 µm were selected along with the oozing male. Three breeding set was arranged, and in each set 2-male and one female was introduced. From the three sets two set were administered with hCG@300 IU/Kg and other one set were with LHRHa @ 70 µg/kg, and males were given half the dose. After 36 h of post-injection LHRHa injected set was spawned and the embryo was semi-buoyant in nature, and after 16-18 h of incubation hatching was observed. After 12 h of post-hatching concentrated algae (*Nanochloropsis aculeata)* were introduced in the rectangular larval rearing tanks @ 20 lit/400 lit and after 48 h rotifer, *Brachionus plicatilis* feeding was started. In total fifty thousand larvae of Crescent Perch were produced during last year.

Eggs and larvae of Crescent Perch, *Terapon jarbua*

Breeding of grey mullet in captivity: milestones achieved and challenges ahead



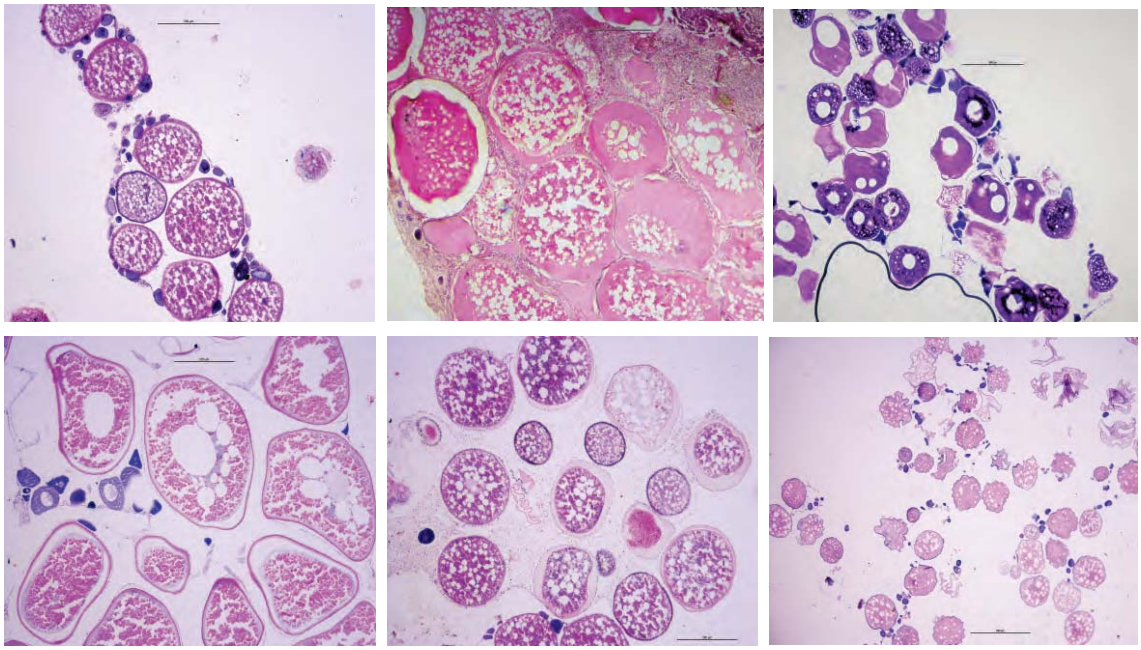
Embryonic stages of grey mullet under captive conditions

Captive breeding and closing the life cycle of grey mullet in captivity is one of the priority areas of research in ICAR-CIBA. For this, an alternate approach of farm-reared captive broodstock for induced breeding was tried at the west coast. Five successive induced breeding trials conducted between June to July 2017 were successful and resulted in larval production. Female fish with average oocyte diameter above 550 µm were selected and administered with exogenous hormones. Latency period was between 12-16 h. After ascertaining completion of final oocyte maturation and ovulation, dry stripping was done, 0.7- 1.5 million eggs were obtained. Fertilisation percentage varied from 5 to 75% in the different trials; average fertilisation rate was 35-40%. Size of fertilised egg ranged from 750- 870 µm. Size of oil globule was 270- 300 µm. Eggs were packed under oxygen packing and sent to fish hatchery, MES, CIBA. A maximum of 10,000-15,000 larvae was obtained post transportation to MES, CIBA. Larval survival was obtained upto 8 DPH. At farm site 5-10% of the fertilised eggs were retained; the larvae obtained were 1000 numbers, 30,000, 24,000, 12,000 and 10,000 numbers in the respective trials. Maximum survival was obtained upto 5 dph at the farm site. Size of newly hatched larvae was 2.1 mm. After 24 h and 48 h tl of larvae was 2.4 mm and 2.55 mm respectively. Research efforts will be continued for filing the gap of getting successful juvenile production from the larvae produced.

Dr. K. K. Vijayan, Director, ICAR-CIBA, Shri. M.A. Nissar and Mr. Dani Thomas with hatched out larvae of grey mullet

Domestication and year-round maturity status of spotted scat under captive condition

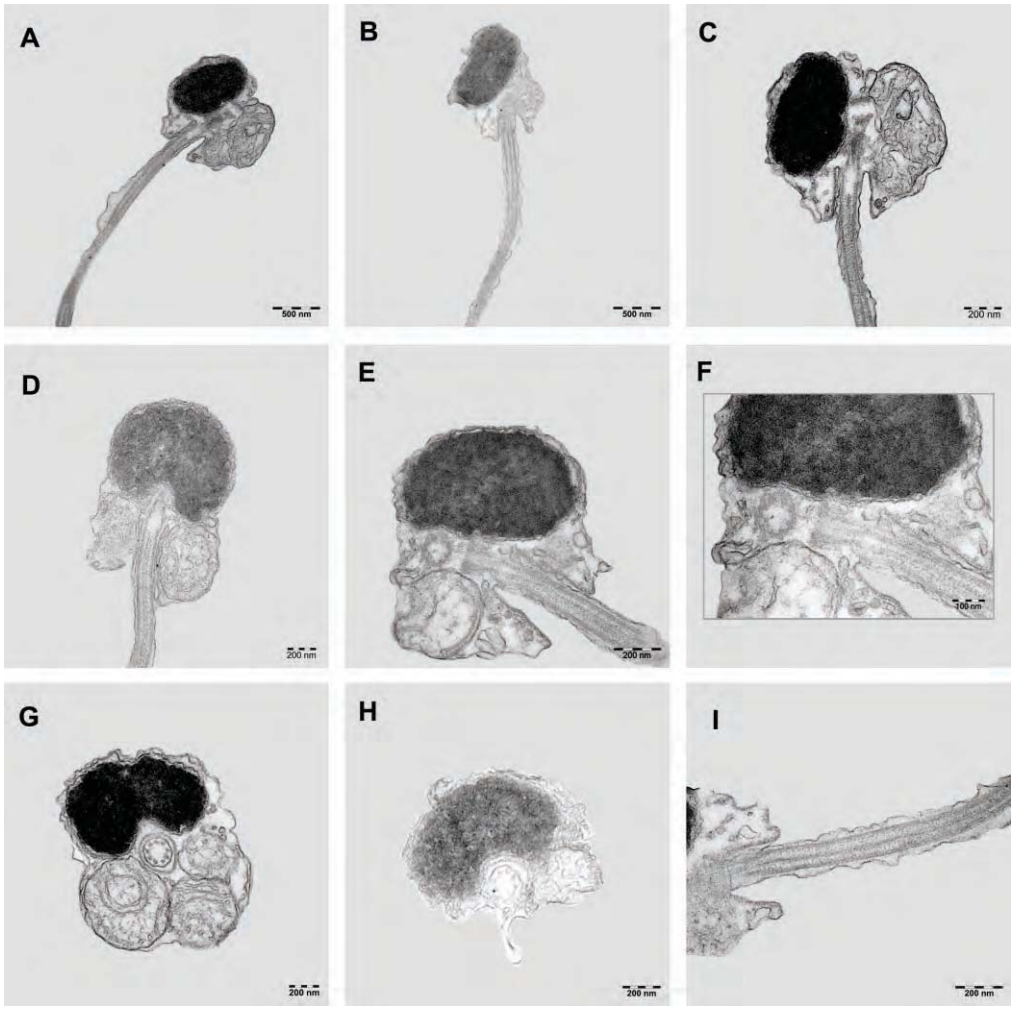
Spotted scat brood stock in pond-based systems was refined. Year round maturation profiles of adults in stock was monitored monthly. Mature fishes of both sexes were reported from April to November months where highest (28 %) milting males were found during June and the highest 33% of mature females (Tertiary yolk stage Oocytes) were found during August. Environmental parameters such as water salinity and water temperature were at peak of 31 ppt and 32 ° C during June & July respectively. Longest day length hour of 12.5 was recorded in the month of June. Each month biopsy samples of oocytes were collected and stored for histological preparation which revealed different phases of maturation during different months. Successful spawning was achieved during May – November months with highest fertilization (25.9 %) and hatching (70 %) percentage in August. A total of 21,639 fries were produced this year.



Oocytes maturation stages of female spotted Scat

Broodstock development of silver moony, *Monodactylus argenteus*

A total of 200 wild caught juvenile *Monodactylus argenteus* were maintained to brood size in net hapas with the participation of the fishermen of Venangupattu village, Kanchipuram district, Tamil Nadu. During the rearing period, fishes were fed with feed developed by CIBA. The fishes were reared up to 60- 70g and 110 fishes were transferred to the hatchery site and stocked in 2x1x1 net cages for captive maturation and breeding experiments. Monthly sampling was conducted to assess the health and maturity. Milting males could be observed during December 2017 to April 2018. Histological examination of the gonadal tissue indicated that the females were found to be in different stages of developing oocytes and it resembles like ovary of a batch spawner.



Transmission electron microscopy of sperm cells in *Monodactylus argenteus*

Spermatological characteristics of *Monodactylus argentus*

Variables	Mean	SE
Seminal fluid volume (µl)	20	10
Sperm Density (x 10 ^{9}/ml)	7.75	3.25
Total number of spermatozoa	18.75	14.25
Motility (%)	80	15
Seminal fluid osmolality ((mOsmol L $^{-1}$)	363	13
Sodium (mML $^{-1}$)	25.45	0.85
Potassium (mML $^{-1}$)	2.46	0.23
pH	7.7	0.1

Culture of Cyclopoid copepod using a combination of micro algae and yeast

An experiment was conducted for the culture of cyclopoid copepod isolated from Adyar creek using a combination of microalgae and yeast for a period of 20 days in a test tube. The study was conducted to find the best combination of microalgae as diet in order to produce the maximum number of copepod nauplius with a minimum period of time. The microalgae fed at the rate of 30000-35000 no/ml. Newly hatched copepod nauplii matured within 7-16 days depending upon the combination of microalgae given as feed on daily basis. Salinity tolerance was observed between 5-40 ppt and size of the nauplius (Nauplius I- VI) is in the range of 73.2-265.3µm. Size of copepodite (Copepodite I-V) is observed in the range of 272.5- 668.7µm. Copepodite VI (Adult) is observed in the range of 670- 1012.5µm. Average fecundity was 20 (Range 12-45). Mass culture of copepod was carried out in 500 litre tanks fed with a combination of microalgae, baker's yeast and rice bran. Highest density was observed i.e. 1500- 4500 no/litre within 14 days using a combination of Nannochloropsis sp and Isochrysis sp, Chaetoceros sp and Nannochloropsis sp, rice bran powder and baker's yeast

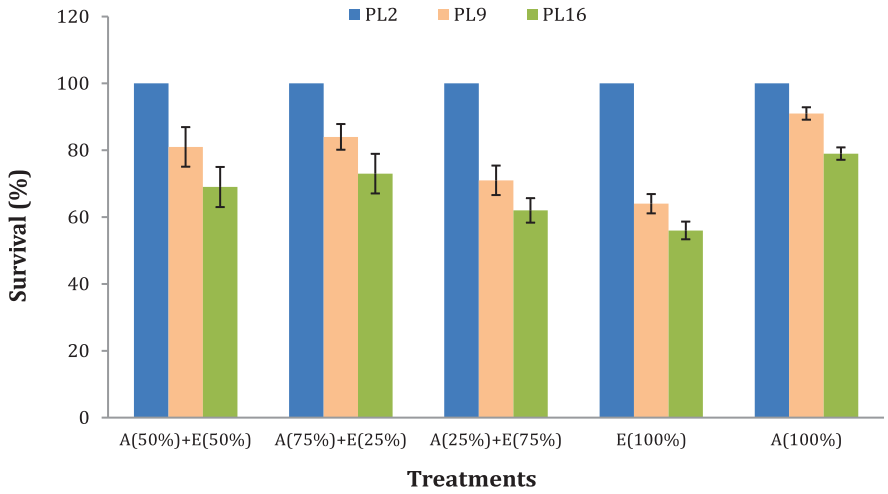
Cyclopoid copepods are emerging live food organisms and procedures for mass rearing of a novel cyclopoid copepod was developed. Highest density was observed within 14 days using mixture of micro algae rice bran and baker's yeast.

Life stages of cyclopoid copepod reared under captivity

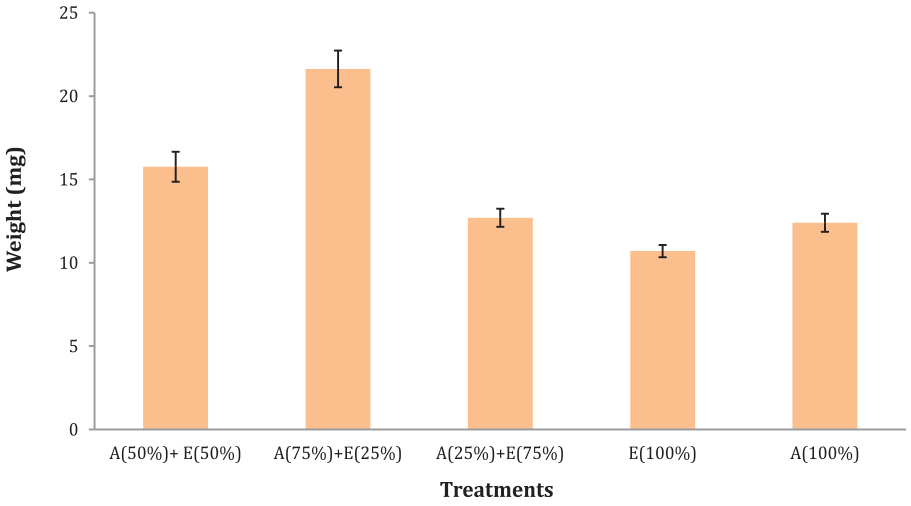
Evaluation of potential of frozen crab zoea and cyclopoid copepod as live feed for post larvae of *Penaeus indicus*

An experiment was conducted to check frozen crab zoea, copepod and *artemia* nauplii as feed for post-larval stages of *P. indicus*. Post larvae were stocked at a rate of 100 number per 20 l tub and fed with frozen crab zoea, cyclopoid and *Artemia* nauplii at the rate of 5 number at a time twice in a day and water exchanged on daily basis for a period of 15 days. Highest survival of postlarvae was observed in the treatment fed with *Artemia* naupli (92%) followed by Copepod nauplii (82%) and Frozen crab zoea (72%). Copepod nauplii (73-350 µm) can be taken as a feed which is comparatively less compared to treatment with *Artemia* nauplii due to its fast jerking movement. In most mud crab hatcheries only less than one million zoeas

are used for rearing and remaining are unused. These unused larvae could be used for rearing of shrimp as an alternative to *Artemia* nauplii An experiment was conducted using cladoceran species which was collected from the Adayar creek for the complete or partial replacement of artemia nauplii during the post-larval 2 stages of *P. indicus*. This species was mass cultured using different combination of diet and found that highest diversity was observed at 30ppt salinity within 7 days fed with chicken manure and *Chlorella* sp (4000-5500 nos/litre) A feeding experiment was conducted in 20 litre tubs for a period of 14 days and the postlarvae of *P. indicus* was fed with artemia nauplii and cladoceran species at the rate of 4-6 nos/ individual thrice in a day with daily exchange of water. The overall result found that survival of postlarvae was higher (79%) in treatment with A(100%) compare to other treatment but weight of postlarvae was higher in the treatment with A(75%) + E(25%) followed by A(50%) + E(50%). There is a significant difference in weight of post larvae between control and A(75%) + E(25%). The results conclude that partial replacement of artemia nauplii was possible using the cladoceran species (up to 50%) during the post-larval stages of *P. indicus*



Survival of *P. indicus* postlarvae fed different live feed



Growth performance of *P. indicus* postlarvae fed different live feed

NUTRITION AND FEED TECHNOLOGY

Feed is the crucial input in aquaculture production systems. CIBA focuses to develop cost-effective feed for all life stages of brackishwater candidate species

Pilot scale feed mill at Muttukadu experimental station of CIBA

Nutrition and Feed Technology

In aquaculture, feed and its management continue to be the major recurring cost, which often ranges from 40 to 60 % of the total cost of production and a key factor in determining the profitability to the farmer. India's aquafeed sector was more vibrant with current production around 2 million metric tons of feed, and it is expected to grow geometrically in coming years. Our dependency on overseas companies for the hatchery feeds continues and it creates a pressure on the hatcheries in producing quality seeds in a cost-effective way. 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

Feed ingredients are drivers in determining the quality and price of the feed. Having more choice of ingredients in the feed basket will assure a stable feed price irrespective of volatile ingredient prices. India being an agri based economy, there are hundreds of agricultural byproducts and terrestrial byproducts available for use in aquafeeds. CIBA continue bringing in more and more potential ingredients to feed basket with an aim for cost-effective feeds for brackishwater candidates.

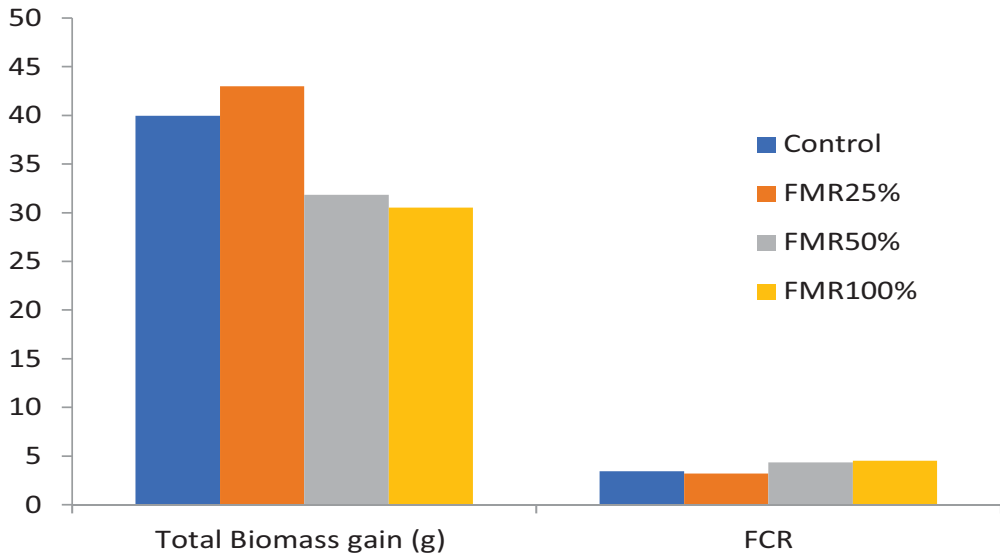
Indigenously sourced feed ingredients in the Vanami^{Plus} formula are mixed for further processing

Rice gluten as an alternate for soybean meal in the diet of shrimp, vannamei

Rice Gluten (RG), a byproduct of rice, with a protein content of 60.0% has been identified as a novel protein ingredient source and explored for its nutritional value in the diet of shrimp. Amino acid profiling revealed its richness in Lysine (2.65%) and Methionine content. A feeding trial for 60 days was conducted using RG to study the effect of replacement of soybean meal, a very common plant protein source widely used in shrimp feeds. RG was included at 10,15,20,25 and 30% replacing hi-protein soya on (W/W) basis in the shrimp diet. The results indicated that RG could be effectively used up to 20% in the vannamei diet.

Dried distillers grain with solubles (DDGS) as an ingredient in polyculture feed replacing high priced ingredients

Indoor experiment was carried out to study the potential of dried distillers grain with solubles (DDGS) in replacing fish meal in polyculture feed with an objective of further reduction of feed cost for species composition of *Mugil cephalus, Liza parsia, L.Tade, Scatophagus argus, Mystus gulio* and *Penaeus monodon* in the ratio of 1:1:1:1:3:1 respectively. The experiment revealed that when 25 % fish meal was replaced with DDGS, there was no difference (P>0.05) in biomass gain and FCR when compared with control. When 50 and 100% fish meal was replaced biomass gain was significantly (P<0.01) lower and FCR was higher as compared to control. Therefore, it can be concluded that DDGS can replace 25% of the fish meal, 30 % sunflower cake and 11.25 % mustard cake in polyculture feed without affecting the production performance.



Effect of fish meal replacement with DDGS on biomass gain and FCR

Fermented rapeseed meal as a feed ingredient for Indian white shrimp *Penaeus indicus*

The inclusion level of rapeseed meal (RSM) is very limited (2.5%) in shrimp diets due to its high fibre fractions (10%) and antinutritional factors like glucosinolates, tannins and phytic acid. The solid-state fermentation offers several economical and practical advantages to the agricultural by-products by enriching their nutritional quality and also reducing the antinutritional factors. The RSM was

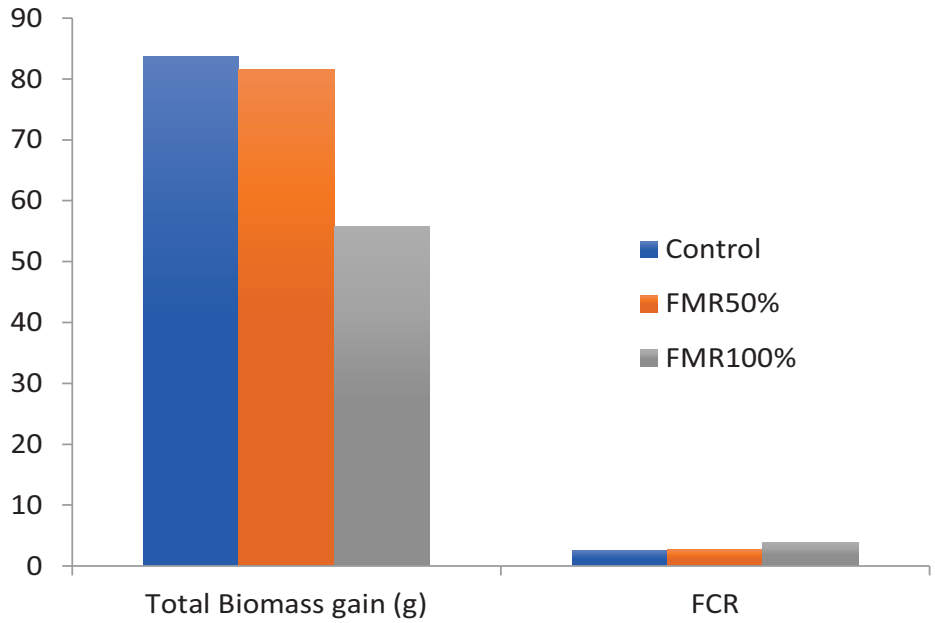
fermented with *Aspergillus niger* for three days. The fermentation has significantly (P<0.05) reduced glucosinolates, tannins and phytic acid from 3.13, 8.89, 27.4 to 1.28, 5.09 and 8.97, respectively. Both unprocessed and fermented RSM were incorporated at 0, 2.5, 5, 7.5 and 10% in the diet by replacing fish meal. The experimental feeds were tested in *P. indicus* juveniles (2.6 g) in a 45-day feeding trial. The weight gain was significantly (P < 0.05) higher in shrimp fed with diets having fermented ingredients compared to raw ingredients at all inclusion levels. The results indicated that incorporation could be increased up to 7.5% by using fermented RSM in *P. indicus* diet compared to 2.5% with raw RSM.

Effect of incorporation of fermented RSM on growth and nutrient utilization in *Penaeus indicus*

	Control	2.5%		5.0%		7.5%		10%	
		RSM	FRSM	RSM	FRSM	RSM	FRSM	RSM	FRSM
SGR	2.43^{a}	2.49^{a}	2.41^{ab}	2.37^{ab}	2.39^{ab}	2.14^{cd}	2.32^{abc}	2.02^{d}	2.06^{cd}
DGC	1.43^{ab}	1.46^{a}	1.47^{a}	1.38^{abc}	1.40^{ab}	1.26^{bcd}	1.35^{abc}	1.16^{d}	1.20^{cd}
Survival (%)	91.11	91.11	91.11	91.11	80	86.67	86.67	86.67	91.11

Dried fish silage powder as an ingredient in polyculture feed

The indoor experiment was carried out to study the potential of fish silage in replacing fishmeal in polyculture feed with an objective of further reduction of feed cost. A 42 days experiment was conducted with juveniles of *Mugil cephalus* (2 no), *Liza parsia* (2 no), *L.Tade* (2 no), *Scatophagus argus* (2 no), *Mystus gulio* (6 no) and *Penaeus monodon* (2 no) per replicate and were stocked in fibre reinforced plastic (FRP) tanks containing 600 liter strained clear brackish water with continuous aeration. The experiment indicated that when 50% fish meal was replaced with fish silage there was no difference (P>0.05) in biomass gain and FCR when compared with control. When 100% fish meal was replaced biomass gain was significantly (P<0.01) lower and FCR was higher as compared to control. Therefore, it can be concluded that dried fish silage powder can replace 50% of the fishmeal, 20 % sunflower cake and 5 % mustard cake in polyculture feed without affecting the production performance.



Effect of fish meal replacement with fish silage powder on biomass gain and FCR

Dried fish silage produced from low value fishes and fish trimmings not suitable for human consumption

Nutritional value of fermented ingredients in combinations as alternates for fishmeal in diets of Pacific white leg shrimp, *Penaeus vannamei*

In our earlier studies, the effect of utilization of fermented ingredients was studied individually and the maximum level of inclusion of was determined. The results revealed that the *Aspergillus niger* fermented ingredients such as soybean meal, groundnut oil cake, rapeseed meal and sunflower oil cake could be used up to 15 (in addition to the 20% in control diet), 10, 7.5 and 5%, respectively. Based on the level of inclusion and dry matter digestibility, three fermented ingredients: groundnut oil cake, rapeseed meal and sunflower oil cake were mixed in the combination of 6.3:4.8:2.5, respectively and the four fermented ingredients: soybean meal, groundnut oil cake, rapeseed meal and sunflower oil cake were mixed in the combination of 13.7:6.3:4.8:2.5, respectively. Three ingredient combinations were used to replace fishmeal at 0, 30, 40, 50 and 60% levels and four-ingredient combinations were used to replace fishmeal at 0, 50, 60, 70, 80 and 90% levels. These diets were evaluated in a 45-day growth trial in *Penaeus vannamei*. The three fermented ingredient combinations were able to replace 30-40% of fishmeal whereas four fermented ingredient combinations were able to replace up to 70% of fishmeal.

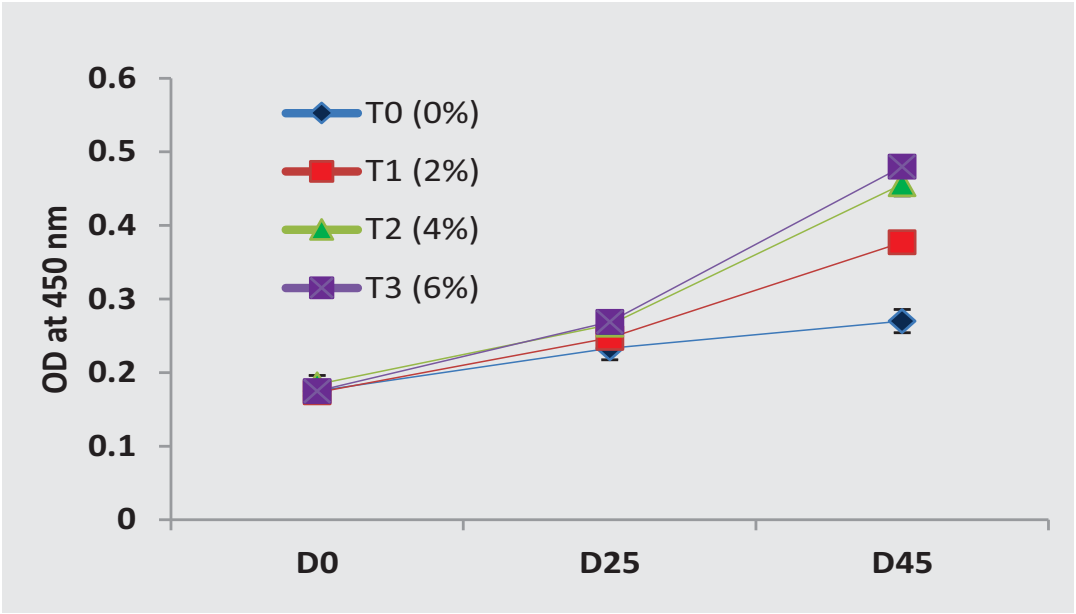
Effect of graded fishmeal replacement using combinations of fermented ingredient mixture on performance and nutrient utilization in *Penaeus vannamei*

	SGR	DGC	Survival (%)	FCR	PER	APU
Control	2.28^{a}	1.37^{a}	93.33	1.82^{c}	1.38^{a}	22.86^{ab}
50%	2.27^{a}	1.37^{a}	93.33	1.78^{c}	1.46^{a}	23.78^{a}
60%	2.26^{a}	1.35^{a}	95.56	1.86^{c}	1.37^{a}	22.26^{ab}
70%	2.23^{a}	1.32^{a}	93.33	1.88^{c}	1.36^{a}	21.37^{b}
80%	2.02^{b}	1.18^{b}	95.56	2.17^{b}	1.21^{b}	19.45^{c}
90%	1.75^{c}	1.00^{c}	95.56	2.65^{a}	0.98^{c}	15.64^{d}

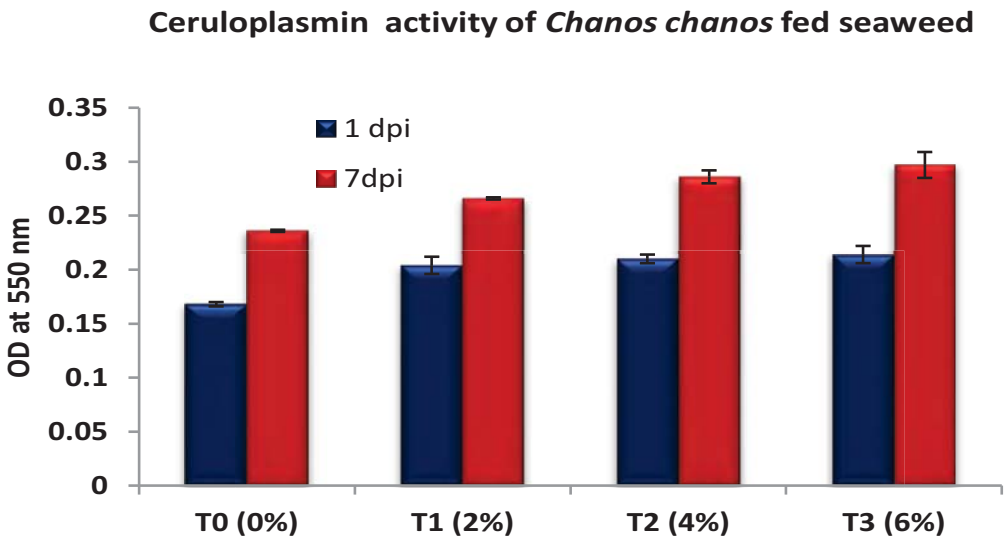
* The columns sharing different superscripts are significantly different

Seaweed as a growth and health-promoting feed additive in milkfish (*Chanos chanos*) fingerlings

Among the commonly available seaweeds, *Enteromorpha intestinalis* was found to contain the highest protein (CP-19.04%) as compared to *Catenella repens* (CP-8.49%) and *Ulva lactuca* (CP-5.25%). *E. intestinalis* has an antioxidant property which helps to enhance immunity. A forty-five days feeding trial was conducted to study the effect of seaweed supplementation on growth and health of in the in milkfish fingerlings. The group fed 4% level recorded the highest weight gain followed by 6% inclusion. Similarly, a better FCR (1.13) was observed in 4% inclusion level compared to the rest of the diets. Ceruloplasmin level increased significantly with an increased percentage of seaweed supplementation in the diets. The Myeloperoxidase activity levels of milk fish increased significantly ($P < 0.05$) with an increase in days of feeding with seaweed. The results suggest that seaweed (*E. intestinalis*) can be used as an additive in milkfish for enhancing the immunity of the fingerlings.



Myleoperoxidase activity *Chanos chanos* fed seaweed



Non-specific immune parameters of milkfish supplemented with different percentage of seaweed

Demonstration of practical feeds developed by CIBA in farmers pond

Vanami^{Plus} - a cost effective indigenous shrimp feed

In an addition to the series of demonstrations completed, a demonstration of Vanami^{Plus} feed was carried out in Ernakulam, Kerala in collaboration with CMFRI. About 1,00,000 Post larvae of *P. vannamei* stocked in one-acre pond owned by, Mr. Josey Jacob and fed Vanami^{Plus} feed throughout the culture as per the guidelines are given by CIBA. The shrimps attained an average body weight of 24.5 g at 72 days of culture, with a production of 550 kg.

Performance of Vanami^{Plus} was demonstrated at farmers pond in Kerala

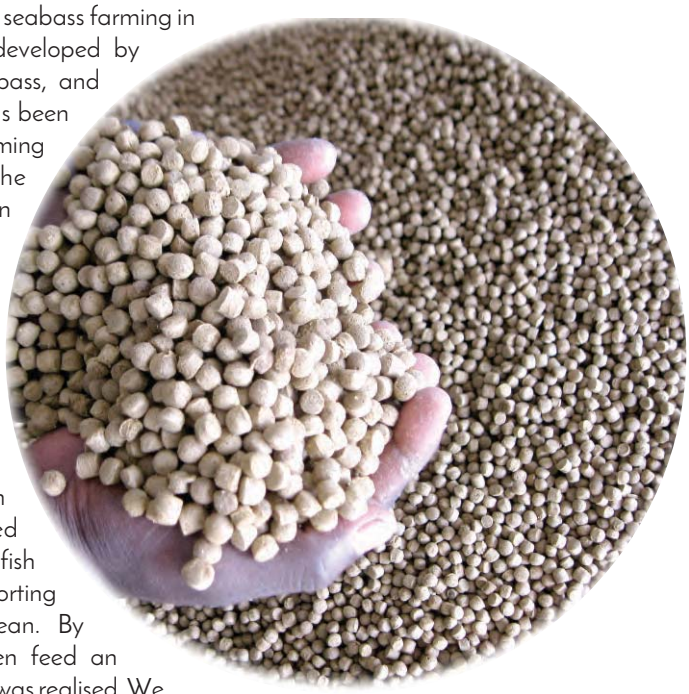
Seebass^{Plus} -Nursery feed

Nursery rearing is the critical link in seabass farming wherein the provision of apt feed is the key element which determines the success of seabass farming. Considering this essentiality, CIBA developed a speciality nursery feed and branded Seebass^{Plus} Nursery. The performance of this feed has been demonstrated in a farmer's pond using hapas at Atiramapatinam near Pattukkottai. About 22,000 seabass fingerlings of 5 to 7 g size were stocked in hapas and the nursery rearing was carried out for 90 days. During the entire nursery phase, CIBA Seabass^{Plus} Nursery was fed to satiety at three feeding frequencies. A survival of 95% was achieved with the final average body weight ranged from 50 to 200 g at the end. The juveniles were transferred to the grow-out pond for further rearing.

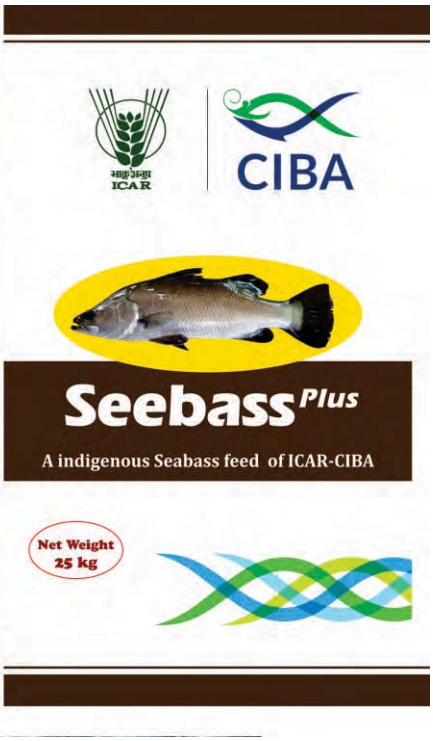
Nursery rearing of Seabass using Seebass^{Plus} Nursery in a battery of cages installed inside the pond

Seebass^{Plus} - Grow-out feed

Lack of an indigenously manufactured cost-effective seabass feed is another missing element in the expansion of seabass farming in India. A cost-effective, indigenous feed developed by CIBA especially for cage farming of seabass, and branded as Seebass^{Plus}. Its performance has been demonstrated in a three-tier cage farming model with appropriate feeds for the respective life stages in partnership with an inland fisher group. A slow sinking feed costing around Rs 80 to 90/ kg was formulated to contain 42-48% protein and 13% of lipid. The final standing biomass during harvest was 15 kg /m^3. In the grow-out phase, the juveniles were grown to a marketable size of 900 g - 1.25 kg within 6 months. A productivity of 460 kg was realised with an average Feed Conversion Ratio (FCR) of 1.85:1. A unique feed management strategy, algivorous Rabbit fish (*Siganus javus*) were stocked as supporting species for keeping the cage mesh clean. By consuming the macro algae and uneaten feed an additional fish biomass of 30 kg Rabbit fish was realised. We demonstrated the feasibility of seabass farming using indigenously formulated feed as a farming option in open brackishwaters.



Floating pellets of Seebass^{Plus} - Growout



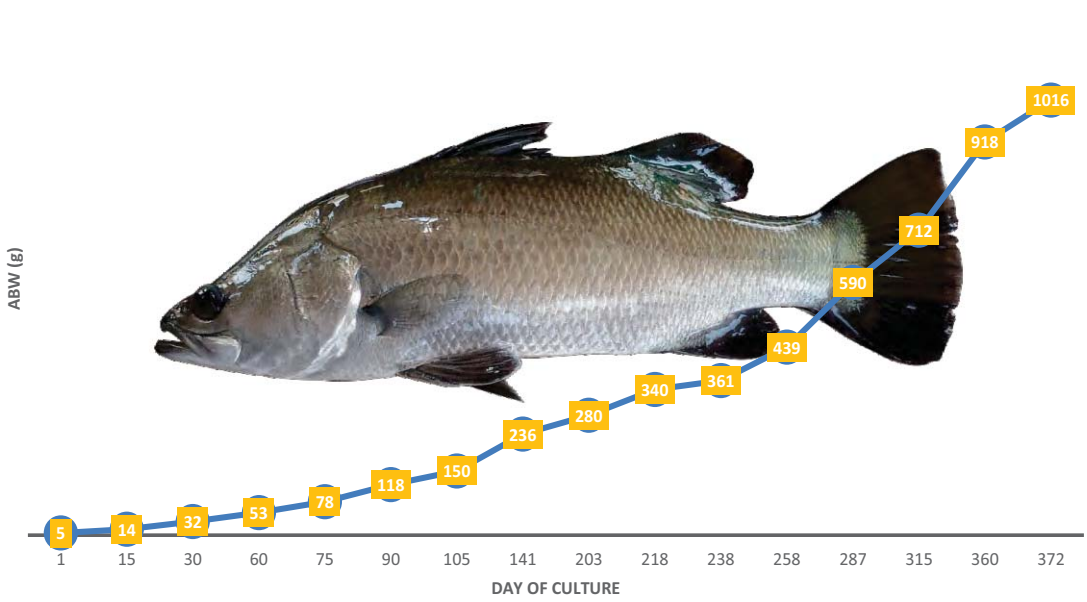
Scylla^{Plus} - Grow-out feed for crab in recirculating aquaculture system (RAS)

A formulated compressed pellet feed was tested in an indoor RAS system specially engineered for crabs at Avanigadda, Krishna district, Andhra Pradesh. A total of 54 crab holding containers (9 columns x 4 rows) were stocked individually with mud crab *Scylla serrata* 200 g. The crabs were fed with a 4.5 mm Scylla^{Plus} having 36% crude protein 6.5% ether extract. At the end of 4 weeks, 22% of the crabs showed moulting and 93 % of the crabs survived.

RAS based indoor system for mud crab rearing using formulated feed Scylla^{Plus}

Growth performance of fish seabass grown in floating cages using indigenous feed Seebass^{Plus}

A slow sinking feed costing formulated to contain 42-48% protein and 13% of lipid was used for the farming demonstration in a three-tier cage model. Vaccum infiltratration was used for addition of such a high level of oil after pelleting in extruder. The farming cycle began with stocking of fish fry (1cm size) initially in the nursery cages, where they were grown to fingerling size (7-8 cm size) in 45-60 days, then transferred from nurseries to pre-grow-out cage and subsequently 90-100g size juveniles from pre-grow out were transferred to grow out cages and reared until harvest. Slowing dry feed of suitable pellet sizes were offered twice in a day @ 10-8%,6-4% and 4-2% of their body weight in nursery, pre-grow-out and grow out stages respectively. The growth performance was on par with the data reported elsewhere in the seabass farming nations.

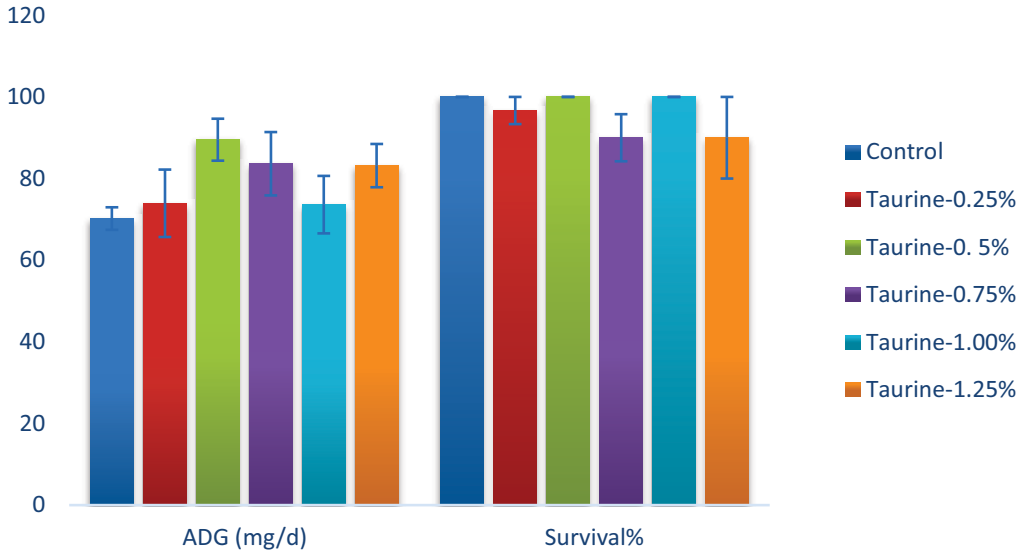


Growth curve of seabass in cages fed formulated feed over the entire grow-out culture

Optimization of nutrient requirements

Requirement of taurine in seabass larval diet

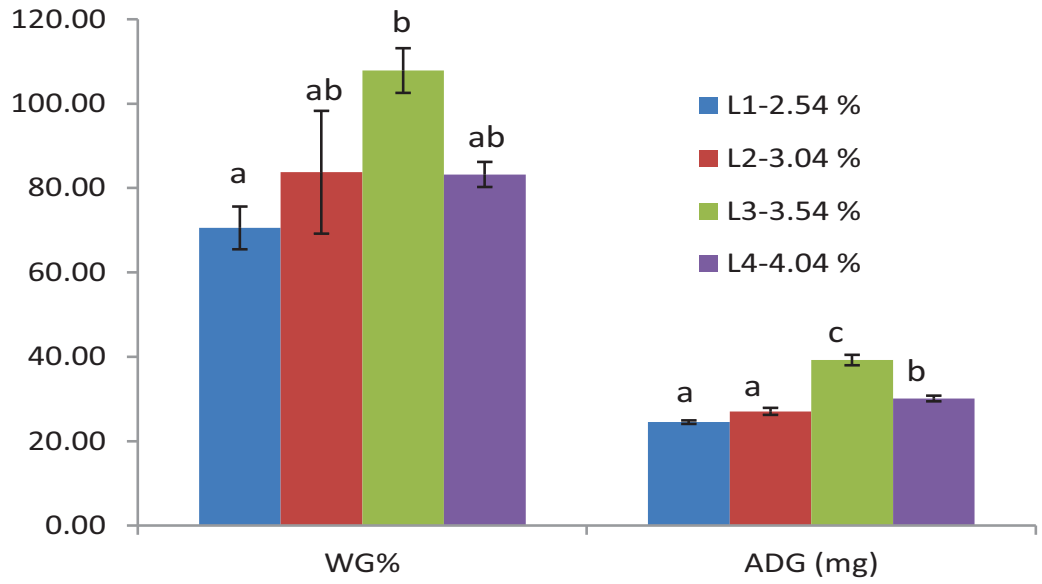
Larval feed of Asian seabass was prepared with a different level of taurine i.e., 0, 0.25, 0.5, 0.75, 1.0 and 1.25 %. All the feed were isoproteinous and isolipidic. Asian seabass larvae (Av. Body wt. 0.497 g) were randomly distributed in glass tanks (90 L water each) of recirculatory aquaculture system (RAS) @ 40 larvae per tank and the feeding trial was carried out in triplicate for 6 weeks. Average daily weight gain, weight gain percent, specific growth rate were higher and FCR was lower in seabass supplemented with 0.5 % taurine. No difference in survival was observed in seabass supplemented with varying level of taurine. The experiment revealed that 0.5 % taurine supplementation was found to be optimum in the diet of seabass larvae.



Effect of taurine supplementation on average daily weight gain and survival of seabass larvae

Methionine and lysine requirement of hilsa fry

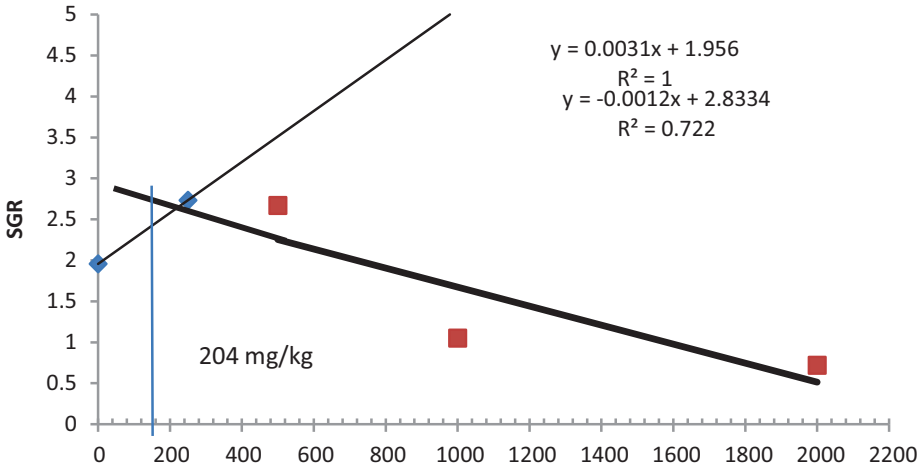
Though protein is considered to be the costliest nutrient, it is not protein matters for the fish and it is only their amino acid composition. Methionine and lysine are the two limiting essential amino acids in manufacturing of compounded feeds farmed aquatic species. This study was conducted for optimising the level of this two important amino acid for hilsa fry. Graded level of lysine and methionine inclusion in larval diets revealed that average daily gain was higher (P<0.01) in hilsa fry fed with 3.54% lysine and 1.64% of methionine. FCR was lower (P<0.05) and PER and SGR were higher (P<0.05) in hilsa fed with 3.54% lysine. FCR was also lower (P>0.05) in hilsa fed 1.64% methionine. Results of the experiments indicated that optimum lysine and methionine requirement of hilsa fry is 3.54% and 1.64 % of feed dry matter.



Growth performance of hilsa fry with varying level of lysine in the diet

Optimum dietary vitamin- C for better growth and survival of milkfish, *Chanos chanos* larvae

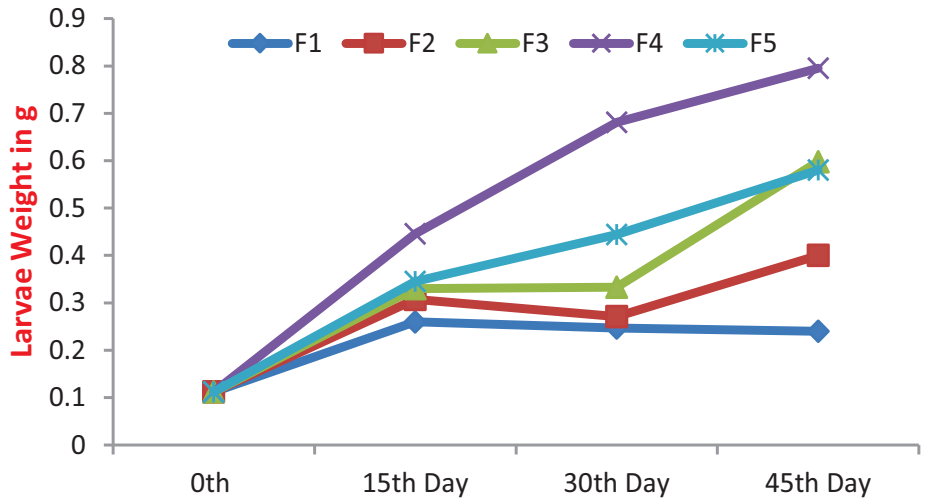
Vitamin C is an important nutrient in fish larval feed and fish larvae are extremely sensitive to vitamin C deficiency. A forty five-day study was conducted to examine the effect of dietary ascorbic acid (AA) levels on the growth of milkfish, *Chanos chanos* larvae. Five iso-nitrogenous and iso-energetic (550 g protein per kg and 70 g lipid per kg) experimental basal diets were prepared with different levels of ascorbic acid such as control (0), T_1 (250), T_2 (500), T_3 (1000) and T_4 (2000) mg ascorbic acid (L-ascorbyl-2-polyphosphate) equivalent per kg diet. Milkfish larvae (ABW 9.64 mg) were stocked (hundred larvae per tank) in triplicates following a completely randomized design. The results revealed that milkfish fed 250–500 mg/kg of vitamin C was optimum in realizing a better growth performance and survival. On the other hand, the milkfish larvae fed above 1000–2000 mg/kg showed a poor growth performance and survival. Broken-line regression analysis revealed that the dietary vitamin C requirement for the growth of *C. chanos* larvae was estimated to be in the range of 183–204 mg ascorbic acid per kg. The results will be helpful for the formulation of cost-effective ascorbic acid incorporated diets for milkfish, *C. chanos* larvae.



Dietary vitamin C requirement for growth of *Chanos chanos* larvae using broken-line regression analysis

Dietary fish oil and lecithin ratio on growth performance, survival and fatty acid composition of milkfish (*Chanos chanos*) larvae

The influence of five different ratios of fish oil (F) and lecithin (L) on growth and survival of milkfish, *Chanos chanos* larvae (0.112g), was evaluated in a 6-weeks experimental trial. Fish oil was gradually replaced with lecithin F1 (F100/L0), F2 (F75/L25), F3 (F50/L50), F4 (F25/L75) and F5 (F0/L100) in each treatment. A 30-day feeding trial was conducted in triplicate following a completely randomized design. The results revealed that milkfish larvae fed F50/L50 and the F25/L75 ratio of fish oil and lecithin showed highest ($P < 0.05$) growth performance and survival rate. *C. chanos* fed with F50/L50 and F25/L75 ratio of fish oil and lecithin diets achieved significant ($P < 0.05$) improvement in growth performance and muscle biochemical compositions while milkfish fed with F25/L75 showed enhanced performance. Diet fatty acid composition was affected by phospholipid incorporation, dietary n – 3 HUFA concentration decreasing with the incorporation of PL. The growth and survival of milkfish was positively related to the dietary PL concentration.



Pattern of growth in milkfish larvae fed containing different level of fish oil and soy lecithin

Optimization of lipid requirement of *M. gulio* fry

A 42-day feeding experiment was conducted to evaluate dietary fat requirement of *M. gulio* (ABW 1.05 g) Five practical diets containing five graded levels of fat (3%, 6%, 9%, 12% and 15%) with 25 % protein were fed to *M. gulio* fry. The experiment was conducted in 100 l FRP tank with five treatments and three replicates containing ten *M. gulio* fry in each. It was found that 6% dietary fat with 25 % protein is optimum. Body composition didn't show any difference with different level of fat in the diet.

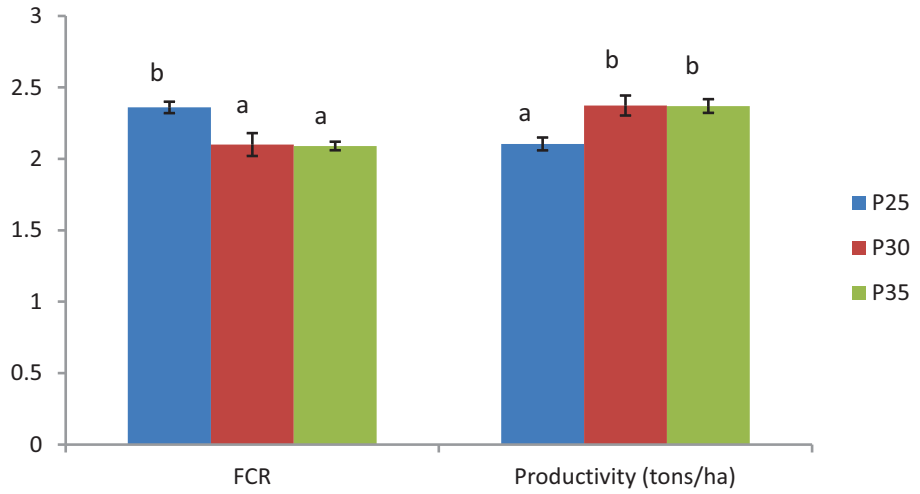
Performance *M. gulio* fed different level of fat in the diet

Parameter	Control	T1	T2	T3	T4
Final body weight (g)	2.09±0.03	3.64±0.05b	2.47±0.01	2.34±0.01	2.18±0.30
FCR	2.76±0.04	1.14±0.03	1.86±0.19	1.63±0.08	2.52±0.16
Survival (%)	70.00±00	93.33±3.33	83.33±3.33	80.00±00 b	66.67±3.33
PER	1.43±0.02	3.50±0.09	2.18±0.25	2.40±0.11	1.58±0.10

Control, (EE-3%), T1 (EE-6%), T2, (EE-9%), T3, (EE-12%), T4, (EE-15%)

Study on growth and production of *P. vannamei* fed varying level of protein in low saline pond culture system at KRC

Pond trial was conducted at Kakdwip Research Centre to evaluate the performance of shrimp feed with different level of protein (25%, 30% & 35%) **in** *P. vannamei*. Shrimp were stocked @28 nos/sqm in triplicate ponds and duration of culture was 94 days. The result showed that *P. vannamei* fed a diet with 30 and 35 % protein attained 23.02 and 22.22 g after 94 days of culture in low saline pond culture system. Production (2.37 t/ha) and FCR (2.09-2.10) were similar in *P. vannamei* fed diet with 30 and 35% protein. Growth, production and FCR were affected in shrimps fed diet with 25% protein. Results revealed that 30% protein is optimum for *P. vannamei* in low saline pond culture system.



Effect of varying level of protein on production performance of *P. vannamei* in low saline pond culture system

Feed management options

Utilization of periphyton biomass for partial replacement of feed in milkfish culture

Periphyton based culture systems have been found to provide better natural feed as well as act as an *in situ* biological filters in the rearing system. Milkfish being a herbivore fish, it can reared using this periphyton biomass by reducing the feed inputs. To study this milkfish (ABW 14.68 g) grow-out culture was undertaken in four different feeding regimes, (P0) control with total feeding, (P75) periphyton grown in 75% surface area (SA) + partial feeding, (P100) periphyton grown in 100% SA + partial feeding and (P125) periphyton grown in 125% SA + partial feeding with stocking density of 15000/ ha in 50 m^2 pond enclosures. After 180 days, fish growth (242.29±5.22 g) was significantly highest ($P<0.05$) with the lowest FCR of 1.17±0.02 in P125. This trial indicated that periphyton can be utilized to reduce FCR (up to 46%) in a monoculture of milkfish for better productivity.

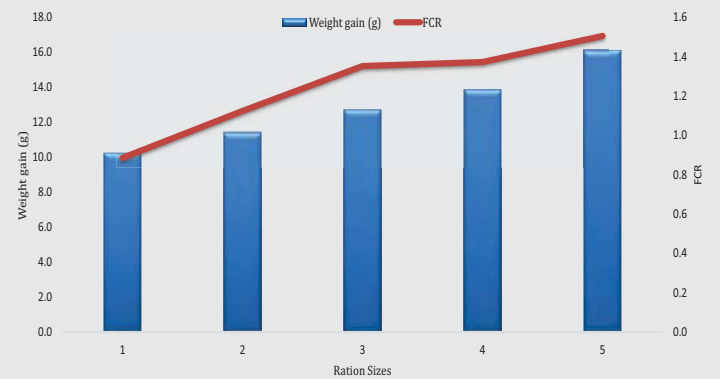
Production performance, FCR and economic return of milkfish monoculture under four different systems

Parameter	P0	P75	P100	P125
Final ABW (g)	132.24±2.32^{d}	214.89±7.75^{c}	237.18±4.25^{b}	242.29±5.22^{a}
Survival (%)	76±2.7^{d}	79.1±0.5^{c}	83.1±0.9^{b}	86.7±3.4^{a}
Productivity (kg/ ha)	1509±79^{d}	2549±77^{c}	2844±71^{b}	3146±60^{a}
FCR	2.15±0.11^{d}	1.63±0.05^{c}	1.34±0.03^{b}	1.17±0.02^{a}

Means with different superscripts in a row differ significantly ($P<0.05$); values are mean ± SD of three replicates; total feeding and no periphyton (P0), and partial feeding with periphyton grown on 75 (P75), 100 (P100) and 125 (P125) % of pond surface area.

Optimum daily feed ration for the grow-out rearing of fish, Pearlspot

Pearlspot being an omnivorous fish they prefer to eat plant-based foods in nature. Considering this we developed a grow-feed to contain more of plant-based agriculture by-products as ingredients. Feed management which involves provisioning feed in right quantity in right time and intervals is a critical component for better utilization of nutrients. In this study, we tested the different ration levels such as 3, 4, 5, 6 and 7% per day in indoor clear water systems. In the tanks juveniles of 4 g reached ABW of 110 g in 155 days and 133 g in the same duration in cages. Feed ration of 5% was found to be optimum for the juvenile pearlspot, in which better utilization of feed was found based on the growth and FCR. Survival was obtained 100% irrespective of the ration size. Nursery rearing in microcosm produced 1080 juveniles of 1.22 g in 57 days and 2.34 g in 84 days from 22 mg initial weight with 90% survival on practical CIBA's microbound feeds.

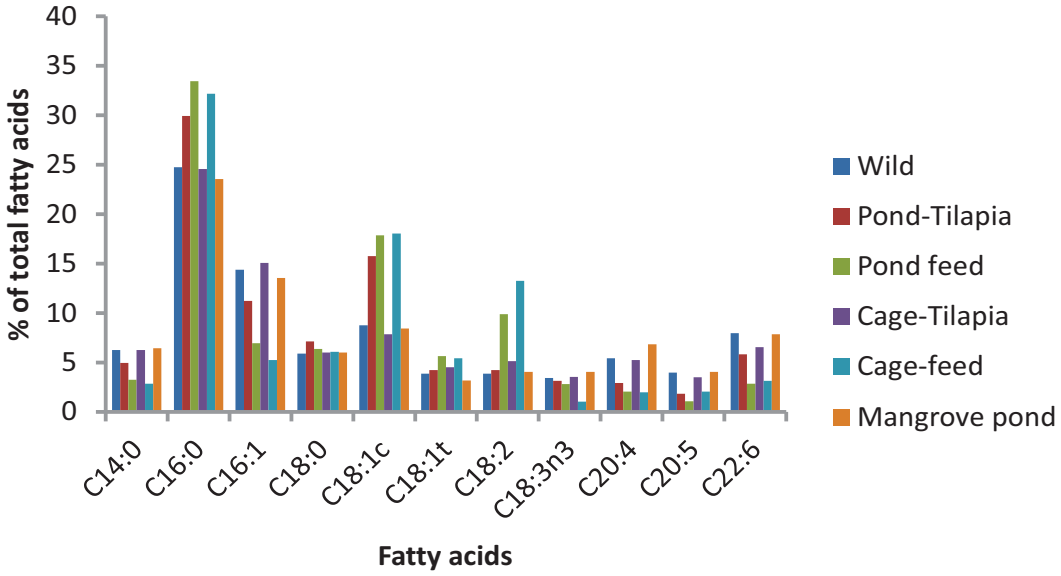


Weight gain and FCR of juvenile pearlspot fed varying daily rations

Influence feed on the final nutritional quality of the seafood

Effect of rearing system on fatty acid profiles of Asian Seabass, *Lates calcarifer*

Asian seabass, *Lates calcarifer* is a high-value finfish species widely farmed in brackishwater. There were assumptions and evidence in other farmed fishes on the variation in nutritional quality and taste. In this study, Asian seabass were collected from wild and five different farming systems, viz., pond (fed Tilapia), pond (fed formulated pelleted feed), open water cages (fed Tilapia) open water cages (fed formulated pelleted feed) and extensive culture in mangrove ecosystem to study the effect of culture system on fatty acids profile. The fatty acid profiles varied significantly ($P<0.05$) between rearing systems. Although the proportion of n-3 fatty acids are reduced in fishes fed on pellet feed in both the systems, the absolute quantity of n-3 fatty acids are higher due to the higher lipid content.

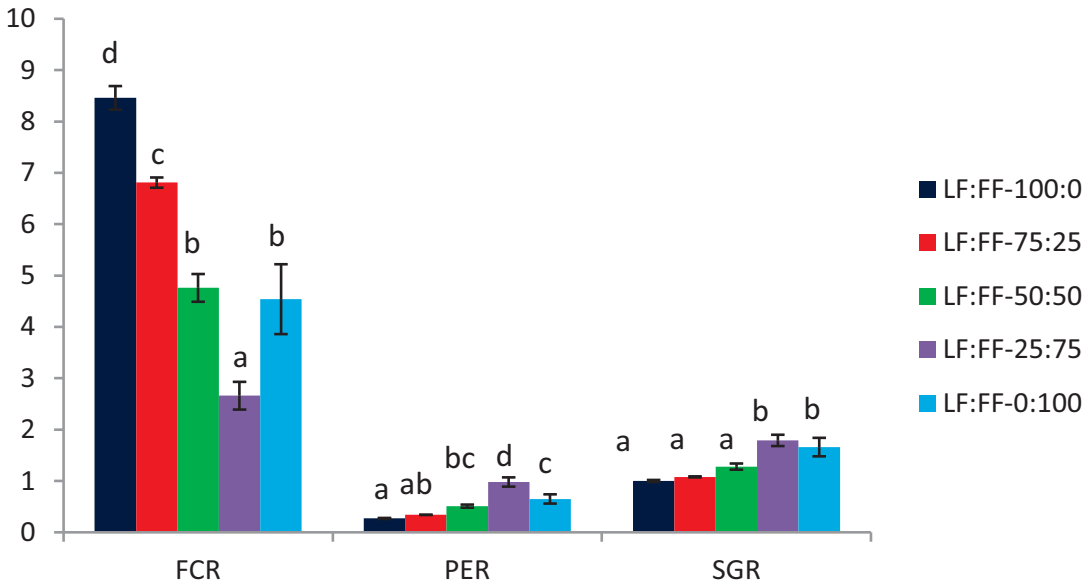


Fatty acid profiles of Asian Seabass reared in different rearing

Live feeds: a key element in hatchery seed production of fish and shellfish

The optimum combination of formulated and live feed for hilsa juveniles

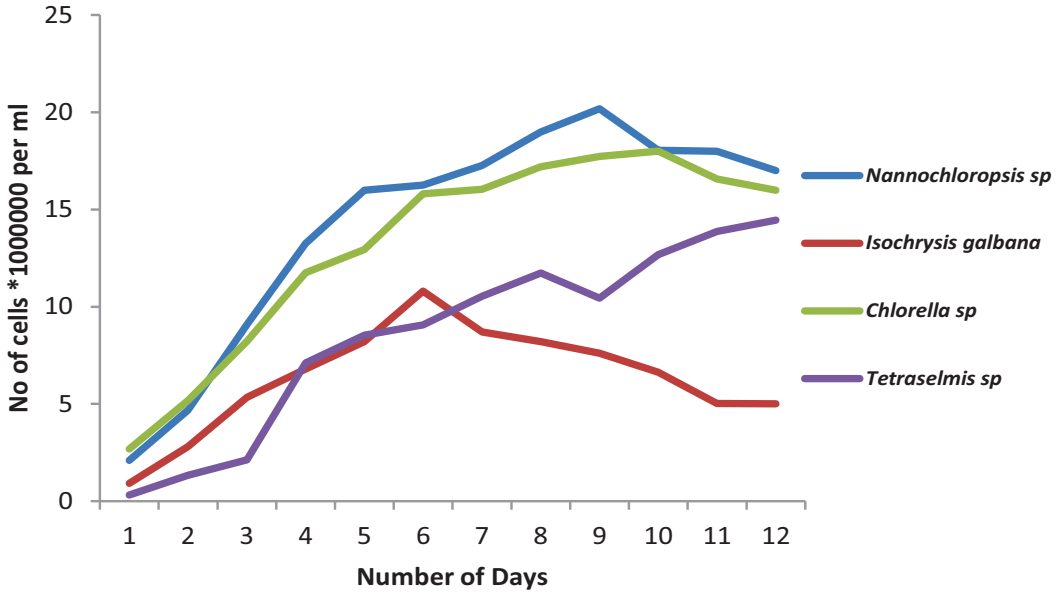
Hilsa juveniles are filter feeders, which filters the live feeds in the water while it flows through the gill rakers. Under captive rearing feeding the filter feeders are challenging. In this study, to optimize the proportion of live feed and formulated feed in diet of hilsa juveniles an indoor experiment was conducted with different proportion of live feed (LF) and formulated feed (FF) i.e., LF:FF-100:0; LF:FF-75:25; LF:FF-50:50; LF:FF-25:75; LF:FF-0:100. The trial was conducted for 30 days. Hilsa fry performed better in terms of weight gain, growth rate and nutrient utilization efficiency when offered with 25% Live Feed and 75 % formulated feed in their diet in indoor experiment.



Growth and feed utilization efficiency of hilsa fry with different proportion of live feed (LF) and formulated feed (FF)

Potential microalgal species and their growth kinetics

Apart from the common microalgae used in aquaculture, many other potential unexploited microalgal species occur in backwaters and estuaries, which may have unique values for use in hatchery production finfishes and shellfishes and human nutraceutical properties. Using the standard isolation and culture methods, microalgae strains such as *Tetraselmis* sp (2 strains), *Nannochloropsis* sp, *Chlorella* sp, *Navicula* sp, (from high saline waters) and *Isochrysis galbana* sp (from seawater) were isolated. The growth kinetics of these isolates is studied and it was observed that *Chlorella* sp and *Nannochloropsis* sp were fast growing compared to *Tetraselmis* and *Isochrysis* sp. The *Tetraselmis* sp was showing extended exponential growth in its growth cycle (>12 days).



Growth cycle of microalgal isolates under controlled conditions

Microalgae facility at CIBA, Muttukadu Experimental Station

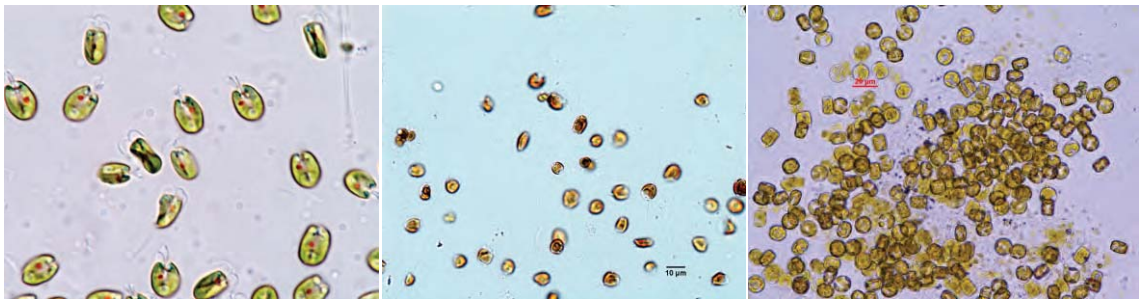
Downstream processing of locally isolated *Arthrospira maxima*

The cyanobacterium; spirulina (*Arthrospira* sp) has a unique set of biological characteristics which are highly useful for a broad range of applications in food, feed nutraceuticals, pharmaceuticals etc. In India, the commercial culture and production of spirulina is mostly depending on the imported strains. A potential strain of spirulina (*Arthrospira maxima*) was isolated from Muttukadu waters for the first time, and its mass culture was optimized for both indoor and outdoor at a cost-effective urea based medium. The biomass obtained was used to produce a high-value pigment phycocyanin. A three-stage extraction procedure was standardized to get a crude form of phycocyanin. By this process, the purity (A620/A280) of about 1.14 is been achieved. The yield of phycocyanin was 15 % of the dry weight. The yield of purity and phycocyanin was compared in each stage with commercially available spirulina a powder (*Arthrospira platensis*). The purity of crude extract was on par with commercially available spirulina.

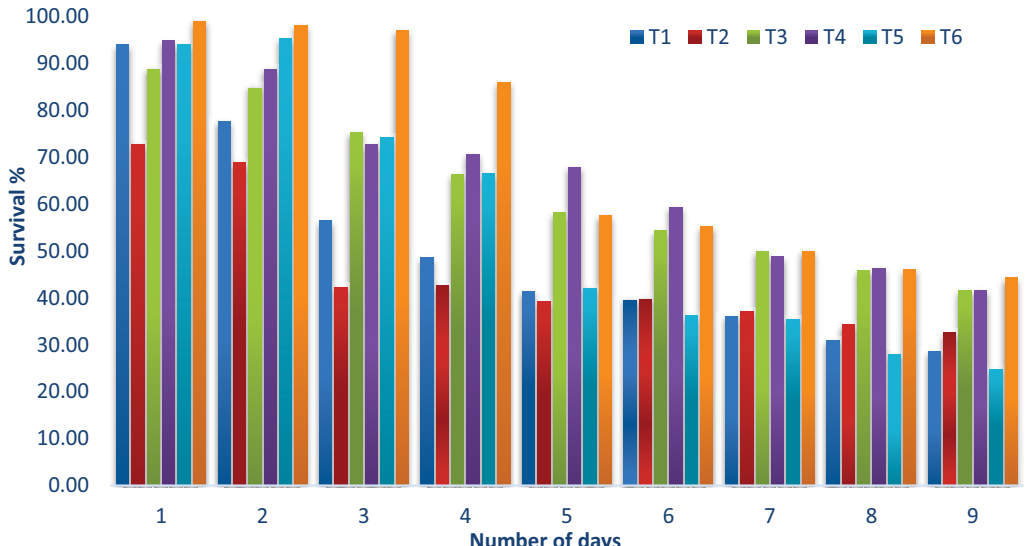
Harvested spirulina and phycocyanin extract

The efficiency of different microalgae in shrimp larval rearing

Over the years, shrimp hatcheries were using different microalgae for larval rearing. Microalgae were selected only based on the practical constrains and without much scientific background. We conducted experiments to find out the best microalgae for penaeid shrimp larval rearing with relevance to its nutrient value as well as ease for mass cultivation. The first experiment was with *Penaeus indicus* larvae. Based on the ease of mass culture micro algae such as *Tetraselmis* sp, *Chaetoceros* sp and *Thalassiosira* sp were selected and tested individually as well as in combinations. The results showed that the highest survival, growth and fast conversion of shrimp larvae were obtained in combination of *Thalassiosira*: *Tetraselmis* (1:1) followed by *Thalssisosira* : *Chaetoceros* and *Thalassiosira*.



Microscopic images of *Tetraselmis* sp, *Chaetoceros* sp, *Thalassiosira* sp

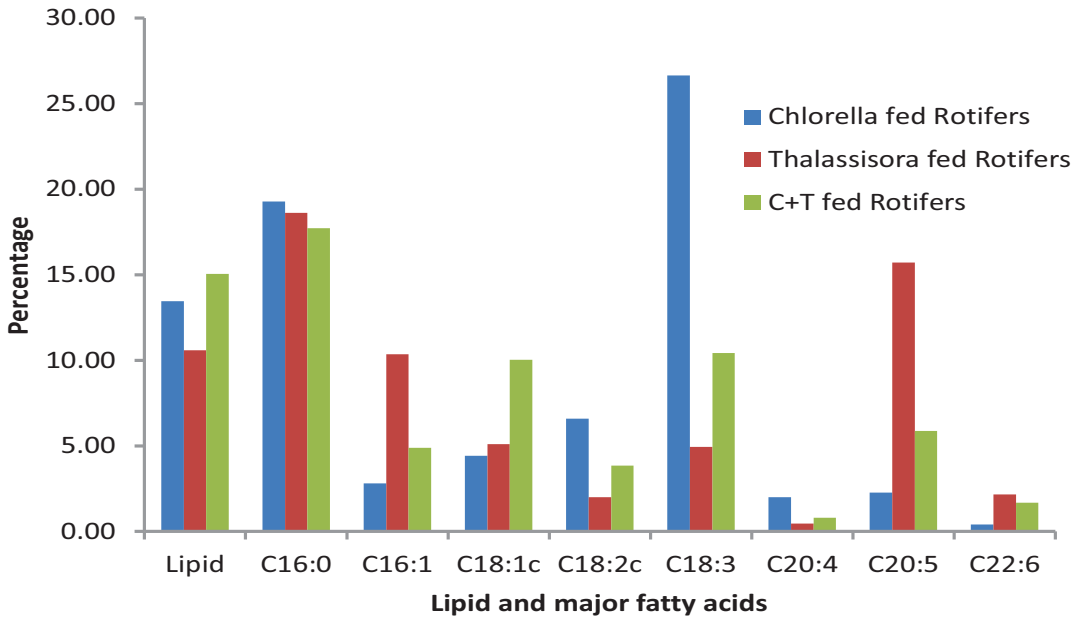


T1: Tetraselmis sp, T2: Chaetoceros sp, T3: Thalassiosira sp, T4: Thalassiosira: Chaetoceros (1:1), T5: Chaetoceros : Tetraselmis (1:1), T6: Thalassiosira: Tetraselmis

Effect of different microalgae on shrimp larval survival

Fatty acid profile of rotifer fed different micro algae

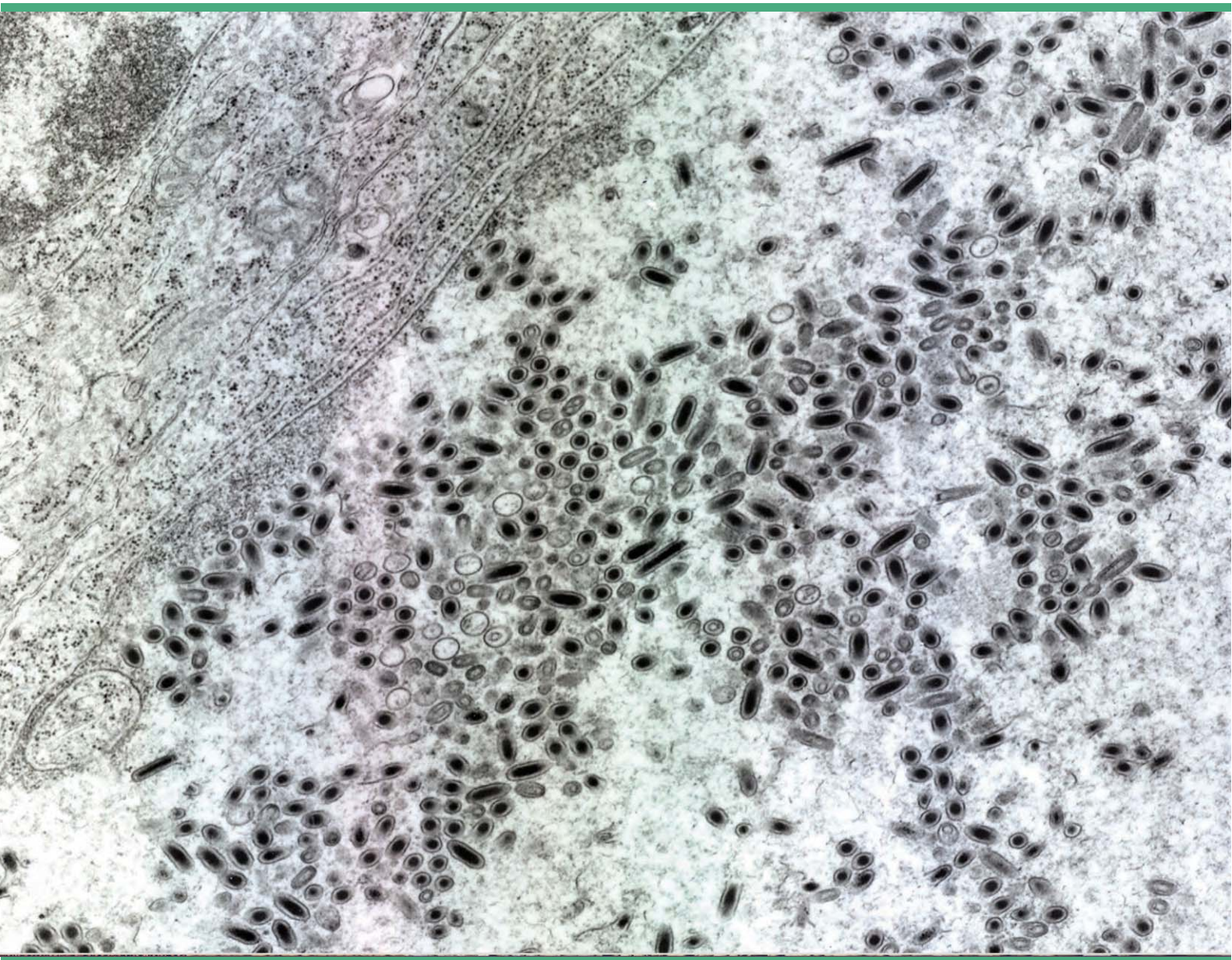
Micro algae are primary producers of the PUFA and HUFA in the aquatic food chain. In order to increase the survival and better performance of mud crab larvae, the larvae were fed with rotifers which were fed on three different microalgae. The rotifers were fed with *Chlorella, Thalassiosira* and both *Chlorella + Thalassiosira* in combination. The nutrient profiling of these rotifers has indicated that the highest lipid in rotifers which were fed on *Chlorella +Thalassiosira* together. The better performance of crab larvae when fed rotifers which were fed on *Chlorella + Thalassiosira* in combination might be due to the better balancing of the fatty acid profiles.



Fatty acid profiles of rotifers fed with different micro algae

AQUATIC ANIMAL HEALTH

Prevention and control of disease in aquaculture is paramount in success of aquaculture. CIBA focuses on various issues of aquatic animal health management



Transmission electron microscopy image of White spot syndrome virus

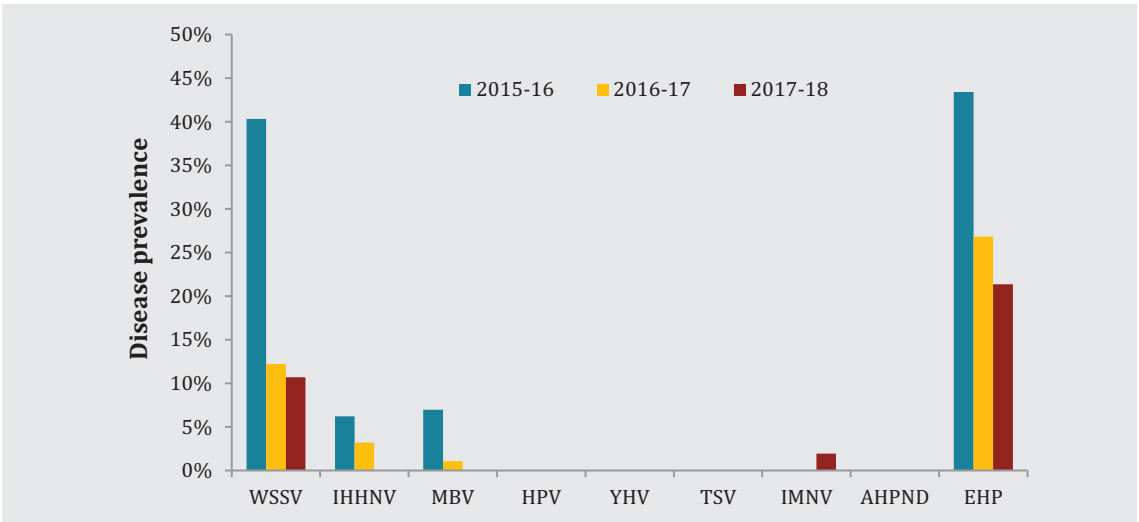
Aquatic Animal Health

Outbreaks of White spot syndrome declining over the past three years

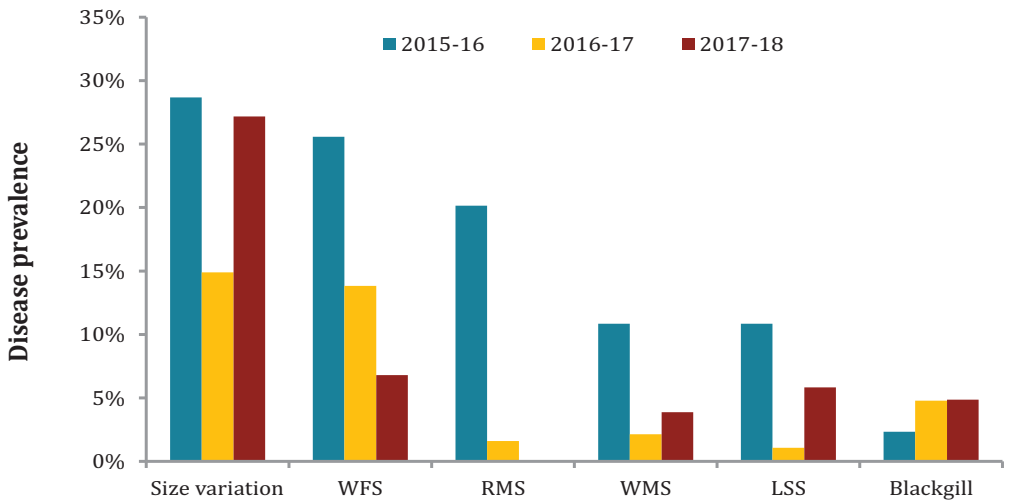
Diseases are the biggest threat to shrimp aquaculture growth and sustainability. As part of the on-going active shrimp disease surveillance programme since the year 2014, a total of over 420 shrimp farms were screened for OIE listed pathogens in three maritime states viz., Tamil Nadu, Andhra Pradesh, and West Bengal. Over a period of three years, the disease prevalence has been showing decreasing trends. The hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP) had the highest prevalence rate of 43% during 2015. However, the prevalence has come down to 21% during the last year. The prevalence of the most dreaded white spot syndrome (WSD), caused by white spot syndrome virus (WSSV) was 40% during 2015 and has declined in the previous year to 11%. The prevalence of infectious hypodermal and hematopoietic necrosis (IHHN) disease also show a declining trend from 6 to 3%, over the last three years.

The other disease syndromes, attributable to poor farm management such as stunted growth, white feces syndrome (WFS), loose shell syndrome (LSS) and black gill were observed in 27, 7, 4, 6% and 5% of the farms, respectively during 2017-18, out of 120 farms investigated.

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 necrotizing hepatopancreatitis (NHP). However, during February- March 2017, infectious myonecrosis (IMN) was detected in two *P. vannamei* farms in East Godavari, Andhra Pradesh and at Nagapattinam, Tamilnadu.



Prevalence of viral, bacterial and fungal diseases of shrimp in AP, TN and WB during 2015 – 18 (n=420 farms)



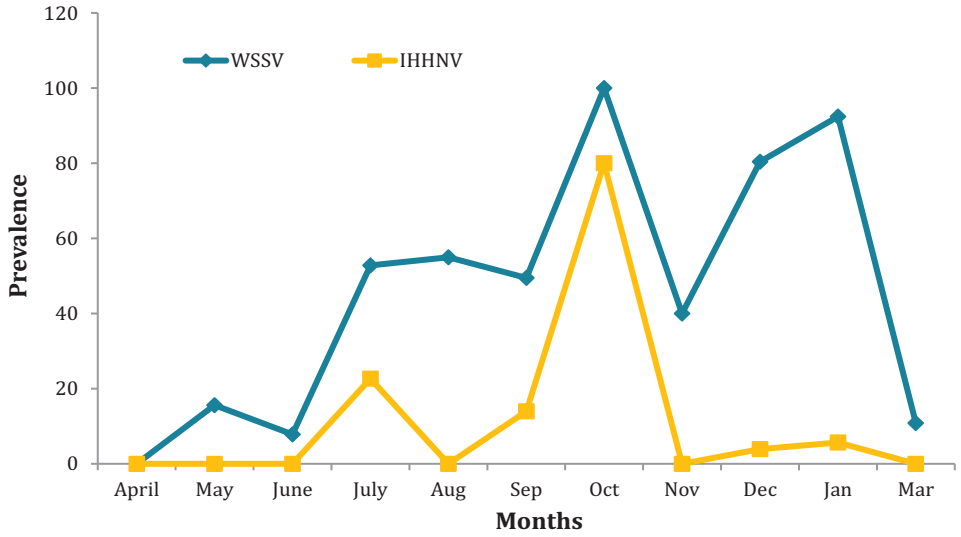
Prevalence of disease syndromes of shrimp in AP, TN and WB during 2015-18 (n=420 farms)

Prevalence of WSSV in Indian shrimp broodstock

A successful breeding program depends upon the supply and maintenance of healthy, disease-free brooders. A round the year surveillance of 661 brooders of Indian shrimp species (*P. indicus, P. monodon,* and *P. japonicus)* was carried out for major shrimp pathogens such as WSSV and IHHNV. *P. indicus* brooders sourced from three locations in Tamil Nadu (Muthukadu, Kalpakkam, and Nainarkuppam), Orissa (Puri) and Kerala (Kollam) indicated that the prevalence of WSSV was significantly high (38.4%). The WSSV prevalence was 37% in *P. japonicus* and 31% in *P. monodon*. The IHHNV prevalence was mostly associated with WSSV and found to be more in *P. monodon* (25.4%) compared to *P. japonicus* (6.7%) and *P. indicus* (6.0%). The incidence of WSSV was minimal during March to June (0-16%), started increasing from July (52.8%) and reached a peak in October (100%). The data indicate that summer and pre-monsoon season (March to June), is an ideal period for collection of wild brooders of *P. indicus* for seed production.

Prevalence of WSSV and IHHNV in brooders of major Indian shrimp species (*P. indicus, P. monodon* and *P. japonicus*)

Species	No. of samples screened	WSSV		WSSV	IHHNV	WSSV + IHHNV	IHHNV
		I step	II step	alone	total		alone
P. monodon	51	7	16	6	13	10	3
P. indicus	565	47	217	183	34	32	2
P. japonicus	45	4	17	14	3	3	0
Total	661	58	250	203	50	45	5

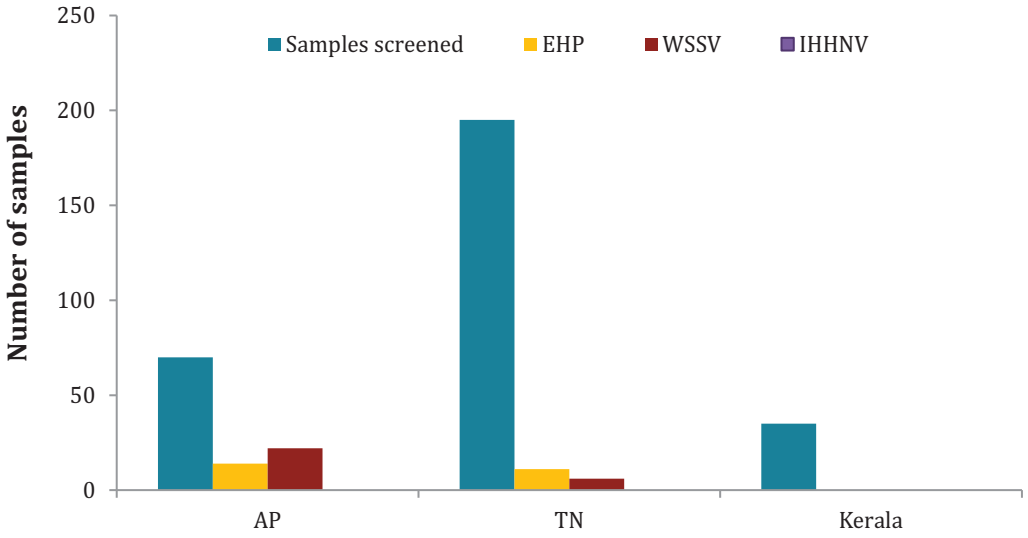


Prevalence of WSSV and IHHNV in *Penaeus indicus*

Polychaete worms (*Marphysia* sp.) as carrier of shrimp pathogens

Polychaete worms were examined as agents of pathogen transmission in aquaculture. Small, medium and large sized polychaete (*Marphysia* sp.) worms of 4 - 45 cm length from Tamil Nadu (TN), Andhra Pradesh (AP) and Kerala were screened for important shrimp pathogens *viz*., WSSV, IHHNV, and EHP by PCR. Polychaete samples from shrimp farming areas of AP and TN revealed a high prevalence of WSSV (34.2%) and EHP (21%). Moreover, 14.6% of polychaetes carried both WSSV and EHP infection. While in the no-shrimp farming area of AP and TN, a very low incidence of EHP (3.2%) was recorded. Overall, 72% of the PCR positive polychaete sample showed infection detectable only by nested PCR and hence unlikely to be a natural host for EHP. However, it is certain that the wild polychaete worms serve as carriers of shrimp pathogens and should be screened while using them as maturation diet for shrimp broodstock.

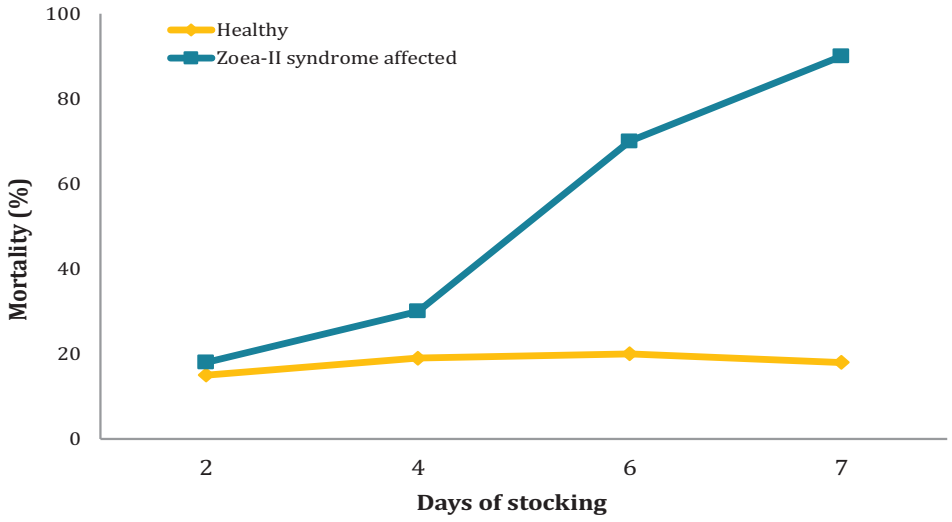
Polychete worm collected from wild sources found positive for WSSV and EHP



Occurrence of EHP, WSSV and IHHNV in wild Polychaetes worms

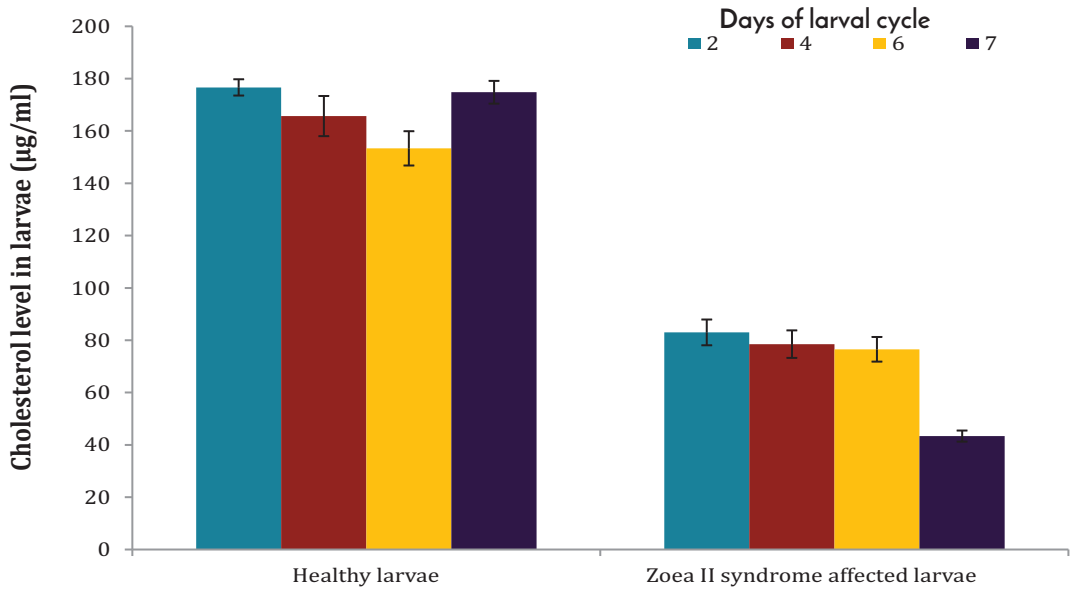
Zoea II syndrome associated with the cycle of larval stocking and reduced cholesterol level in *P. vannamei*

Zoea II syndrome has emerged as a serious threat to Indian shrimp hatcheries, especially after the introduction of *P. vannamei*. It causes delayed molting or impairment of metamorphosis into larval stages followed by mass mortality at the zoea II stage. Our study revealed that zoea II syndrome was always associated after 3-4 days of stocking in the same larval rearing units while the other previous batches of the same hatchery did not have any incidences of zoea II syndrome. The cumulative mortality rate in the affected larval batches was up to 90% compared to 20% in healthy larval batches. The gut of the affected larvae was empty with impaired peristaltic movement and no fecal strands. The



Mortality in normal and zoea II syndrome affected larvae

microscopic examination revealed inflammation, necrosis and whitish ball-like structure in the intestinal lumen. Histological examination showed detachment of hepatopancreatic tubular epithelial cells. The intestinal epithelium showed vacuolization, disintegration of peritrophic membrane with sloughing of epithelial cells from the basement membrane. The biochemical profiling suggested that total lipids and triglycerides decreased over the larval cycles in both healthy and zoea II syndrome affected larval batches. In contrast, the cholesterol level was significantly lower in the affected larval batches compared to healthy larvae. Cholesterol is the precursor of the molting hormone, and hence, its lower level indicates the possibility of delayed molting. Mortality of zoea in affected larval tanks was more than 80% by the 7th day of stocking. Denaturing gradient gel electrophoresis (DGGE) of normal zoea, affected zoea and larval samples from 2nd day, 6th day and 7th day of affected larval batch revealed association of an uncultured bacteria of *Flavobacterium* (*Nonlabens* sp) with zoea-2 syndrome.



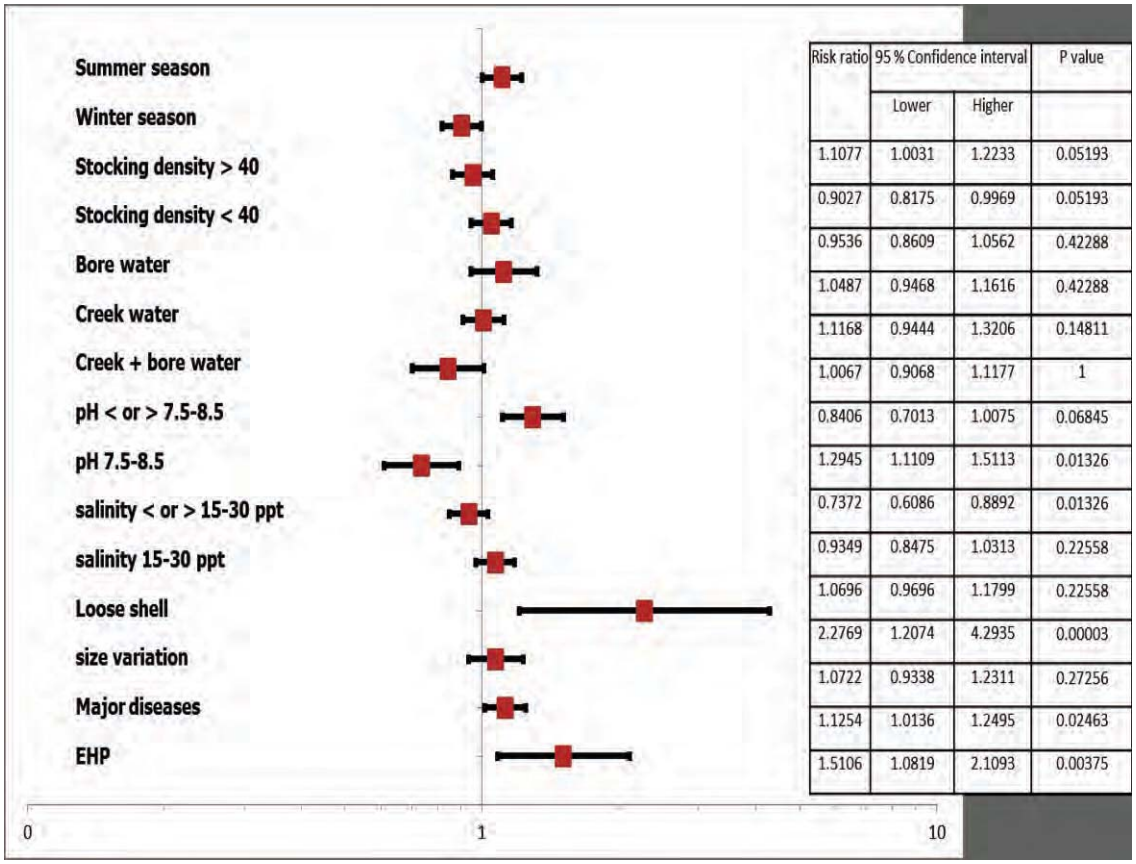
Cholesterol level in healthy and zoea II affected larvae of *P. vannamei*

Bacteria associated with normal and zoea syndrome revealed by DGGE

Days of Stocking	Identified bacterial species
Zoea normal	*Rhodobacterium, V. alginolyticus*
Second day	*Roseavarius* sp (*Rhodobacterium*), Alpha proteobacterium (Proteobacter), Rhodobacteracea , *V. proteolyticus*
Sixth day	Shimia sp (*Roseobacter*), Nonlabens sp (*Flavobacterium*), *Rhodobacterium* , *V. alginolyticus* , *V. proteolyticus*
Seventh day	Nonlabens sp (*Flavobacterium*), Rhodobacteracea
Zoea Affected	Nonlabens sp (*Flavobacterium*)

White feces syndrome showed a strong epidemiological association with EHP and loose shell

White feces syndrome (WFS), chronic/running mortality syndrome (CMS/RMS), and white muscle syndrome (WMS) have been prevalent in vannamei farms since 2011. The WFS alone is responsible for up to 20-30% reduction in production of farmed shrimp. Out of 317 farms investigated during 2015 – 17, 17% of the farms were affected with white feces syndrome. Among the WFS affected farms, 30% of the cases were positive for EHP, 20% had size variation, 16% showed symptoms of white muscle, another 20% had loose shells and 16% cases were affected with WSSV. Bacteriological studies indicated the presence of *V. proteolyticus*, *V. corallayticus* and *V. alginolyticus* in a few of the affected farms. The pH range of 7.5-8.5 was found optimal for maintaining a healthy pond. The pH beyond 7.5-8.5 significantly associated with white feces syndrome. Interestingly, 100% epidemiological association between the incidences of EHP and loose shell were associated with WFS. All other risk factors such as season, stocking density, the source of water, salinity were not significantly associated with WFS.



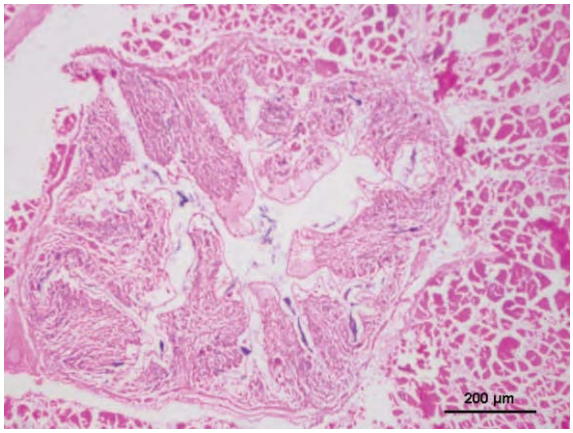
Risk ratio	95 % Confidence interval		P value
	Lower	Higher	
1.1077	1.0031	1.2233	0.05193
0.9027	0.8175	0.9969	0.05193
0.9536	0.8609	1.0562	0.42288
1.0487	0.9468	1.1616	0.42288
1.1168	0.9444	1.3206	0.14811
1.0067	0.9068	1.1177	1
0.8406	0.7013	1.0075	0.06845
1.2945	1.1109	1.5113	0.01326
0.7372	0.6086	0.8892	0.01326
0.9349	0.8475	1.0313	0.22558
1.0696	0.9696	1.1799	0.22558
2.2769	1.2074	4.2935	0.00003
1.0722	0.9338	1.2311	0.27256
1.1254	1.0136	1.2495	0.02463
1.5106	1.0819	2.1093	0.00375

Association of white fecal syndrome with loose shell syndrome and EHP in famed *P. vannamei*

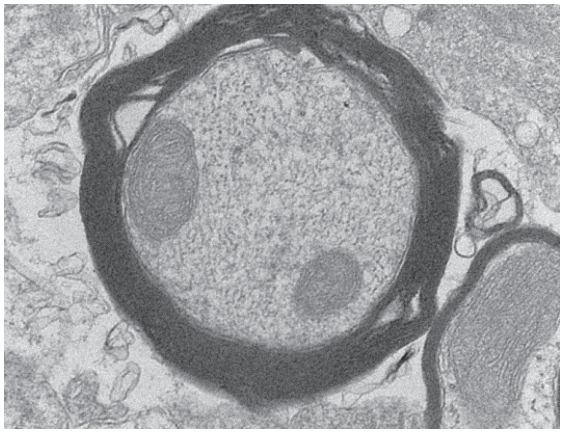
Infectious Myonecrosis Virus (IMNV) is an emerging threat to Indian shrimp aquaculture

Infectious Myonecrosis Virus (IMNV) till recently was restricted to Brazil in South America and Indonesia in Asia. CIBA disease surveillance study revealed the presence of Infectious Myonecrosis Virus (IMNV) in 2017 at two shrimp farms (DOC: 60), one each from AP and TN. The affected *P. vannamei* (~16 ±2 g at 70-120 DOC) appeared dark red with extensive white necrosis in the distal abdominal muscle. A 70 - 90% mortalities and emergency harvest reported from the affected farm. The bioassay study was carried out to reproduce the disease in *P. vannamei* (n: 30; ABW: 15±2 g) using IMNV infected muscle of shrimp collected from AP outbreak. The challenged *P. vannamei* developed typical whitish necrotic lesions in abdominal segments. Challenge trials by intramuscular injection of healthy shrimp with viral preparation and co-habitation of healthy shrimp with infected animals, produced 80% and 70% mortalities respectively. Histopathologically coagulative necrosis of skeletal muscle with hemocytic infiltration, fibrosis, and vacuolation of muscle tissue observed in IMNV challenged *P. vannamei* shrimp. The TEM analysis further revealed ultrastructural changes such as fibrosis and vacuolation in the muscle of experimentally challenged shrimp.

P. vannamei showing white necrotic lesion after experimental challenge with IMNV



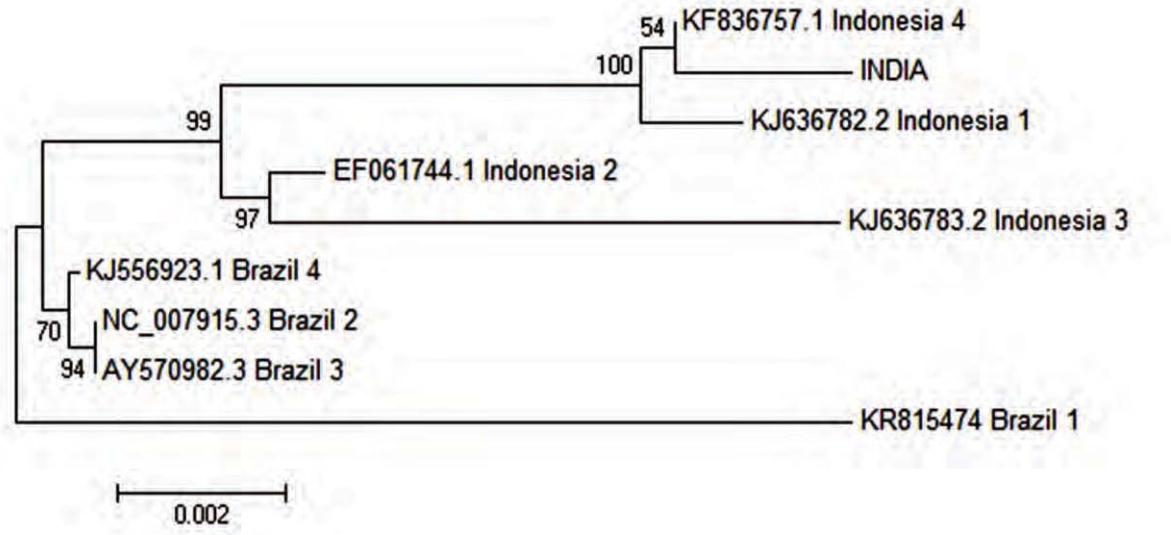
Fibrosis of skeletal muscle due to IMNV in experimentally challenged *P. vannamei*



Fibrosis and vacuolation of skeletal muscle in IMNV challenged *P. vannamei* revealed by TEM

Whole genome sequencing of Infectious myonecrosis virus (IMNV) showed the highest similarity to Indonesian strain

IMNV genome was sequenced using eight sets of primers from the conserved region, covering the entire genome. A total of 8266 bp was sequenced. The Indian isolate showed maximum identity with Indonesian IMNV strain KF836757.1. The phylogenetic analysis clustered the Indian isolate with four Indonesian strains whereas the four Brazil strain formed a separate cluster. The study signifies that recently emerged Infectious myonecrosis virus in India probably entered through Indonesia.

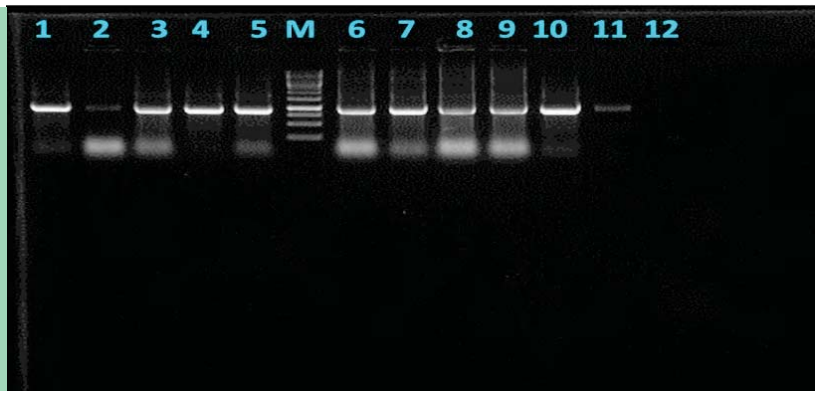


Report of Tilapia Lake Virus (TiLV) infection in GIFT Tilapia from brackishwater farming regions of Andhra Pradesh and Tamil Nadu, India

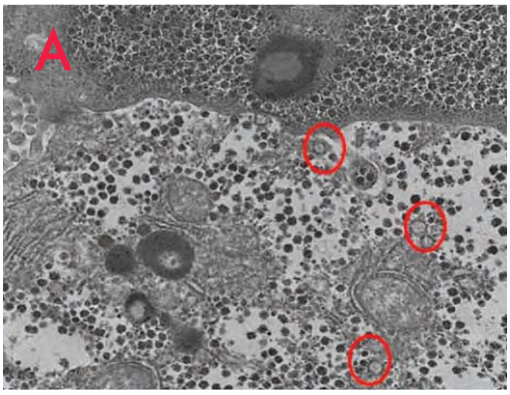
Tilapia Lake Virus (TiLV) is an orthomyxovirus characterized with segmented RNA genome. It was the first time reported in 2014 from Israel. The GIFT tilapia with a history of mortality, skin erosion, ulcers, lesion in the eye, the opacity of the lens, hemorrhages on the body and caudal fins collected from Vijayanagaram district, Andhra Pradesh and Kolavai Lake, Chengalpet, Tamilnadu. The affected fishes also had multifocal areas of necrosis with syncytia and hemorrhages in liver, brain, spleen, and

Sunken eyes with deep ulcers in moribund tilapia infected with TiLV

heart. These samples were found negative for viral nervous necrosis (VNN) and Iridovirus infection: the two most commonly reported viral infections from brackishwater and marine fishes in India. Further investigation found the presence of emerging Tilapia Lake Virus (TiLV) by semi-nested RT-PCR. The transmission electron microscopy (TEM) of affected liver showed icosahedral particles of 60–100 nm diameter, with a central electron-dense core and several electron-dense projections of 10–15 nm width at regular intervals. Histological examination of the liver of TiLV infected fish revealed haemorrhages and loss of architecture of hepatocytes. The TiLV was adapted in primary tilapia brain cell culture. The cytopathic effect (CPE) was observed in confluent monolayers after infection with liver or brain tissue homogenate of affected tilapia. The disease was re-established in tilapia by bioassay experiments with 86.67% and 66.67% cumulative mortality by intraperitoneal injection of primary culture supernatants and cohabitation study respectively. The study confirms the presence of tilapia lake virus in India which has the potential to cause a high level of mortality.



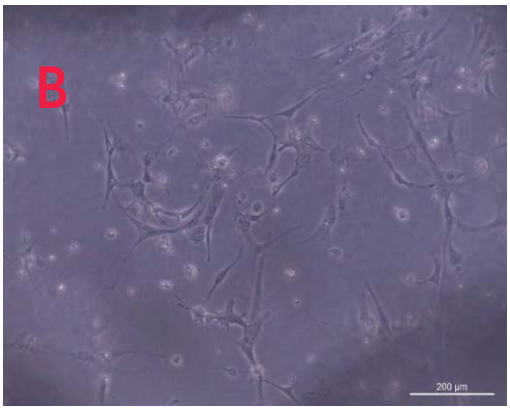
Screening of fish samples for TiLV. Lane M: 100bp marker. Lanes 1-5: Liver samples, Lane 7-11: Brain samples, Lane 12: Negative control.

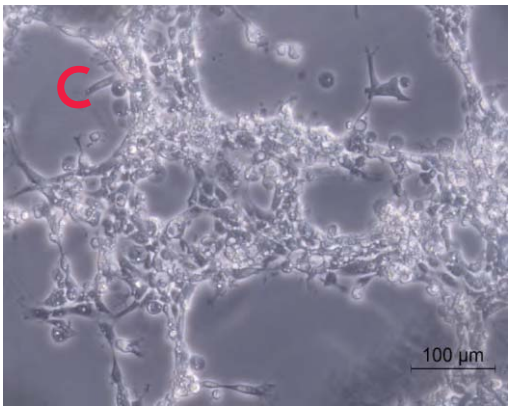


A Tilapia lake virus in liver of infected fish observed by transmission electron

B Primary tilapia brain culture

C Syncytia formation in tilapia brain culture by TiLV

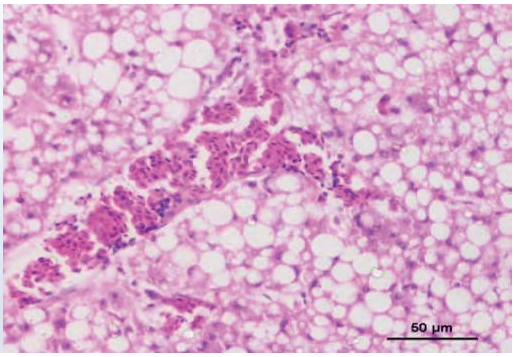




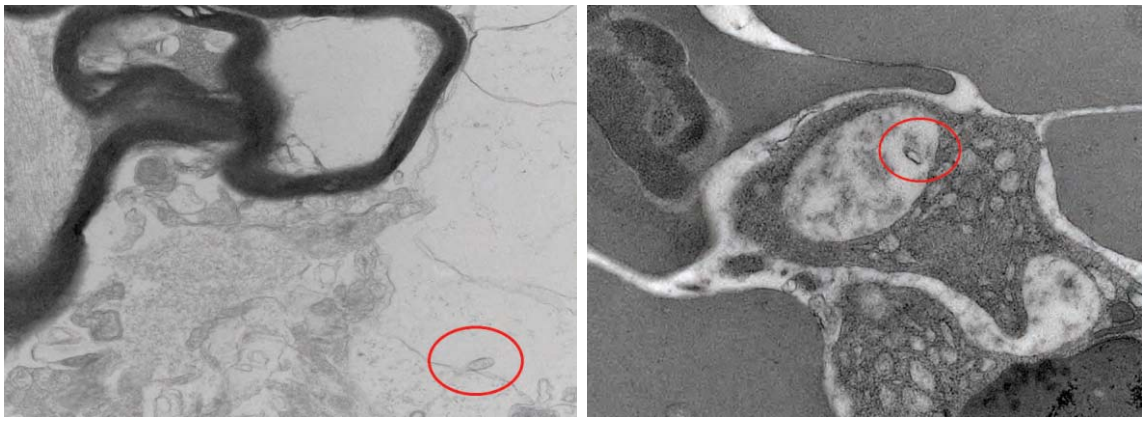
Virus-like particles detected in pearlspot associated with mortalities

Mortalities of Pearlspot brooders (100±5 g) maintained at the Institute's Muthukadu experimental station exhibiting hemorrhages was investigated. The affected pearlspot brooders showed hepatomegaly, splenomegaly and empty guts. Histological examination showed vacuolation and hemorrhages in liver, gills, spleen, and heart of affected fish. The transmission electron microscopy (TEM) analysis of affected spleen and brain showed the presence of putative virus-like particles of ~200nm.

Haemorrhages on the skin of diseased Pearlspot



Haemorrhages and vacuolation in liver of infected Pearlspot (H&E 40 X)



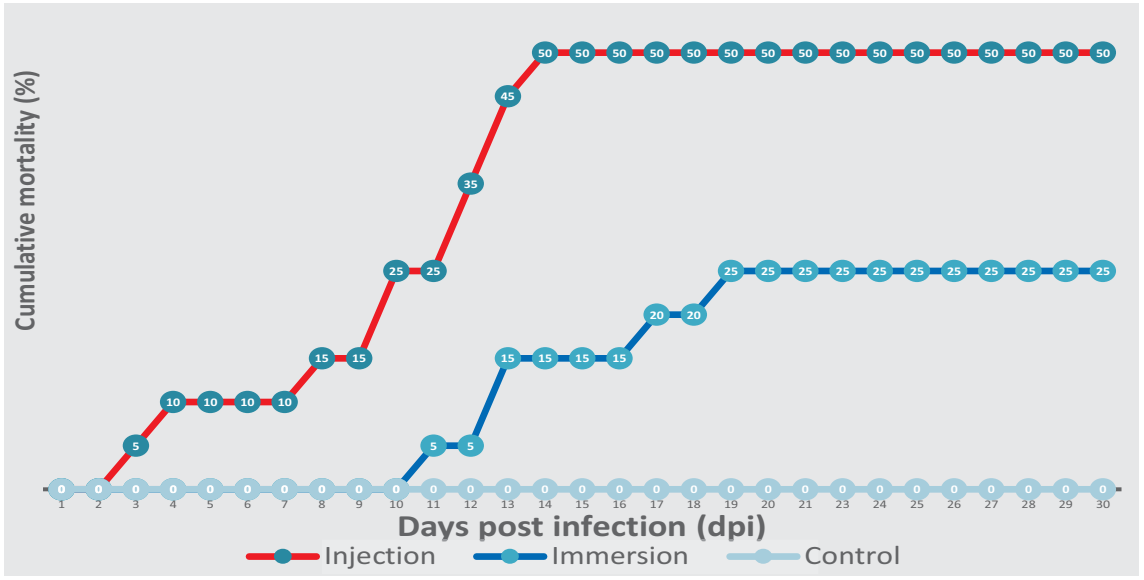
Electron micrograph showing putative virus likes particles (bullet shaped) in brain and spleen of infected Pearlspot

Orange chromide, *Etroplus maculatus* as model fish for experimental infection of *Betanodavirus*

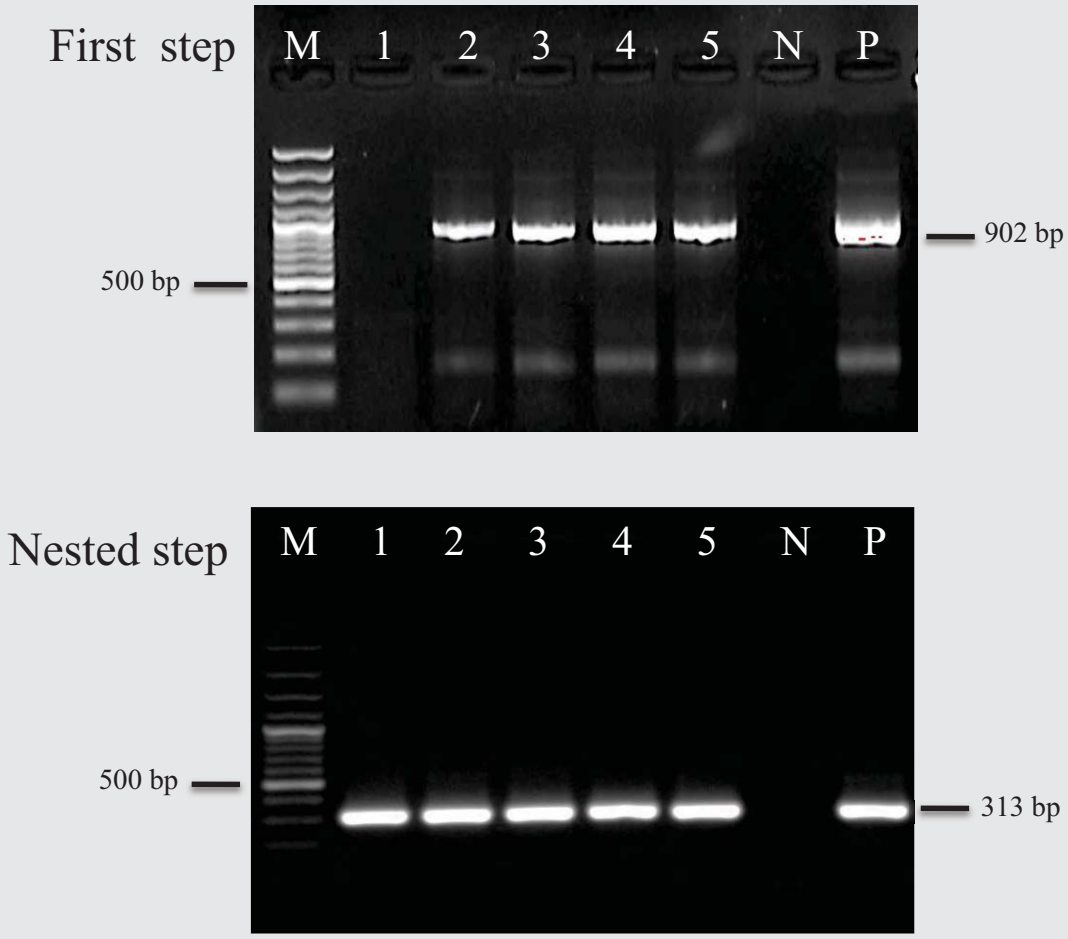
Viral nervous necrosis (VNN) is an acute viral disease of fish causing high mortalities in larval and early juvenile stages. For developing therapeutics and vaccines, a model fish highly susceptible to nervous necrosis virus (NNV) is desired. Hence, a brackishwater cichilid, orange chromide (*Etroplus maculatus*) was examined as a model fish for VNN infection. The susceptibility of *E. maculatus* to NNV was tested by two different modes of challenge using RGNNV strain of NNV. The fingerlings of *E. maculatus* (n=60) were equally divided into three groups; Group 1 (immersed in seawater containing 10^5 viral particles ml^{-1} for one hour); Group 2 (i/m injected with 10 µl of 10^5 viral particles ml^{-1}); Group 3

(control fish without the viral inoculum). All the experimentally infected fish were positive for NNV, amplifying 903 bp PCR product. Morbidity and mortality rate was significantly higher by injection route compared to immersion. This resembled natural infection in juvenile of marine fishes. Mortality started in the injected group by three dpi and almost 50% mortality recorded by 15 dpi. The affected fishes exhibited corkscrew movement before succumbing to death. These fishes showed severe neurological disorders accompanied by extensive vacuolar degeneration and mild to moderate neuronal necrosis of the brain. However, most of the larger fishes in the group survived without showing any signs. *E. maculatus* inhabits both fresh and brackish water systems. Hence this fish species can be used as a model to study the age-related resistance to NNV and to develop potential NNV vaccine.

Infected orange chromide showing reddish discoloration in dorsal fins after infection



Cumulative mortality in experimentally infected *E. maculatus* by different mode of transmission

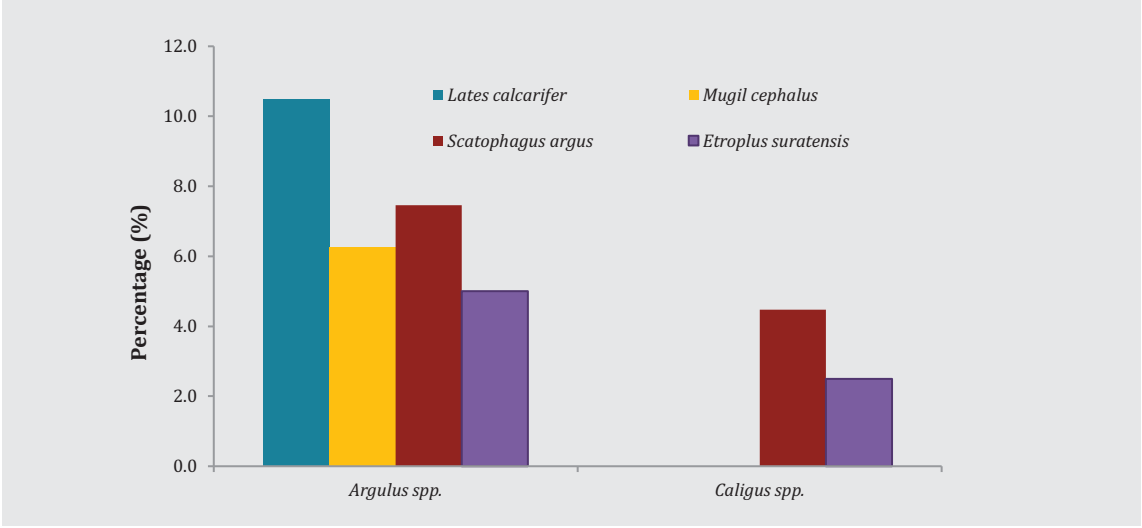


M- Marker (100 bp), Lane 1-1 dpi, Lane 2- 7 dpi, Lane 3- 14 dpi, Lane 4- 21 dpi, Lane 5- 30 dpi, N- Negative control, P- Positive control.

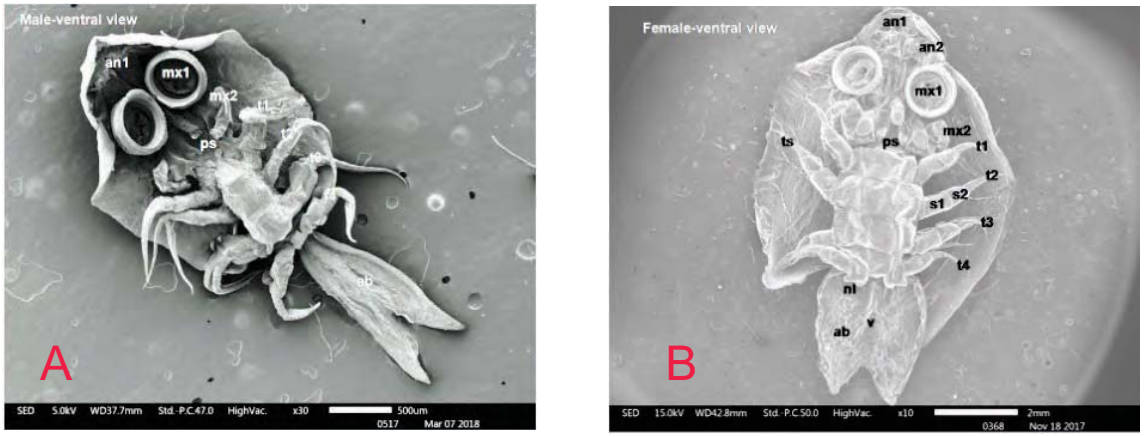
Confirmation of NNV infection by RT-PCR in fish orange chromide

Fish lice *Argulus* is the predominant parasite infesting seabass

Intensification in aquaculture parallels with an increase in disease outbreaks. Parasitic infestations are one of the major issues in finfish aquaculture. Studying the prevalence of such infection will help in formulating the control measures against parasitic diseases. Profiling of parasites was carried out in 588 fishes of five candidate species including *Lates calcarifer* (352 no.), *Mugil cephalus* (112 no.), *Chanos chanos* (17 no.), *Scatophagus argus* (67 no.) and *Etroplus suratensis* (40 no.). These fishes were collected mainly from Muthukadu experimental station (MES). *Argulus* and *Caligus* were found to infect the majority of the brackishwater finfishes. The percentage of *Argulus* spp. infection in *L. calcarifer*, *M. cephalus*, *S. argus* and *E. suratensis* were 10.5, 6.3, 7.5 and 5.0%, respectively. *Caligus* spp. infection was found only in *S. argus* (4.5%) and *E. suratensis* (2.5%). Interestingly, no parasitic infection was recorded in milk fish, *C. chanos*. The fish lice, *Argulus* spp. infection was most predominantly observed in *L. calcarifer* broodstock. The parasite was identified as *A. quadristriatus*, based on the morphological characterization by transmission electron microscopy and molecular characterization targeting cytochrome oxidase I and hemocyanin genes.



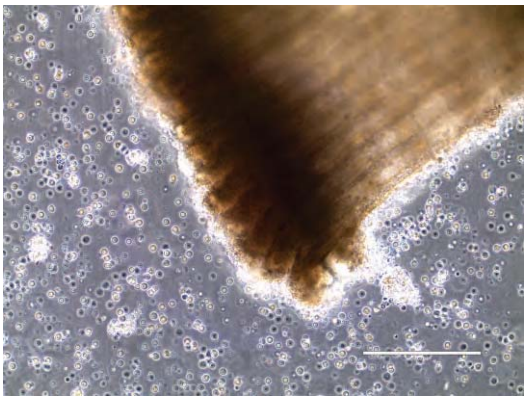
Prevalence of parasitic infections in brackishwater finfishes



Electron micrograph of *Argulus* (A) Male (B) Female

Explant culture from gill and heart of Green mussel, *Perna viridis*

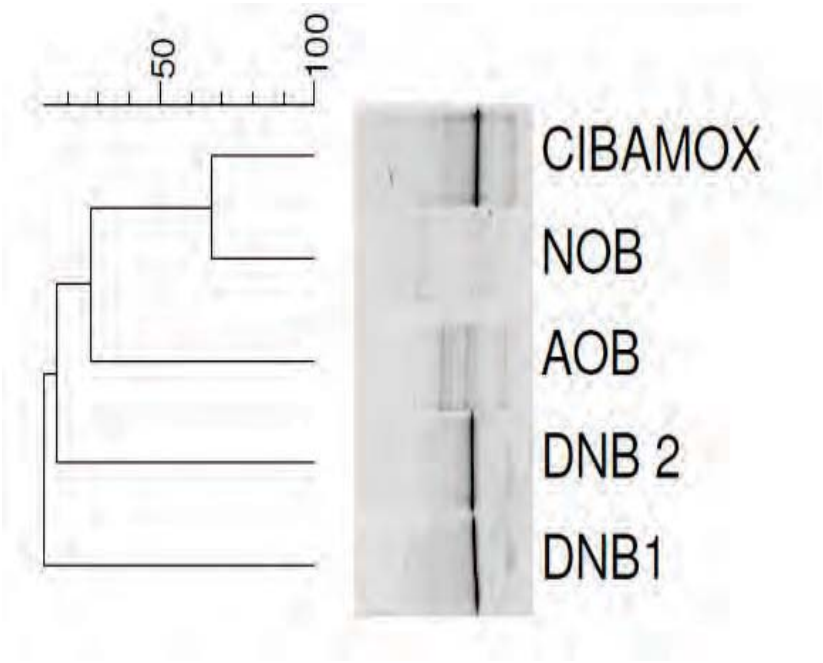
The explant culture from gill and heart of Asian Green mussel, *Perna viridis* was carried out in L15 medium augmented with salt and incubated at 26 to 28 C. Explant cultures of both organs showed the migration of epithelial cells at 24 h. The gill epithelial cells had both ciliated and non-ciliated cells and measured 11.54±1.94 µm and 15.30±5.84 µm at 24 and 48 h, respectively. The heart epithelial cells were somewhat smaller and measured 8.68±2.58 µm and 11.61±4.31 µm after 24 h and 48 h. Eight passages of these epithelial cells were successfully carried out. These explant cultures could be used for environmental toxicants study and shrimp virus propagation.



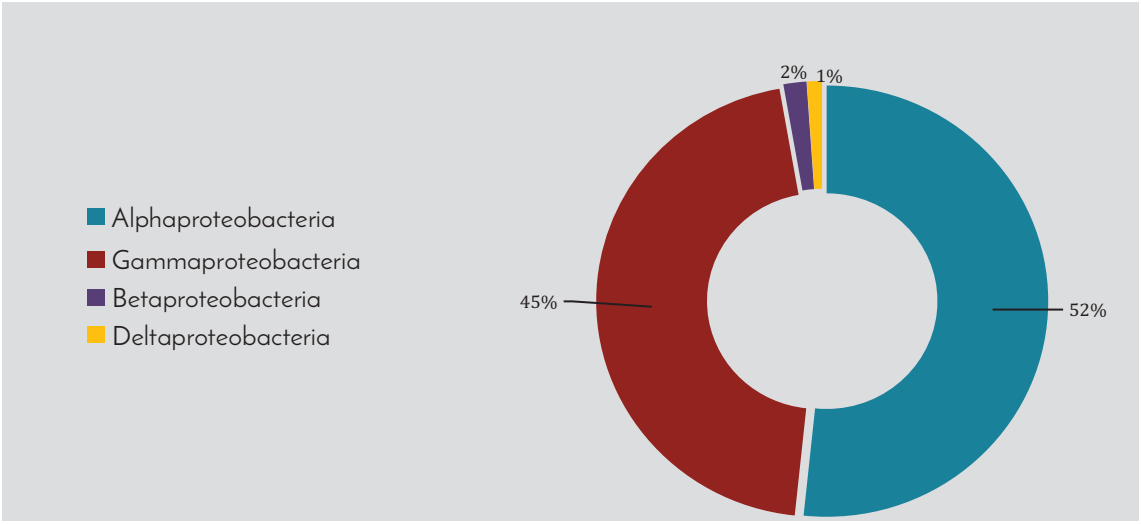
Gill explant culture of Green mussel, *Perna viridis*

Microbial profiling of nitrifying and denitrifying bacterial product 'CIBAMOX'

CIBAMOX, a product of CIBA, containing enrichments of ammonia oxidising bacteria (AOB), nitrite oxidizing bacteria (NOB) and denitrifying bacteria (DNB) was analyzed for the associated microbial composition by PCR-DGGE. The product contained two DNB, eight AOB, and 11 NOB groups. Metagenomic analysis recovered 199 operational taxonomic units (OTUs) covering 21 phyla, consisting of proteobacteria (62%) which includes Alphaproteobacteria (32.4%), Gammaproteobacteria (28.6%), Betaproteobacteria (1.0%) and Deltaproteobacteria (0.7%). Patent for unique consortia and manufacturing methodology was filed (Patent No. 201841010230, Priority date March 20, 2018).



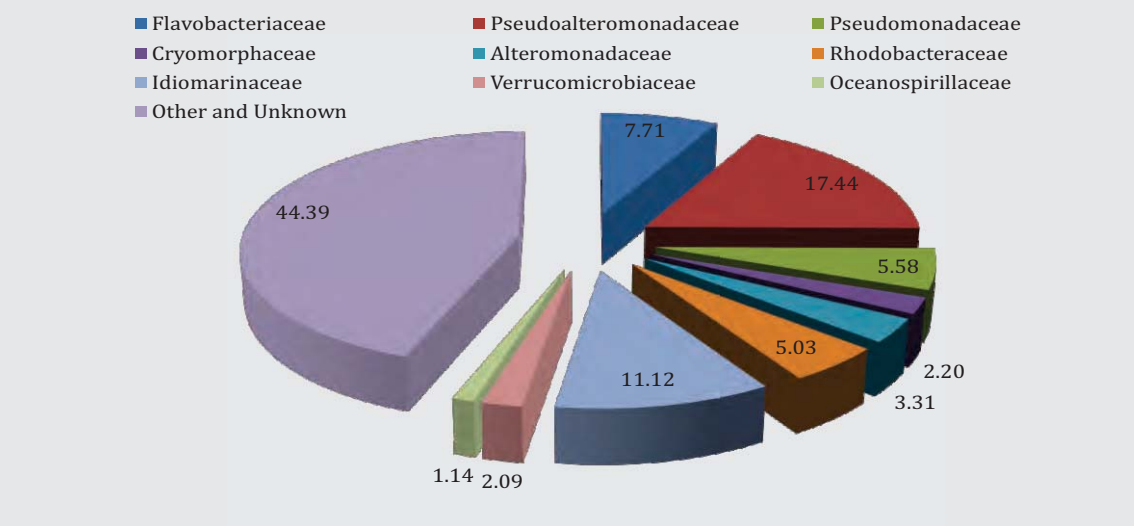
PCR-DGGE analysis of AOB, NOB, DNB and CIBAMOX



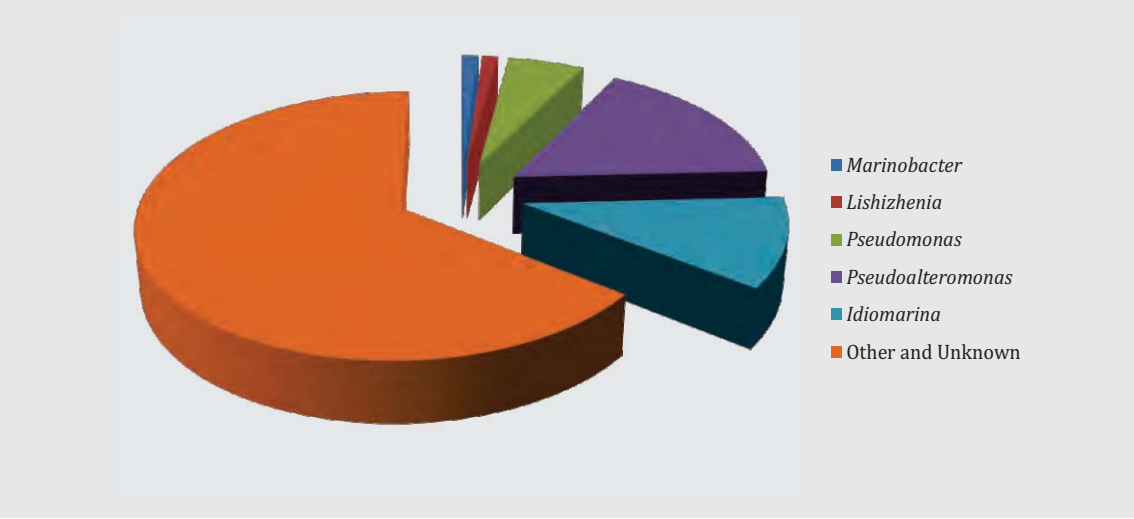
Microbial composition of CIBAMOX

Metagenomic analysis of EHP and white fecal syndrome (WFS) affected shrimp pond

Enterocytozoon hepatopenaei (EHP) infection and white fecal syndrome (WFS) are the emerging threats in shrimp culture. For understanding the disease process, microbial profiling through metagenomic approach was carried out in a shrimp culture pond affected with EHP and WFS syndrome at Bhadrak, Odisha. The high throughput DNA sequencing at Illumina Miseq platform was carried out using V3-V4 regions of 16S rRNA gene. The dominant bacterial families found in the water sample were Pseudoalteromonadaceae (17.44%), Idiomarinaceae (11.12%), Flavobacteriaceae (7.71%), Pseudomonadaceae (5.58%), Rhodobacteriaceae (5.03%), Alteromonadaceae (3.31%), Cryomorphaceae (2.20%), Verrucomicrobiaceae (2.09%) and Oceanospirillaceae (1.14%). Among dominant bacterial genus, the presence of *Pseudoalteromonas* (16.54%), *Idiomarina* (10.99%), *Pseudomonas* (5.45%), *Marinobacter* (1.17%) and *Lishizhenia* (1.09%) were prominent. Only 0.12% of the total OTUs belong to *Vibrio* spp.



Family-wise microbial diversity in EHP and WFS affected shrimp pond



Microbial genera associated with EHP and WFS affected shrimp pond

EHP affected shrimp showed higher microbial diversity in hepatopancreas

The culture-dependent and culture-independent bacteriological profiling of EHP infected shrimp hepatopancreas were carried out to assess the role of bacteria in EHP disease progression. A total of 22 hepatopancreas samples; 12 EHP infected and 10 uninfected were processed by culture-independent PCR- DGGE method. The EHP infected hepatopancreas showed increased microbial diversity compared to normal healthy hepatopancreas. Further, the microbial diversity in I-step positive EHP cases (n=5) were higher than II-step positive EHP cases (n=7). The higher bacterial count witnessed the progression of secondary bacterial infection with an increase in EHP infection of shrimp.

By culture-dependent method, 37 bacterial isolates from 18 EHP positive cases were characterized and further confirmed by 16S rRNA gene sequencing. The analysis revealed 58% prevalence of *Vibrio* species such as *V. alginolyticus, V. parahaemolyticus, V. azureus* and other vibrios followed by 42 % of miscellaneous bacteria such as *Shewanella sps, Staphylococcus epidermididis, S. sciuri, Rothia terrae* and unidentified bacterial sps. The pathogenicity of vibrios was tested using immersion based challenge trial and was found to be non-pathogenic to shrimp postlarvae. The study confirms the bacterial isolates from the hepatopancreas of EHP infected shrimp are of secondary pathogens gained entry due to disruption of hepatopancreatic tubules.

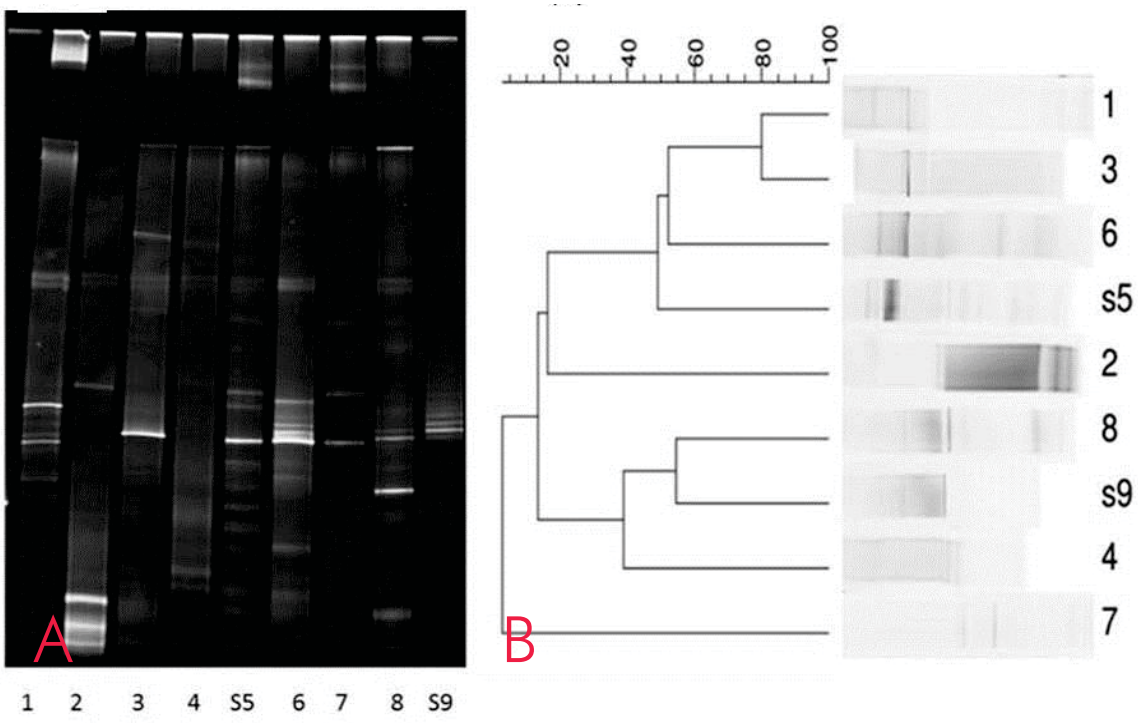
Microbial profiling in milkfish (*Chanos chanos*) larval rearing systems

Milkfish (*Chanos chanos*) is a herbivorous euryhaline fish known for its relative resistance to disease and infections. Through rigorous effort, ICAR-CIBA has succeeded in the breeding of milkfish. Understanding the normal microbiota is essential for devising the strategies for upscaling the seed production and promoting the health. Taking initiative in this direction, a study on microbiota associated with milkfish larvae and culture water was carried out by culture-dependent and culture-independent methods. Further, microbial association from the day of spawning to postweaning period was carried out to ascertain the beneficial nature and any relation to larval survival and productivity. The maximum heterotrophic and *Vibrio* population in the larval rearing system reached to 10^4 to 10^5 CFU/ml with no significant effect on survival. Gram-positive bacteria, especially, *B. polymyxa, B. brevis, and B. circulans* were predominantly present in rearing water and larvae. Among Vibrios, *Vibrio fischeri, V. coralliilyticus, V. superstes and V. hepatarius* were common in rearing water and fish larvae. However, presences of *V. mimicus* and *V. metschnikovii* were not established in fish larvae. The culture-independent analysis using density gradient gel electrophoresis (DGGE) suggested the maximum microbial diversity during the pre-weaning period. Further, microbiota of pre-weaning and post-weaning period clustered separately. The study indicates the feeding and spawning have a significant contribution to bacterial profiles of milkfish and gram-positive bacteria *Bacillus* were more prominent in rearing water and fish larvae.

Bacteria associated with milkfish larval rearing cycle

Bacteria	Rearing Water	Milkfish Larvae
Gram positive	*Bacillus polymyxa*	*Bacillus polymyxa*
	Bacillus brevis	*Bacillus brevis*
	Bacillus circulans	*Bacillus circulans*
	Vibrio fisheri	*Vibrio fisheri*
	Vibrio coralliilyticus, Vibrio superstes	*Vibrio coralliilyticus, Vibrio superstes*
	Vibrio hepatarius	*Vibrio hepatarius*
Gram negative	*Vibrio mimicus*	Not established
	Vibrio metschnikovii	Not established
	Not established	*V. mytilli*

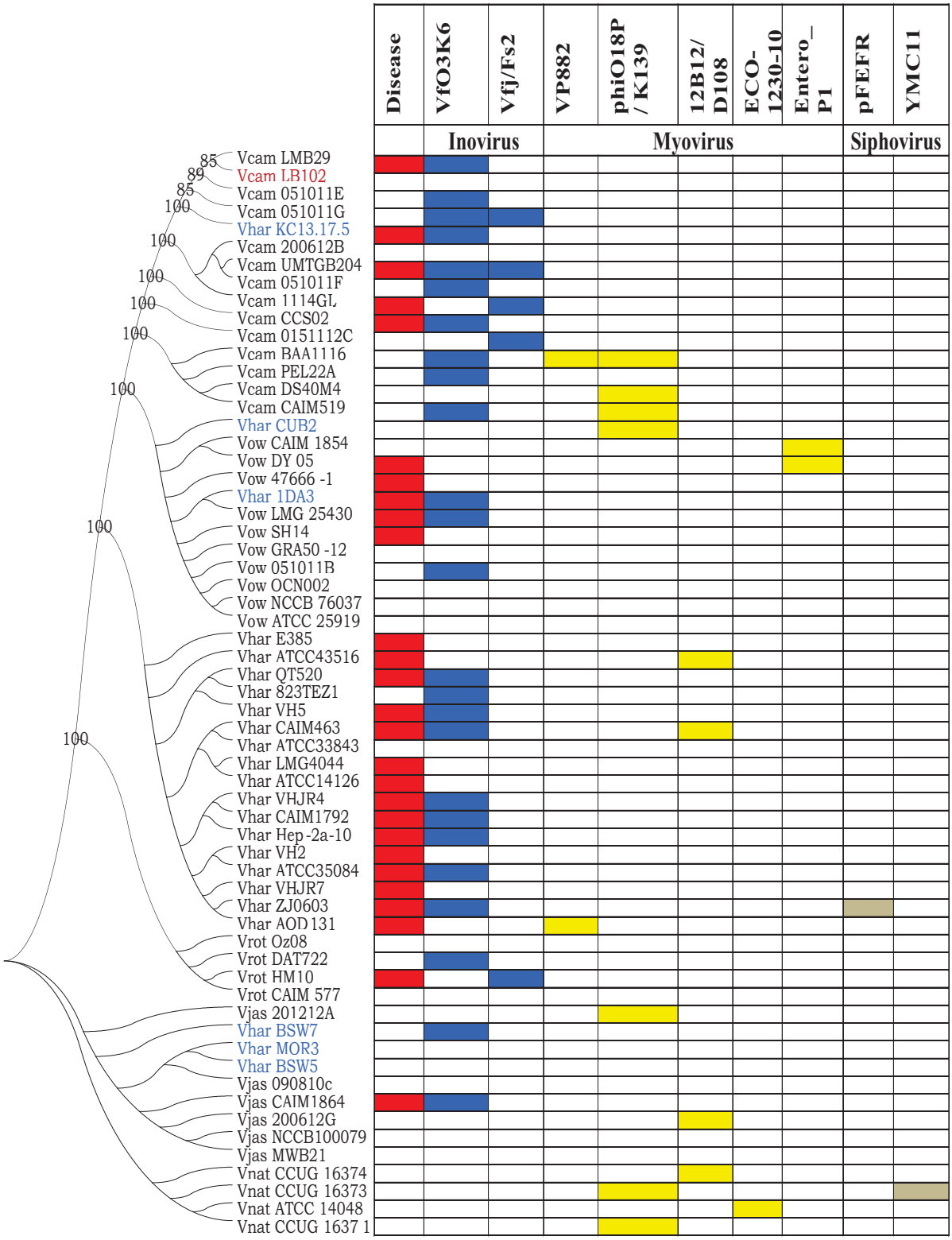
Hatchery produced milkfish early fry reared in tank based rearing system



Profiling of microbiota from milkfish larvae using DGGE PCR (A) and dendrogram analysis using UPGMA algorithm (B), Lane 1, 2, 3, and 6 were profiles of microbiota during pre-weaning period, 4, 7 and 8 were post-weaning, S5 and S9 were on the first day of spawning.

Wide distribution of lysogenic filamentous phages among Indian isolates of *Vibrio campbellii*

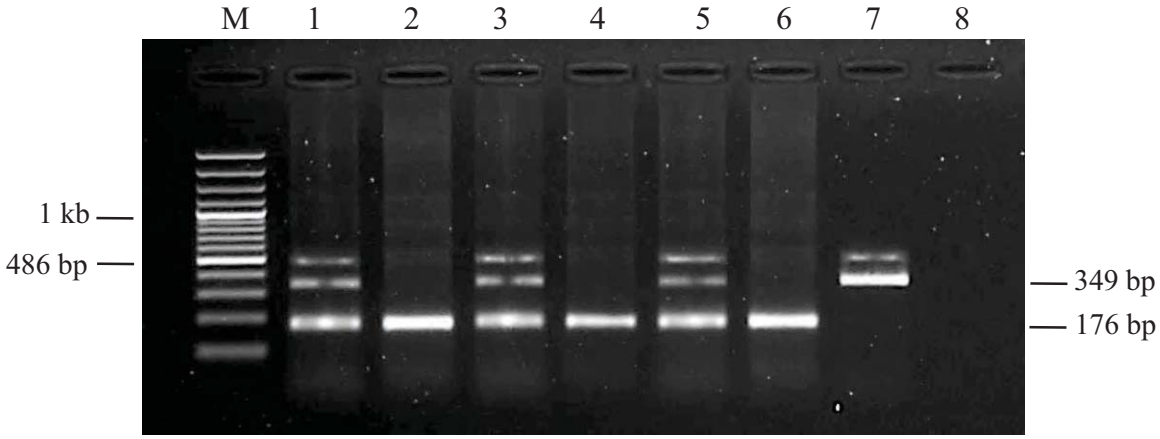
Lysogenic phages play a major role in virulence of many *Vibrio* species such as *V. cholerae* and pandemic strains of *V. parahaemolyticus*. For understanding the role of lysogenic phages in Harveyi clade species, 60 isolates within six Harveyi clades including *V. campbellii* and *V. harveyi* were examined using bioinformatic tools. The results indicated that an inovirus, a filamentous phage was present in as many as 29 isolates. Other phages such as myovirus were found in 15 isolates and siphovirus in two isolates. The PCR analysis revealed the presence of inovirus phages in 33% *V. campbellii* isolates maintained at CIBA. The role of these phages on the virulence of vibrios is under investigation.



Distribution of lysogenic phages in *harveyi* clade. The phylogeny of *harveyi* clade is based upon the consensus of 1710 core genes

A semi-nested PCR protocol for the detection of EHP in shrimp

Hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP) is an emerging microsporidian parasitic disease in *P. vannamei* and *P. monodon*. It is often associated with severe growth retardation and/or white feces syndrome resulting considerable economic loss to shrimp aquaculture. A number of diagnostic tools such as PCR, isothermal loop-mediated amplification (LAMP), real-time PCR and *in situ* hybridization have been described for the detection of EHP parasite in post larvae, shrimp hepatopancreas and feces. A new sensitive nested PCR method based on a gene encoding spore wall protein (SWP) of EHP spore was reported to be more than the other techniques. At CIBA, a new semi-nested PCR protocol targeting spore wall protein (SWP-PCR) gene of EHP in shrimp was developed. The PCR products of 486 bp (first step) and 349 bp (nested) were generated by an optimized amplification cycle. This kit includes β-actin house-keeping gene with the amplicon size of 176 bp to ensure the perfectness of the nucleic acid extraction. The detection of EHP was accurate in experimentally infected *P. vannamei* (n=20) without false positives in healthy (n=20) shrimp. The detection limit of the kit is 20 copies of plasmid DNA. The developed semi-nested PCR protocol was found sensitive and specific to detect EHP in different species of shrimps, artemia, polychaetes, bivalves and environmental samples such as feces, soil, water *etc*. from shrimp ponds.



M-marker (100 bp), 1 - PL (EHP +ve), 2- PL (EHP -ve), 3- hepatopancreas (EHP +ve), 4- hepatopancreas (EHP -ve), 5- faecal thread (EHP +ve), 6- faecal thread (EHP -ve), 7- Positive control (plasmid) , 8- Negative control .

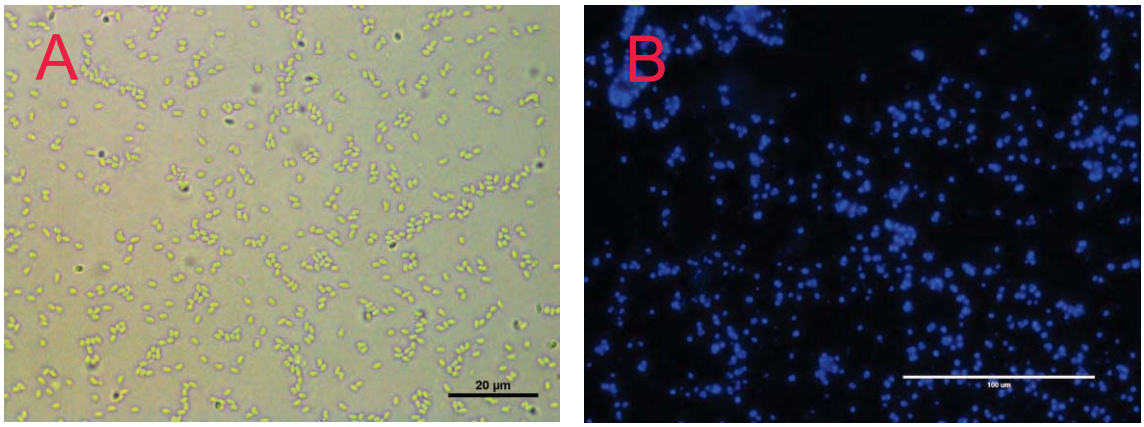
Detection of EHP in different types of samples from shrimp using single-tube nested PCR

Quantitative detection of EHP using TaqMan probe-based real-time PCR

A real-time PCR assay was developed for the quantitative detection of *E. hepatopenaei* (EHP). A TaqMan probe and a pair of specific primers were designed based on the small subunit ribosomal RNA (SSU rRNA) gene sequences. It showed good linearity in detecting positive control plasmid (pGEM-SSU) containing the target sequences for EHP SSU rRNA gene as standards (10^2 to 10^6 copies/reaction) using the optimized protocol. The detection limit of the qPCR method was 40 copies per reaction, which was superior in sensitivity than the conventional PCR and nested PCR. The protocol was found suitable to quantify EHP in slow-growing *P. vannamei* collected from shrimp ponds and experimentally infected shrimps. Overall, the test was found sensitive, specific and easy to perform (96 tests in<3 h) for detecting EHP.

Rapid detection of viable EHP spore using chemifluorescent staining in fresh tissues

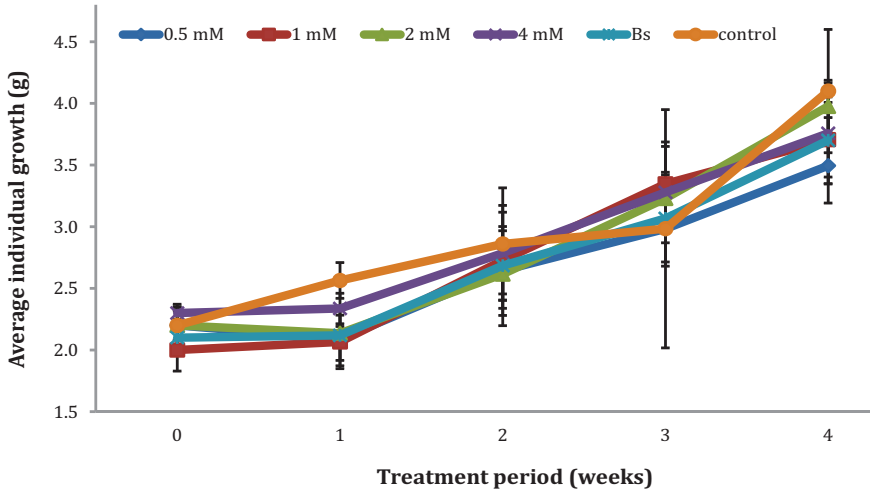
The PCR based assays detect DNA, it is not necessarily a viable pathogen. Therefore, to confirm the presence of a viable pathogen, Calcofluor White, a fluorescent dye, was tested for quick identification of EHP spores and their localization in hepatopancreatic tissue. Calcofluor White is a non-specific fluorochrome that binds with cellulose and chitin present in the cell wall. The microsporidian spores appeared as bluish-white or turquoise oval halos when viewed through EVOS FL Auto Cell Imaging System at wavelength between 345 455 nm of DPAI illumination light cube. The Calcofluor staining protocol is sensitive, fast and requires ~15 min to perform.



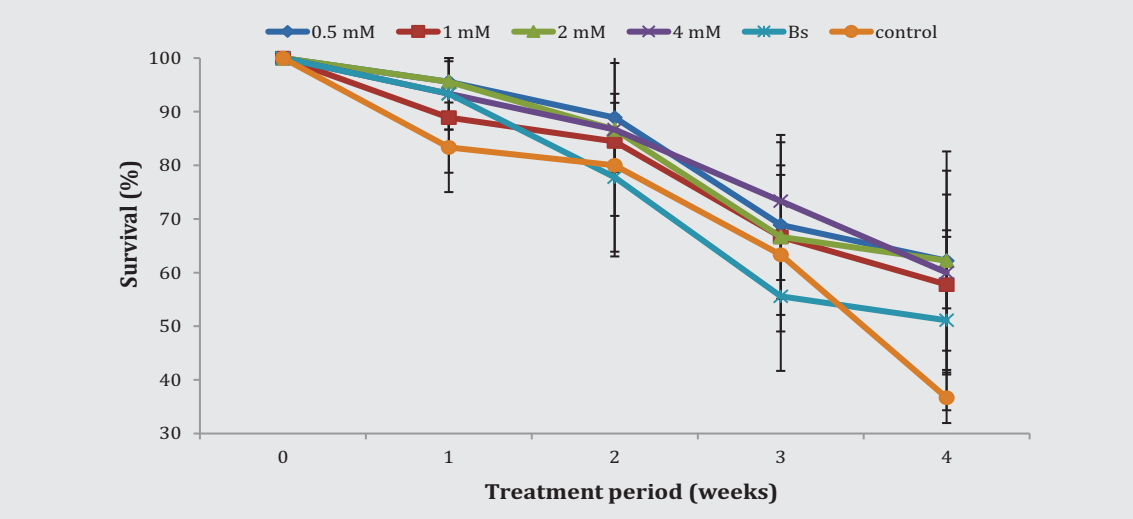
Microscopic detection of *Enterocytozoon hepatopenaei* spores from *Penaeus vannamei*: A: Fresh spores; B- Calcofluor stain (1000 x magnification)

Fortification of probiotics with selenium nanoparticles for enhanced activity

Probiotics has become an integral part of farm inputs to enhance aquaculture productivity. Selenium is an essential dietary nutrient and plays an important role in the functioning of the immune system and promoting cellular immune response. Also, selenium in the bioavailable form has been shown to promote growth and may improve the health of the shrimp because of its anti-microbial property. For harnessing its beneficial effects, selenium nanoparticles (SeNP) were synthesized in the probiotic bacterium and examined for its potentiality to enhance shrimp immunity and larval survival. Wet lab experiments showed 35% and 25% higher survival over control when SeNP incorporated at the rate of 0.5mM in PLs and 2 mM in juvenile *P. vannamei* respectively.



Growth performance of pacific white shrimp fed selenium incorporated diets



Average growth and survival of shrimp juvenile fed selenium nanoparticles (SeNPs)

Lactic acid bacteria (LAB) isolated from shrimp gut inhibited the growth of *V. parahaemolyticus*

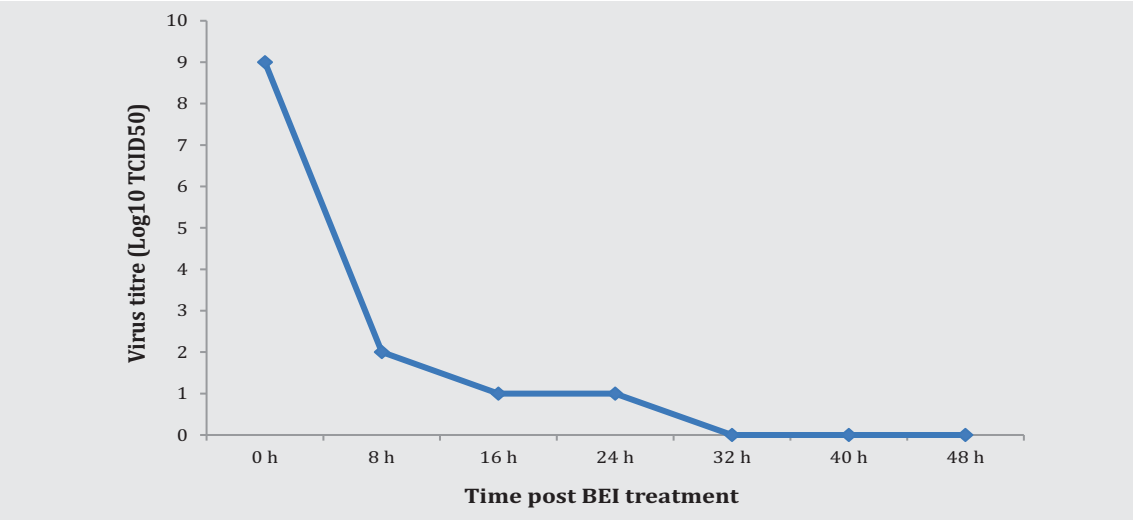
Lactic acid bacteria (LAB) is known for their ability to inhibit bacterial pathogens, stimulate growth and immunity of cultured species. To develop effective probiotics, a number of lactic acid bacteria (n=52) LAB was isolated from the gut of wild shrimp (*Penaeus monodon, P. indicus* and *P. penicillatus*) from Kakdwip and Sagar island of Sundarban, India. Out of tested 52 isolates, 29 isolates inhibited the growth of *V. parahaemolyticus* below 1.0 Log_{10} CFU/mL from ≥ 9 Log_{10} (control). The growth of *V. parahaemolyticus* was also inhibited by the cell-free culture supernatant of 21 LAB isolates. The further characterization by 16S rRNA gene sequencing identified two of the potential LAB probiotic strain as *Lactococcus lactis* subsp. *lactis* and *Lactobacillus casei*.

Lactococcus lactis subsp. lactis on Lactobacillus MRS agar

Development of inactivated vaccine against nervous necrosis virus (NNV)

Viral encephalopathy and retinopathy (VER) also called as viral nervous necrosis (VNN) is an acute viral infection of brackishwater and freshwater fishes. It affects 120 fish species and causes up to 100% mortality in Asian seabass fry. The virus is also transmitted vertically through infected broodstock, eggs, and ovarian fluid. One of the best possible control measures against VNN is by vaccinating the broodstock, fry, and fingerlings. The NNV isolated from infected seabass was plaque purified and propagated in SSN-1 cell line. The virus was inactivated using binary ethylenimine (BEI) for 72 h. The inactivation kinetics suggests that virus could be 100% inactivated by 32 h after addition of BEI. Oral and immersion vaccine was produced by mixing the inactivated cell culture supernatant with Montanide Essai GR01 PR and Montanide IMS 1312 VG NPR adjuvants. The vaccine was orally administered to 30 days old seabass seeds. Twenty-eight days post

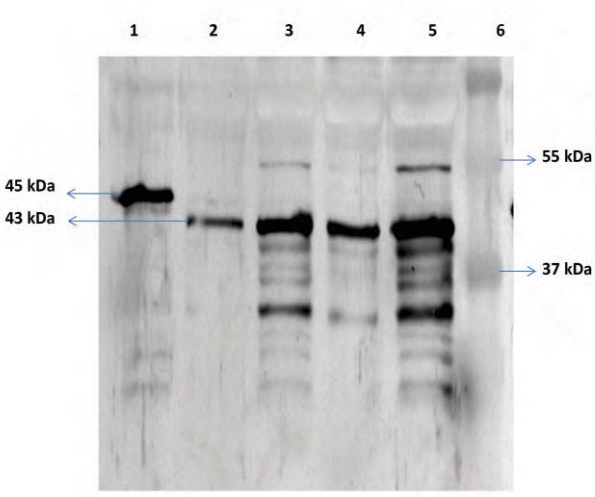
vaccination, the vaccinated and control fish were challenged with virulent NNV through intraperitoneal route. The vaccinated group produced 60% relative percent survival (RPS) suggesting the possibility of developing an effective vaccine against NNV.



Inactivation kinetics of nervous necrosis virus (NNV)

Development of polyclonal antibodies against nervous necrosis virus

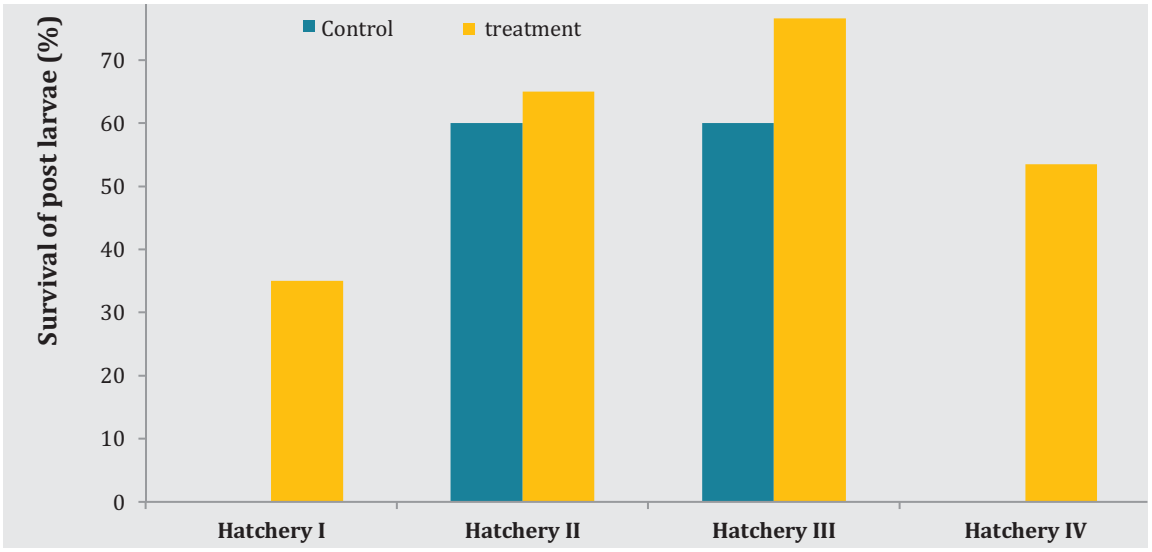
The gene encoding the capsid protein of NNV was amplified using specific primers. The amplified product was initially cloned into pTZ57R/T vector and sequenced. The capsid gene in the recombinant plasmid was purified by double digestion and cloned into pET28b vector. The recombinant plasmid was transformed into BL21 DE3 cells and a pilot expression was carried out. Protein was produced in bulk by IPTG induction, and the expressed protein was purified using nickel affinity chromatography. The purified protein was characterized by SDS-PAGE analysis and quantified. The recombinant protein was used to immunize New Zealand white rabbits to produce polyclonal antibodies against NNV. The antibody titre was estimated by ELISA. The specificity of the antibodies was confirmed by western blot against the recombinant coat protein and NNV. The recombinant NNV coat protein and NNV infected cell culture supernatant was electrophoresed on a 12% SDS-PAGE gel and blotted on to a PVDF membrane. After blocking, the membrane was incubated with polyclonal antibodies and secondary antibodies. The TMB substrate was used to detect the specific binding of the antibodies. The antibodies reacted with both whole virus and recombinant coat protein. The antibody developed against capsid protein could be used for developing diagnostics and testing the efficacy of the vaccine.



Western blot for NNV using polyclonal antibodies against recombinant capsid protein of different concentrations.

Biocontrol of vibrios in shrimp hatcheries using bacteriophages

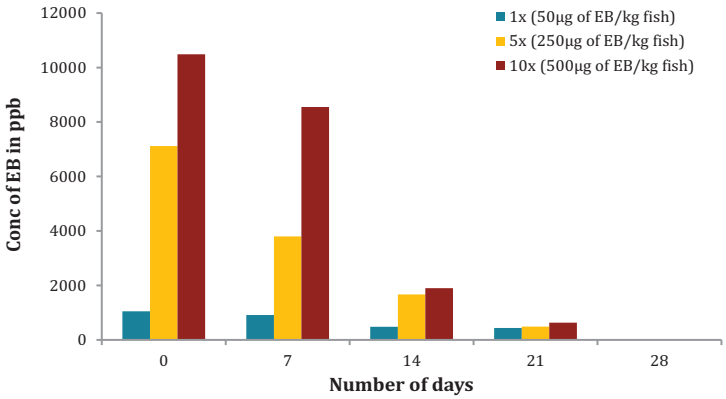
The luminescent bacterial disease is one of the biggest threats in shrimp hatcheries. To control bacterial infection, hatchery operators often apply a large quantity of antibiotic. In recent times, bacteriophage therapy is emerging as an effective biocontrol measure to control bacterial infections. CIBA has a stock of well-characterized bacteriophages. Based upon the lytic spectrum, a consortium of four bacteriophages was formulated for prophylactic and therapeutic application. The growth conditions of these bacteriophages along with their host bacterium were standardised in the fermenter. The yield of phages ranged between 10^{10} pfu/ml to 10^{12} pfu/ml. Before applying in the hatchery, the traces of bacterial contamination were removed by filtration, and its biosafety and efficacy were further tested in the laboratory conditions. As therapeutic measure, the phage consortium was tested at five multiplicity of infection (MOI) with 35% survival (hatchery I) against 100% mortality in the non-treated larval unit. As a prophylactic measure, a higher survival of 15% (hatchery II) and 17% (hatchery III) was obtained compared to control. Bacteriophage application in these hatcheries caused one to two logs reduction in *Vibrio* and luminescent *Vibrio* counts. The hatchery IV had a history of severe luminescent vibriosis with complete loss of stock for two consecutive cycles. The phage therapy resulted in 53% production of shrimp post larvae, and no luminescent bacteria were detected during the treatment. These field trials established the potential of phage therapy for treating luminescent bacterial disease in shrimp hatchery. A provisional patent for consortia of four bacteriophages was filed (# 201841010229).



Survival of *P. vannamei* larvae in commercial shrimp hatchery during bacteriophage therapy trial

Withdrawal periods and degradation of drugs and chemicals used in aquaculture

Study was conducted to evaluate the safety and withdrawal period of emamectin benzoate an effective antiparasitic agent in Asian seabass, *Lates calcarifer* fingerlings (7.69±0.03g). The drug administered at the therapeutic dose of 50 µg of EB kg^{-1} fish BW d^{-1} for 7 d was found to be safe, and no residue of the drug could be identified in LC-MS/MS analysis 28 days after the withdrawal of administration. Studies on the degradation of oxytetracycline indicated the positive role of salinity, temperature, and photoperiod. 98% of OTC was degraded in 2 days at 36 °C compared to 5 days at 25 °C. Similarly, the degradation was faster in lower salinity at 5 ppt compared to that of 25 ppt.



Withdrawal period of emamectin benzoate (EB) in Asian seabass, *Lates calcarifer*

National Referral Laboratory for Brackishwater Aquatic Animal Diseases(NRLD)

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 2017 to March 2018, a total of 53 samples including imported Artemia cyst, frozen tissue and feed samples were tested for OIE listed shrimp and fish pathogens for the AQCS, Chennai. Apart from one positive Artemia cyst sample for EHP, other samples were tested negative for OIE listed pathogens. From disease diagnostic services CIBA generated revenue of Rs. 9,56,060/-

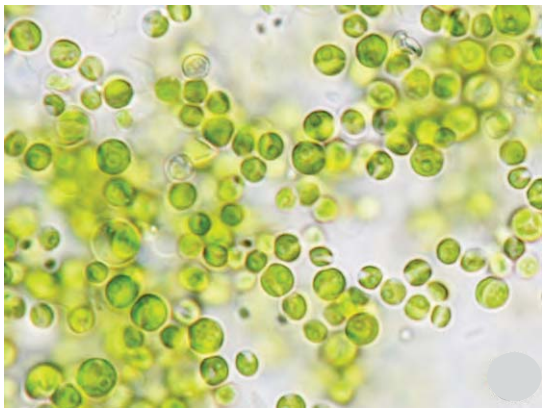
Screening of samples for OIE listed pathogens

Sl.No	Sample	No Tested	DNA viruses		RNA viruses			Bacteria		Parasite
			WSSV	IHHNV	IMNV	TSV	YHV	AHPND	NHPB	EHP
1	Reimported frozen tissue samples	1	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
2	Imported Artemia cyst	39	-ve	-ve	-ve	-ve	-ve	-ve	-ve	1
3	Imported Fish feed	2	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
4	Imported Prawn feed	9	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
5	Imported Krill Oil	2	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
6	Total samples Tested	53	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve

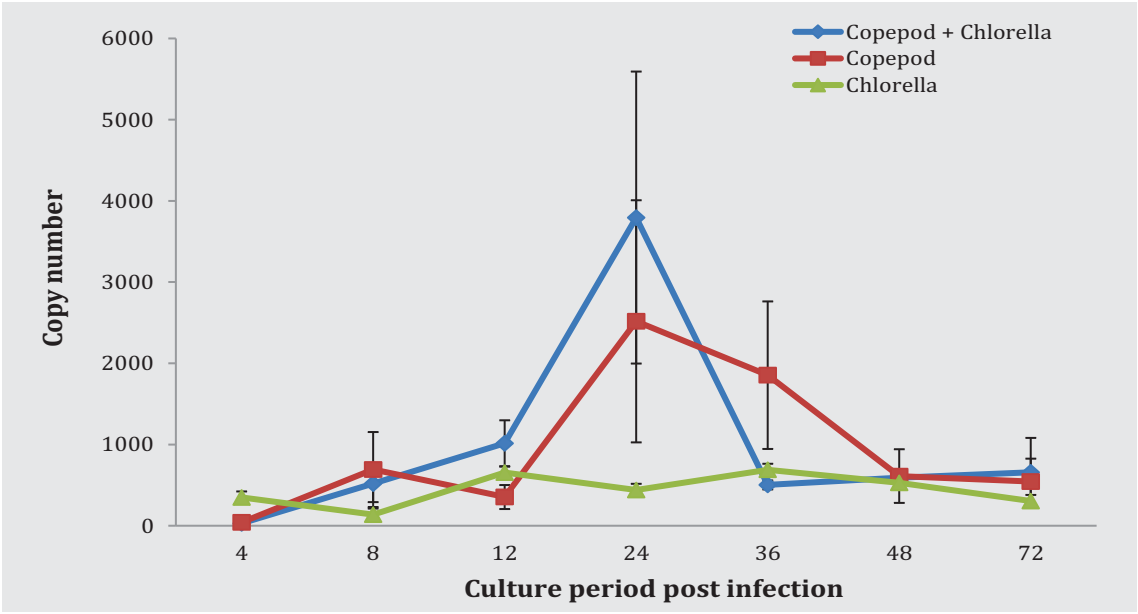
Influence of planktons (Zoo and phyto) in the transmission of WSSV in *Penaeus vannamei*

Experiment on the effect of zooplankton (copepod) and phytoplankton (*Chlorella* sp) on WSSV infection in shrimp (*Penaeus vannamei*) was checked by the in-vivo study. Different concentration of copepod (250,500 and 1000 number/L) with or without chlorella (10^5 cells/ml) were infected with WSSV (10^8 copy number/ml) and added to 30L tubs containing juvenile shrimp. The shrimp infected with WSSV through copepod (1000/L) along with chlorella caused 100% mortality compared to no mortality in the group with copepod only. The shrimp with chlorella experienced partial mortality, indicating chlorella may act as a carrier of WSSV and the virus amplify in copepod enhancing shrimp mortality. Viral kinetics was checked in the copepod by quantitative PCR. Viral copy number increased in copepod with or without chlorella and peaked at 24 hpi, but the copepod with chlorella carried higher number than copepod alone group. The experiment indicates phytoplankton like *Chlorella* may act as a carrier and upon feeding on such phytoplankton, copepod amplifies the WSSV infection to reach disease-causing level in the farming systems.

Copepod



Chlorella sp



Influence of plankton on WSSV kinetics

AQUACULTURE ENVIRONMENT AND CLIMATE CHANGE

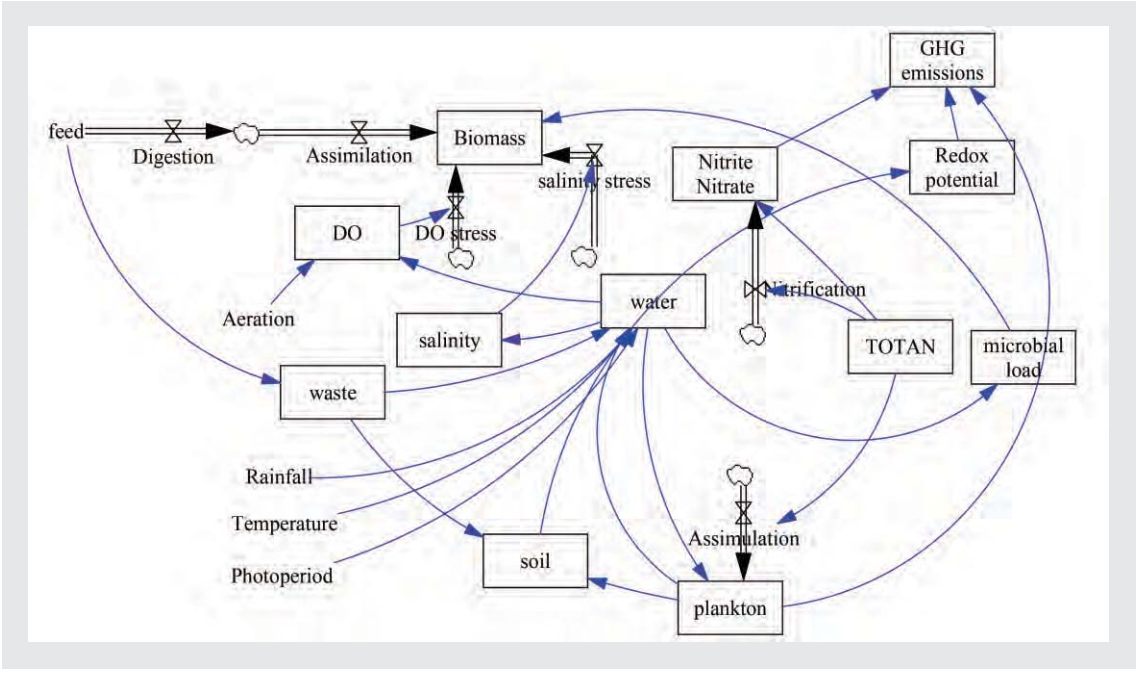
Brackishwater production system is a subset of larger coastal ecosystem, and the harmonious interaction between these system plays a critical role in long term sustainability of brackishwater aquaculture

Sampling of soil for profiling of minerals in aquaculture ponds

Aquaculture Environment and Climate Change

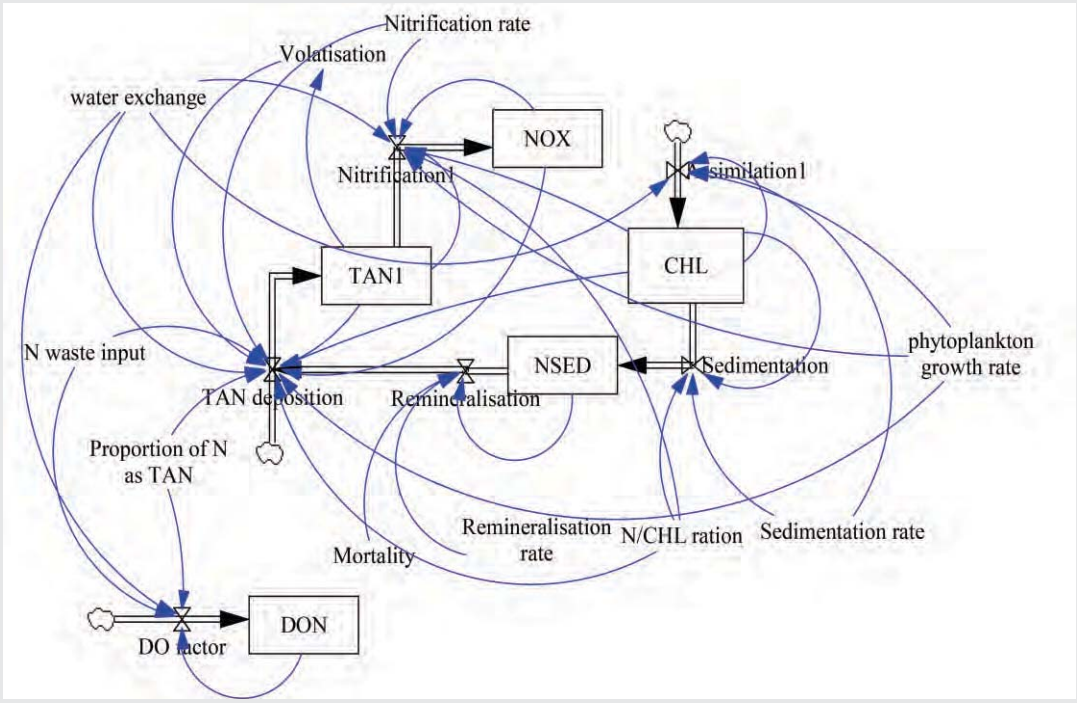
Modelling shrimp growth

To develop dynamic simulation models for shrimp aquaculture, stocks rates and flows were set based on the relational diagram prepared covering all the processes of shrimp farming. The major output parameter of the model is biomass produced from the shrimp culture system. Systems dynamics software Vensim was used to build the model.



Shrimp biomass model using Vensim software

Main model outputs include total biomass, climate effects on growth and greenhouse gas emissions. There are several sub-processes of the model which needs to be addressed first. Nitrogen dynamics sub-process was built first; TAN, NOX, DO, sedimentation, phytoplankton are the five key state variables of the model. This model assesses the discharges into the system which will directly or indirectly affect the shrimp growth. Calibration of the model and parameter estimation is being done with farm-level data.



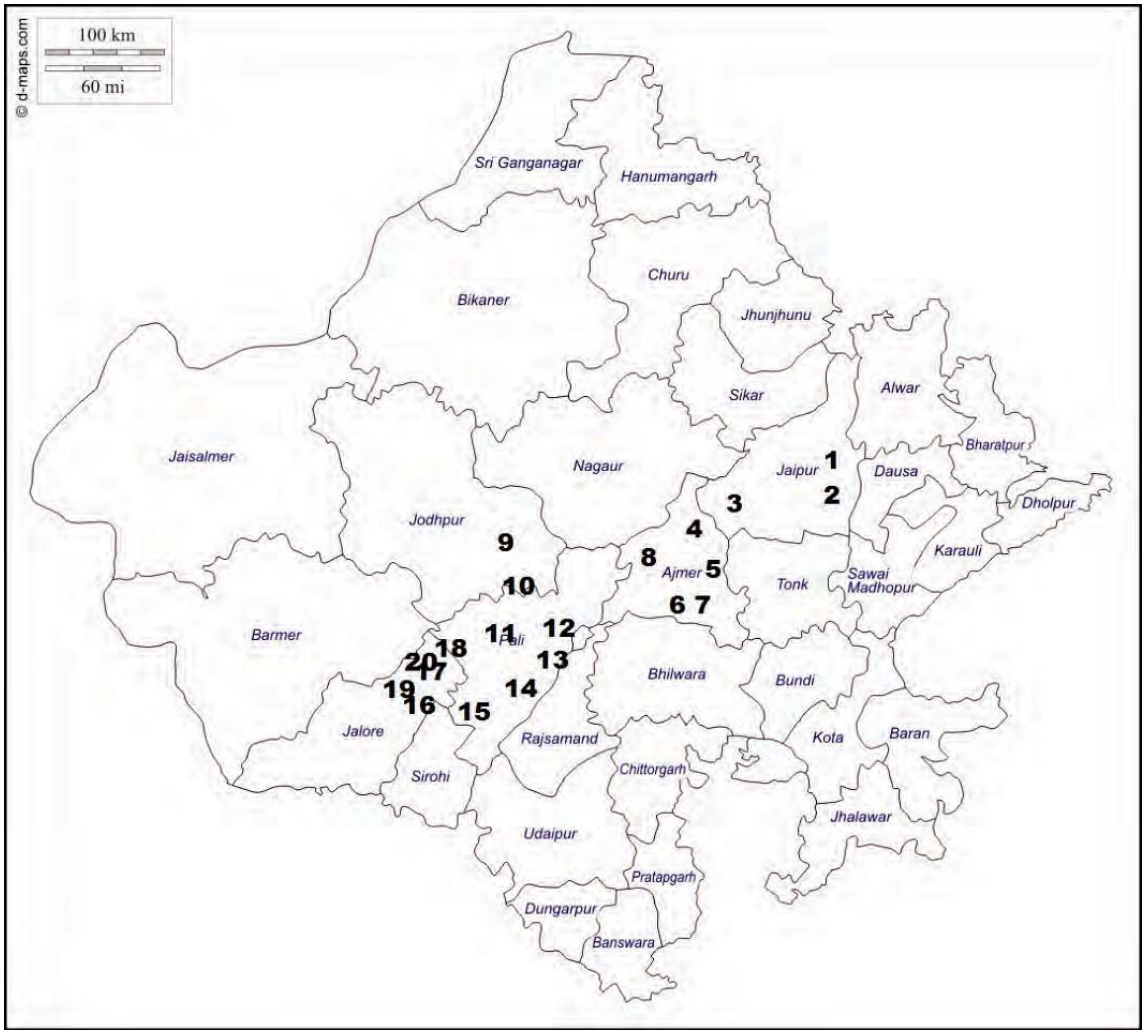
N dynamics sub-process model

Integrated freshwater (low saline) shrimp and paddy farming model

To assess the environmental impacts of freshwater/low saline shrimp aquaculture, case studies were conducted in Orthanadu, Thanjavur District, Tamil Nadu since last two years. Most of the low saline (0 to 1 ppt) shrimp farms are surrounded by rice fields. The shrimp species *P. vannamei* is cultured in 0 to 1 ppt and is well adapted to low salinities due to its osmoregulatory capacity. Salt was not added to the ponds and minerals were applied to mitigate the imbalance in minerals. The discharge water from these farms is being used by the neighbouring agriculture farmers for irrigating paddy crop (Variety: ADT-43, Duration: 100 days) since the last five to six years. Even without paddy crop also, farmers are taking water and ploughing the fields to enrich the fertility status of the soil. Paddy crop irrigated with nutrients rich shrimp farm discharge water resulted in additional paddy production of 8 to 10 bags/ac compared to irrigation with normal water, regularly being followed. Farmers earn an additional income of about Rs. 15,000 for paddy and Rs.25,000/- black gram per acre due to increase in production and also by decreasing the fertilisers application compared to the recommended dose. The sediment from the shrimp culture ponds has been applied as manure for the tree crops within the farm. Better height and diameter of Teak trees with the use of harvested low saline shrimp pond sediment compared to control, showed its potential as manure for horticultural crops.

Suitable sites for inland saline aquaculture in Rajasthan

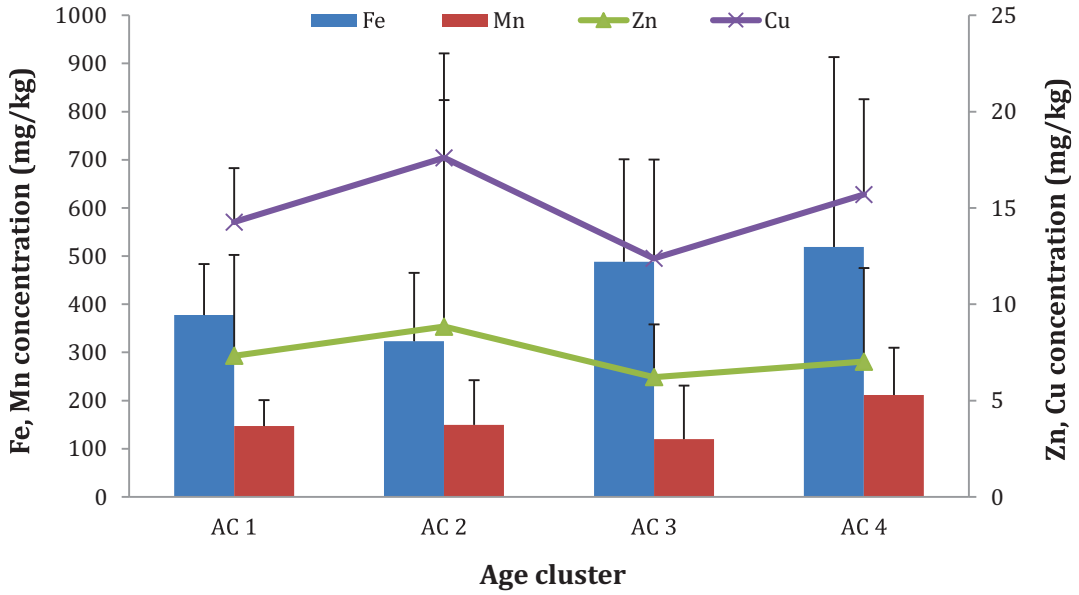
Rajasthan poses vast lands of inland saline areas with varying subsurface water salinity and a survey was undertaken to assess the suitability of sites for aquaculture. Soil and water samples were collected from villages in Jaipur, Ajmer, Jodhpur, Pali and Jalore districts to study the suitability of the areas for inland saline aquaculture. The salinity, pH, alkalinity and hardness of the surface and subsurface water varied from 0-22 ppt, 7.06-9.15, 49-1415 ppm and 84-3480 ppm, respectively. Highly alkaline areas such as Kishangarh and Kanpura were not suitable for aquaculture. The variable productivity of water sources as indicated by nitrate and phosphate concentration of 0.001 to 1.505 ppm and 0.008 to 0.599 ppm, respectively. Ca: Mg ratio range of 0.6 to 28.4, and sodium & potassium concentration of 16 to 27055 ppm and 1 to 254 ppm respectively indicates the variation in mineral profile and the necessity for minerals manipulation. Based on the suitability criteria for farming and willingness of farmers, Jetpura of Jalore district were selected to start aquaculture.



Sampling points in inland saline areas of Rajasthan

Database on minerals status of shrimp culture ponds and source waters

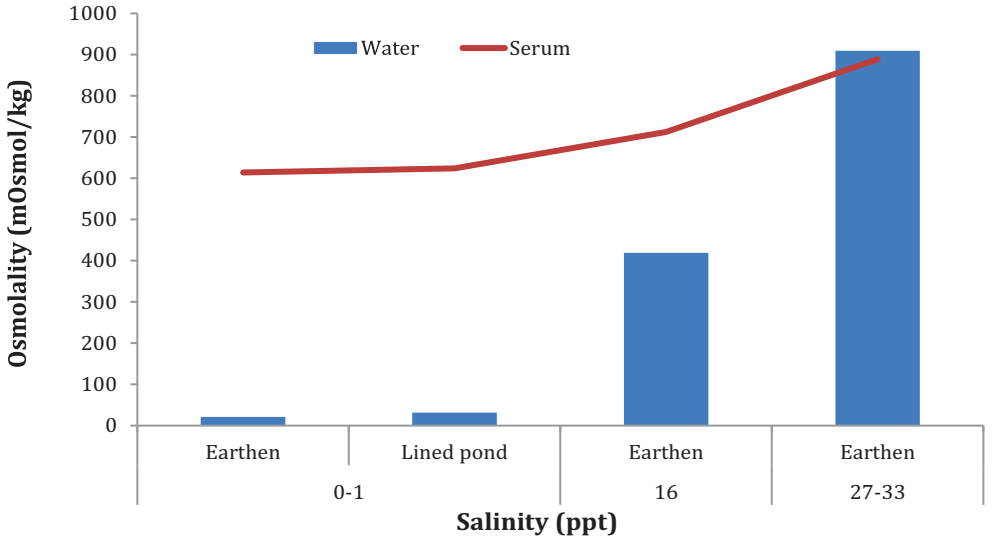
Collection of soil samples from shrimp culture ponds varying in age [age clusters of <5 (Ac1), 6 to 10 (AC2), 11 to 15 (AC3) and 16 to 20 years (AC4)], and source waters was continued from different geographical locations and analysed for major minerals (calcium, magnesium sodium, potassium, chloride and sulphate) and trace minerals (iron, manganese, zinc and copper) concentration along with fertility (physico-chemical parameters) in shrimp pond soils varying in age and mineral composition of source waters creeks and bore wells being used for shrimp farms (creeks and bore wells) was assessed in different geographical locations viz., Andhra Pradesh, Tamil Nadu and Gujarat to understand the changes in soil nutrients and minerals over a period of time. Among the age clusters, soil quality parameters pH, OC, $CaCO_3$, Av. P, Ca, K, Mg, SO_4, Zn and Cu were not significantly varied with pond age. The significantly high concentration of available N, Na, Cl, Fe and Mn concentration were observed in AC4 ponds. Creek and bore well waters from different locations, even with similar salinity varied in their mineral composition and ionic ratios.



Variation in trace minerals concentration

Adaptability of *P. vannamei* culture under low salinities

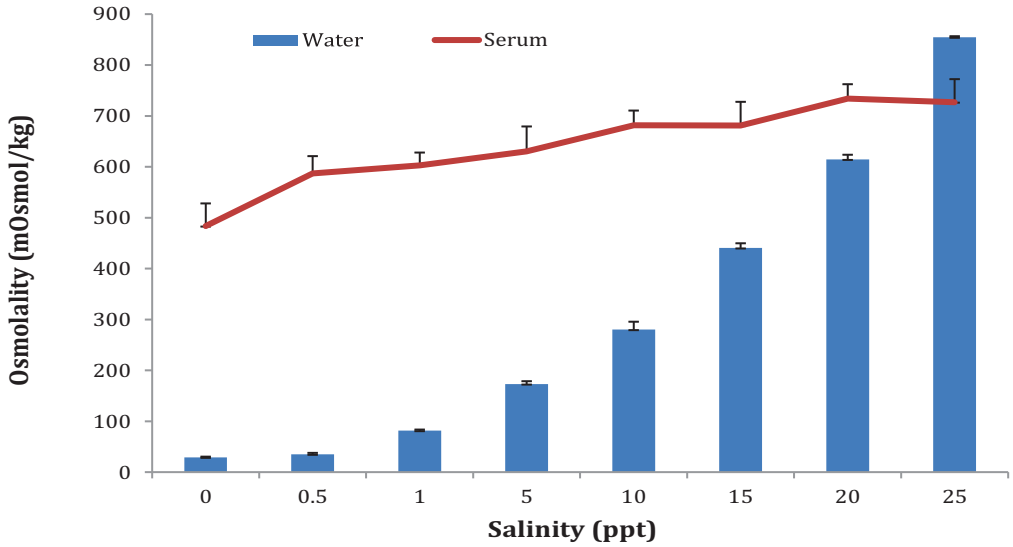
There is a growing trend to culture *P. vannamei* in low saline areas. In order to evaluate the adaptability of *P. vannamei* under different salinities, field samples were collected throughout the culture from shrimp ponds of different salinities 0 (earthen and lined), 16 and 32 ppt. The mean water osmolality varied from 21, 419 and 909 mOsmol/kg under 0, 16 and 32 ppt salinity respectively. However, there was not much change in serum osmolality (614, 713 and 888 mOsmol/kg at 0, 16 and 32 ppt), indicating that *P. vannamei* adapts to varying salinities. Moreover shrimp serum osmolality did not vary during culture period and is independent of animal weight in all salinities. During the culture, calcium and magnesium concentration in whole shrimp and water ranged from 30-60, 240-241, 362-724; and 47-83, 703-704, 1067-1690 ppm for low, medium and high saline pond water respectively.



Variation in water and serum osmolality under different salinities

Influence of steady salinity variation on water and serum osmolality

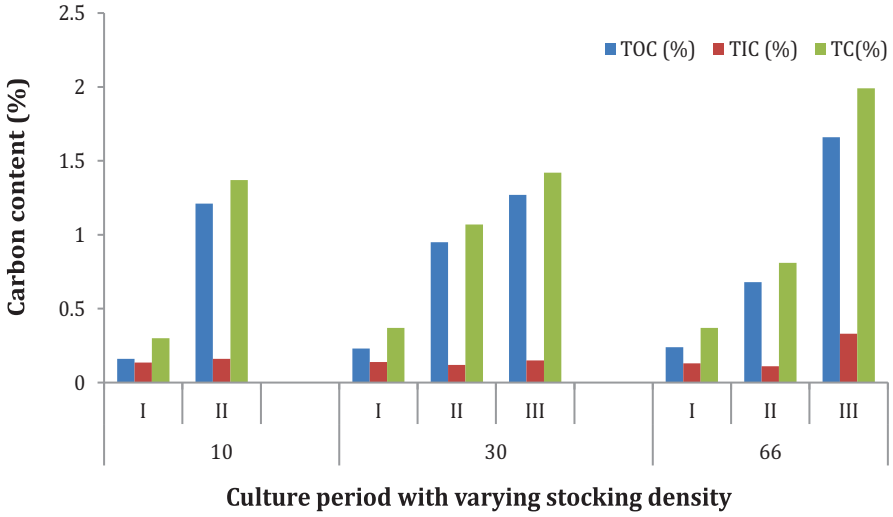
To test the adaptability of *P. vannamei* under the conditions of gradual decrease in salinity, yard experiment was conducted wherein salinity was reduced by 5 ppt from 25 ppt to 1 ppt and by 0.5 ppt from 1 ppt to 0 ppt at every 24 h interval and samples were analyzed for osmolality and mineral content. Water and serum osmolality varied from 855 to 29 and 727 to 484 mOsmol/kg from 25 ppt to 0 ppt. It is quite visible that the osmotic point lies near to 700 mOsmol/kg at 25 ppt of salinity. No major differences in serum osmolality and above 90% survival rate in all salinities indicate that *P. vannamei* shrimp rapidly adapt to drastic changes in the mineral content of water.



Osmolality of water and serum under gradual decrease in salinity

Carbon fractions in pond sediment of shrimp farms varying in stocking density

Investigations on carbon fractions in pond sediment will indicate pond bottom soil deteriorating condition. Carbon fractions were analysed in high saline shrimp culture ponds (55 ppt at the start of culture to 35 ppt during culture period) varying in stocking density (10, 30 and 66 nos./m^2) at Mahabalipuram, Tamil Nadu. The pond with 10 no./m^2 had emergency harvest within 70 DOC. Total organic carbon (TOC) content in sediment increased from 0.16 to 1.21%, 0.2 to 1.27 % and 0.2 to 1.7 % respectively in the ponds with increasing order of stocking density and total inorganic carbon (TIC) content was comparatively low ranged from 0.1 to 0.3%. TOC content in pond waters ranged from 5 to 9 ppm in the surface layer and from 9 to 15 ppm in the bottom layer. The TIC content was comparatively higher and varied from 19 to 40 ppm in the surface and from 17 to 51 ppm in the bottom layer. The labile carbon and water-soluble carbon (WSC) fractions in pond sediment increased linearly during the culture period in all the stocking densities. High labile carbon content in a pond with 10 no./m^2 indicates the poor pond bottom condition, the predisposal for emergency harvest.



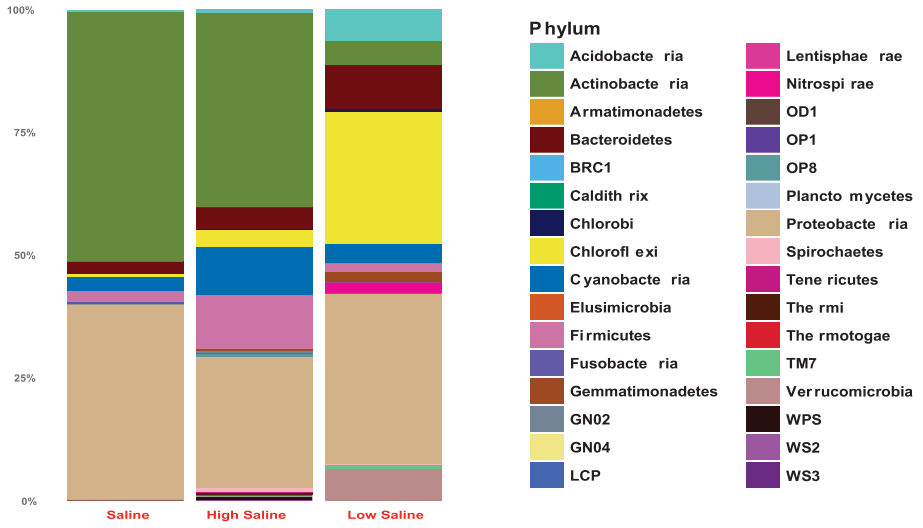
Carbon fractions in pond sediments varying in stocking density during the culture period

Bacterial diversity in shrimp culture ponds by metagenomics

Metagenomics approach was used to understand the diversity of bacterial communities in *P. vannamei* culture ponds of varying salinity 0-1ppt (low saline - 1ppt), 14-16 ppt (saline - 15 ppt) and 42-47 ppt (high saline - 45 ppt). Soil samples were collected at the sediment-water interface (SWI) during 30, 60 and 90 days of culture (DOC). More diverse microbial communities were observed towards the end compared to early days of culture in all salinities. Actinobacteria were dominant at 30 DOC and Proteobacteria at 60 and 90 DOC in saline and high saline culture ponds, whereas in low saline Proteobacteria was dominant during the whole culture period. The predominance of sulfur-reducing bacteria from 60 DOC in low saline, throughout the cropping period in high saline, and at 90 DOC in saline culture ponds indicates the possibility of a build-up of sulphide and reduced condition in the pond and requirement for microbial manipulation with the beneficial microbes in improving the pond bottom condition. Beneficial bacterial communities reported in the culture ponds were *Acidomicrobiales, Commondaceae, Myxococcales, Rhizobiales, Sphingomonadales, Rhodospiralles, Thiotrichales, Chromatiales Cytophagia, Saprospirae, Flavobacteria, Bacilli, Chloroflexi, Synechococcus, Pirellulales, Phycisphaerales, Verrucomicrobia, Acidomicrobia, Nitropspirae, Lentispharae* and *Chlorobi*. Harmful bacterial communities reported were *Actionmycetales, Alkaligenacaee,*

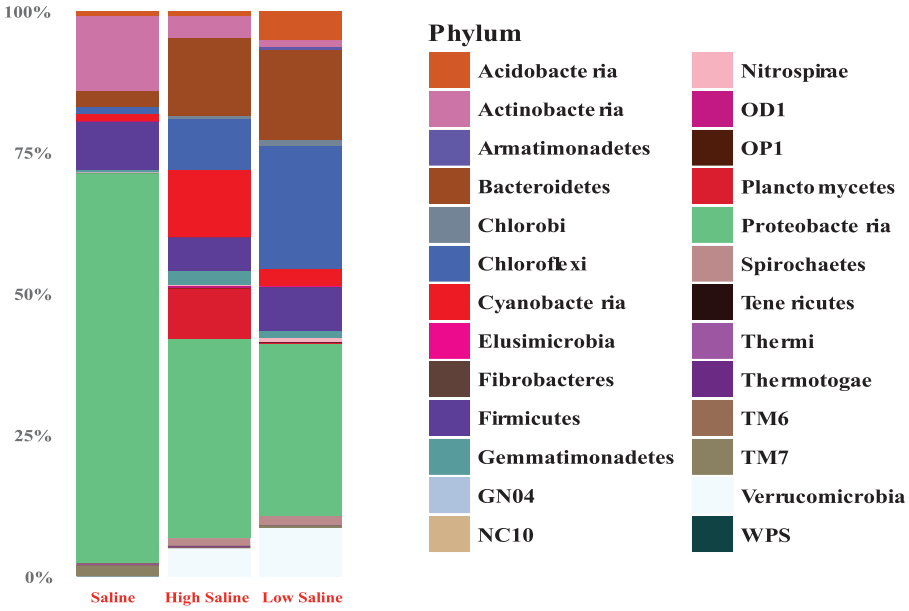
Desulfobacterales, Desulfovibrionales, Syntrophobacterales, Desulfuromonadales, Rhodobacterales, Xanthomonadales, Enterobacteriales, Vibrionales, Alteromonadales, Psuedomonadales, Bacteroidia, Sphingobacteria, Clostridiales, Planctomycetales, Gemmatimonadetes and *Spirochaetes.*

I

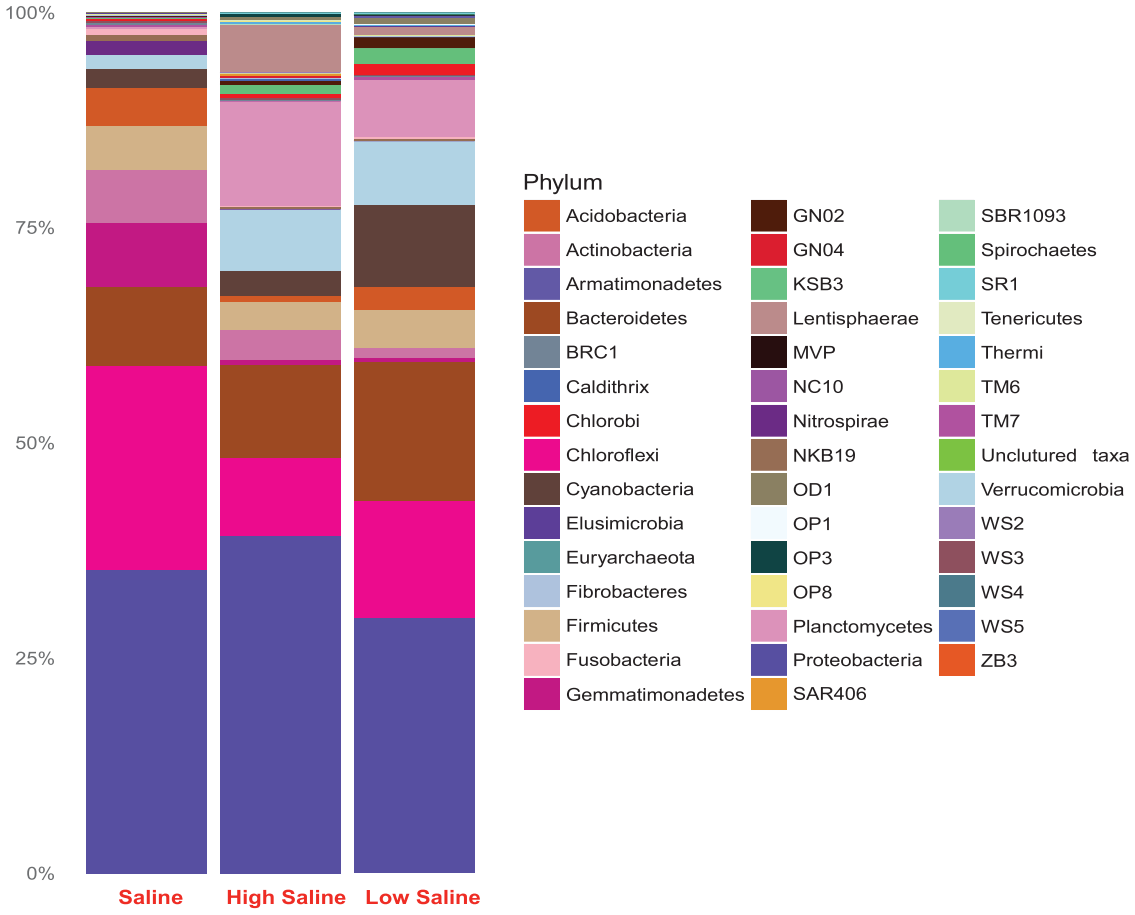


Bacterial diversity in shrimp culture ponds at 30 days of culture

II



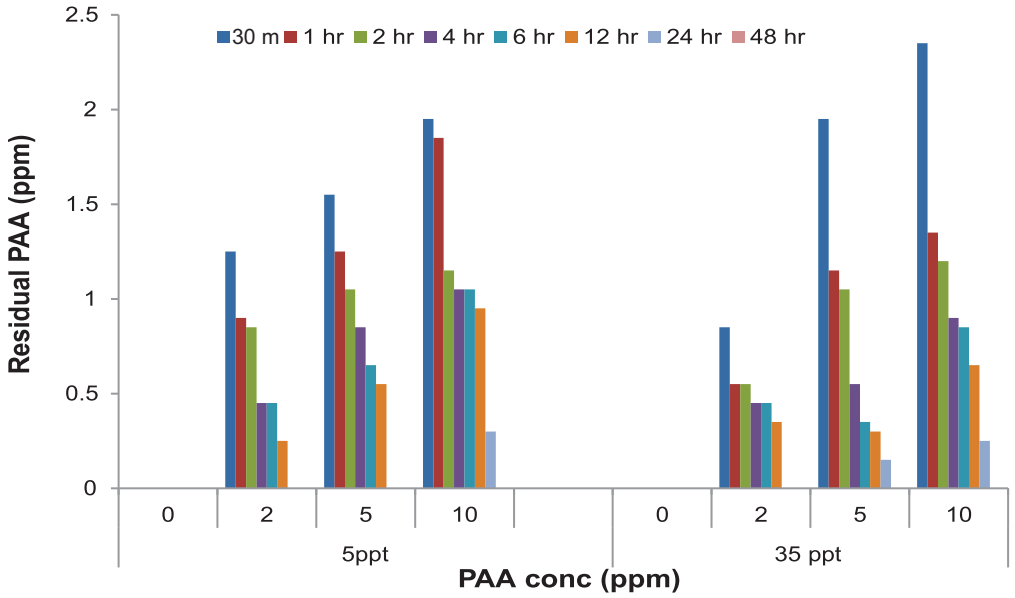
Bacterial diversity in shrimp culture ponds at 60 days of culture



Bacterial diversity in shrimp culture ponds at 90 day of culture

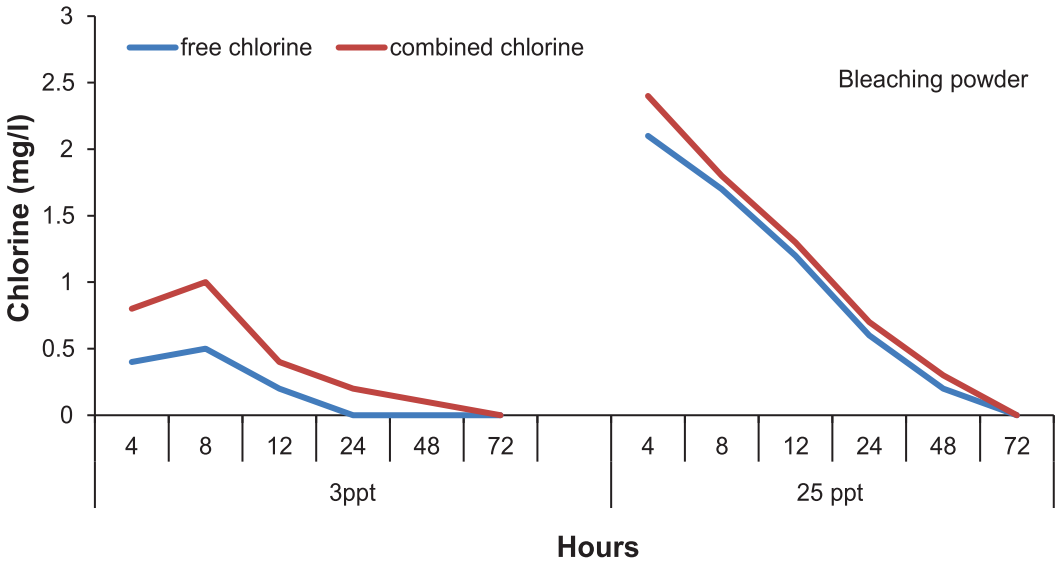
Efficiency of peracetic acid as a disinfectant and comparison with other disinfectants

The efficiency of peracetic acid (PAA) at 0, 2, 5 and 10 ppm as disinfectant in 5 and 25 ppt salinities revealed that the residuals of PAA, viz., hydrogen peroxide and acetic acid, reduced to zero after 24 h of application in 2 and 5 ppm and after 40 h at 10 ppm in both the salinities. However, the degradation was faster at lower salinity. The heterotrophic bacterial count 24 h after treatment reduced from 10^7 CFU in control to 10^4 CFU in low saline and 10^3 CFU in high saline water. The disinfection efficiency of PAA on luminescent *Vibrio* sp. by microbial inhibition study conducted from 2 to 100 ppm showed that a concentration of 10 ppm inhibited the *Vibrio* growth. PAA wasn't effective as a disinfectant in turbid waters (>40 NTU) in both the salinities.



Residual effect of peracetic acid in different salinities

Total residual chlorine (TRC) content was 2.4 and 1.6 mg Cl_2/L compared to 0.8 and 0.7 mg Cl_2/L in high (25 ppt) and low saline (3 ppt) waters after four of application with bleaching powder and sodium hypochlorite at the rate of 10 ppm Cl, respectively. The TRC reduced to zero after 72 h of application in both the cases. Both the disinfectants reduced the heterotrophic bacterial count from 8.3 x 10^4 cfu/ml in low saline and 38 x 10^4 cfu/ml in high saline waters to nil and remained same after 24, 48 and 72 h of treatment. The results indicated that peracetic acid is effective and has a shorter residual effect, and can be used as an alternative disinfectant.

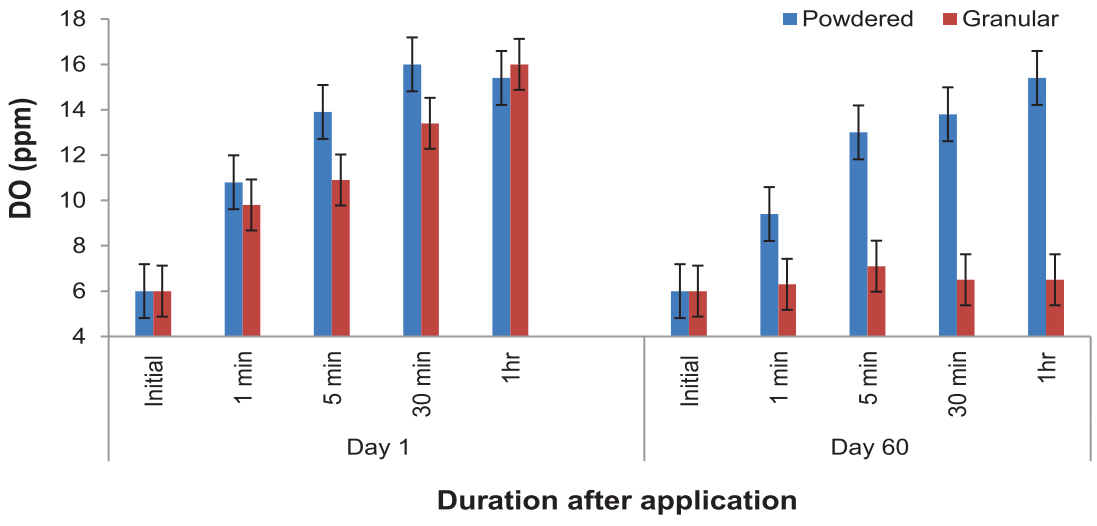


Residual effect of bleaching powder and sodium hypochlorite at different salinities

Enhanced stability of prototype Oxygen Releasing Compound (ORC)

Even though mechanical aerators are commonly used for better aeration, under emergency situation oxygen releasing compounds are applied by the farmers to increase oxygen levels in pond water. Sodium per carbonate-based oxygen releasing compounds were synthesized in granular as well as powder form and their stability was evaluated by their dissolved oxygen release efficiency at different time intervals. The granular form was synthesized by physically mixing the active ingredients, activators, and stabilizers. Powder formulation was synthesized by pulverizing active components individually and mixing the powdered components with each other. The prototype powder form ORC was more stable, as it attained DO level of 15.4 ppm compared to 7.1 ppm with granular form ORC after two months from an initial value of 16 ppm observed with both the forms immediately after preparation. The DO level in control was 4.8 ppm indicating the efficiency of the product to increase DO levels in an emergency situation.

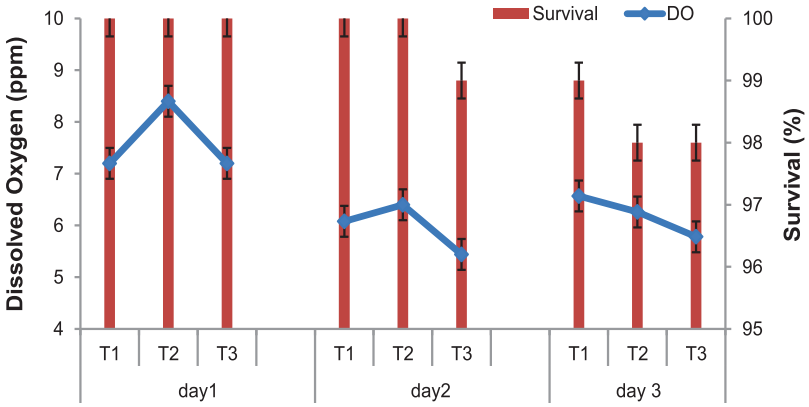
Oxygen Releasing Compound



Effect of storage period on the stability of the ORC formulations

Efficiency of prototype ORC in comparison to aeration

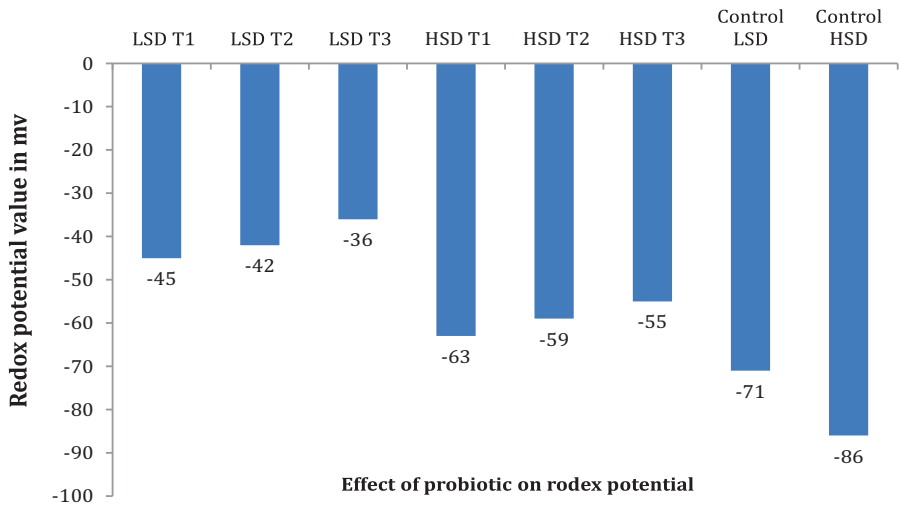
With the objective of studying the effectiveness of ORC in comparison to mechanical aeration a yard experiment was conducted with three treatments namely complete aeration (T_1), partial aeration and ORC (T_2) and ORC alone (T_3). *P. vannamei* was stocked at 45 no./m^2 and ORC was applied twice a day (1g/100 L). Application of ORC was statistically on par with the aeration with respect to survival and water quality parameters for three days and later decrease in survival with the only ORC. The survival was 99, 98 and 98% in T_1, T_2, and T_3, respectively on the third day. The study revealed that ORC could be utilised as a supplement/ replacement to mechanical aeration under the emergency condition for three days.



Effect of aeration and ORC on DO levels and shrimp survival

Prototype probiotic for soil and water quality improvement

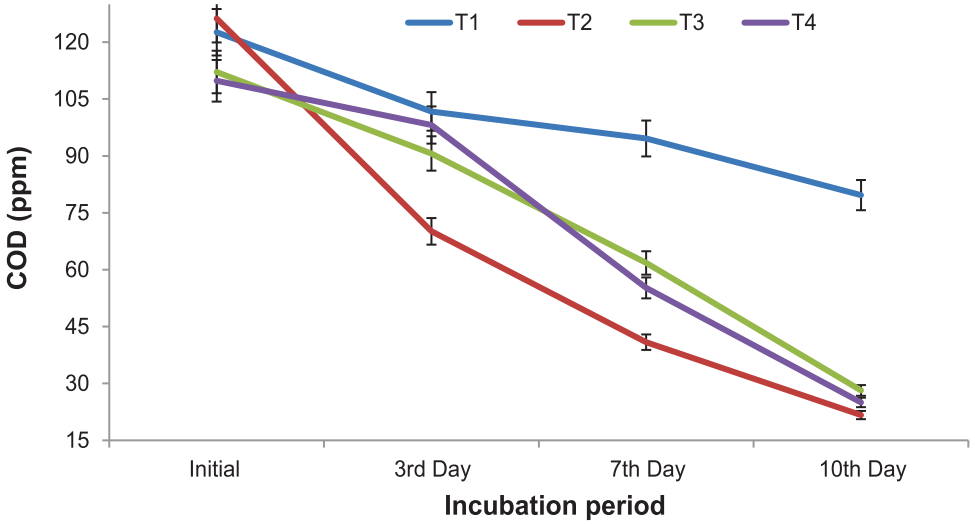
Prototype probiotic with bacterial consortium @ 10^7, 10^9 and 10^{11} cfu/g (T1, T2 and T3) applied at weekly intervals in zero water exchange system of *P. vannamei* (0.65 g) culture with two stocking densities 30/m^2 (LSD) and 60/m^2 (HSD) for 30 days indicated that 10^{11} cfu/g showed better reduction in total ammonia N by 38 & 16%, nitrite N by 46% & 35%, decrease in soil redox potential (E_h) towards oxidation state by 42 & 36 % and increase in shrimp growth by 15 & 17%, in low and high SD treatments, respectively. Treating the post-harvest shrimp culture pond bottom sediment collected from a shrimp farm in Tamil Nadu with probiotic showed an improvement in redox potential by 9, 12 and 15% with 10^7, 10^9 and 10^{11} cfu/g, respectively compared to 4% decrease in control from an initial value of -263 mV.



Evaluation of prototype probiotic for soil and water quality improvement

Treatment of discharge water rich in chemical oxygen demand

According to the Coastal Aquaculture Authority regulations, the chemical oxygen demand (COD) of the discharge water should be less than 100 and 75 ppm if the final discharge point is coastal marine waters and creek/estuary, respectively. In order to decrease the COD of the discharge water, calcium peroxide (T_2), ORC (T_3) and potassium nitrate (T_4) were applied at 5g/ 100 litres. The COD was measured at different time intervals and the results indicated that application of CaO_2, ORC and KNO_3 reduced the COD of discharge water by 83, 78 and 80%, respectively on the 10th day compared to 37% reduction in control (T_1). ORC and other treatments could be utilized for decreasing COD.



Effect of chemical treatments on COD of discharge water

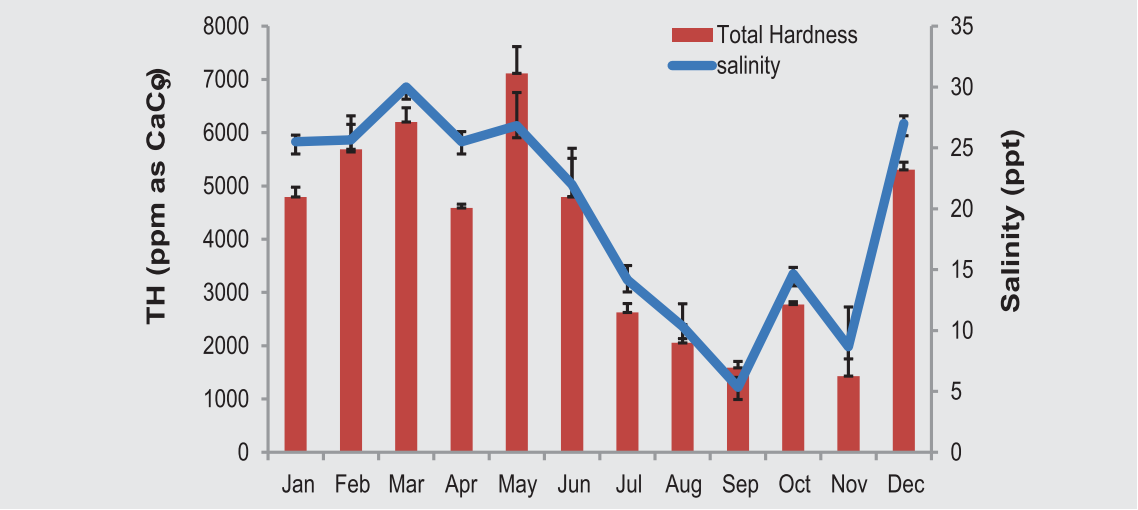
Improved accuracy of portable water analysis kits

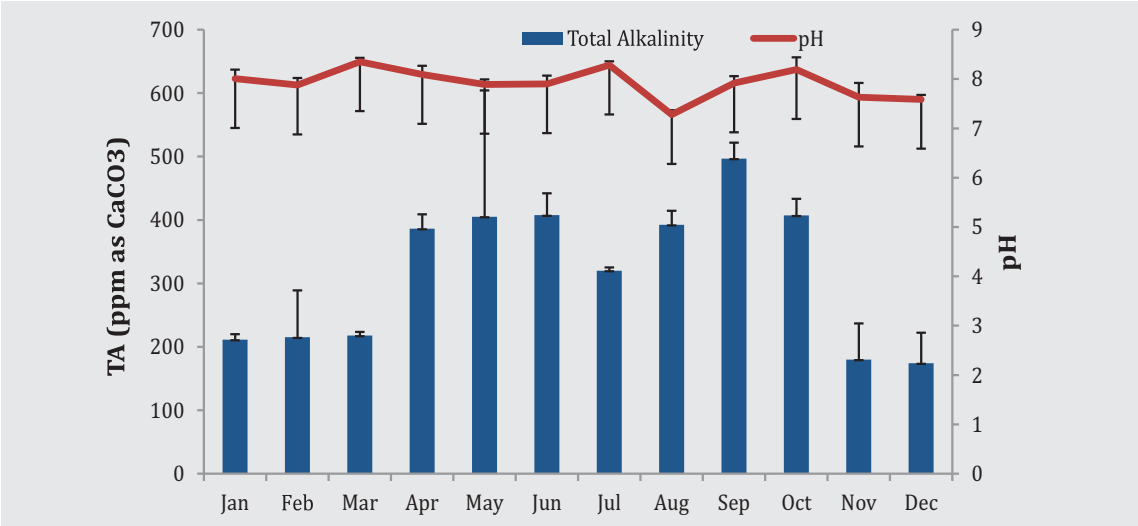
A continual improvement was made in the water analysis kits developed by the Institute and commercialised (DO, pH, ammonia and nitrite). The accuracy was checked and the modifications were made in the concentration of reagents, improving the storage stability of reagents, quality of colour charts etc. CIBA kits were proved to be more accurate than the counterpart kits available in the market. The packing of calcium, magnesium and total hardness analysis kit ($CMH_{Mineral}$ kit) was done and is ready for commercialization as well as a sale from the Institute.

Calcium, Magnesium and Hardness ($CMH_{Mineral}$) kit

Suitability of restored Adyar creek waters for brackishwater cage culture

Monthly monitoring of environmental parameters from six sampling stations in restored Adyar creek and estuary area near Srinivasapuram, Chennai from sea mouth to 1.5 km stretch showed the salinity variation from 22-30 ppt during December to June and 5-15 ppt during July to November. Salinity, metabolites and nutrients concentration at each sampling station varied based on the tidal influx. Based on the variation in the key water parameters over a period, suitable sites were identified for cage culture of finfishes and crab.

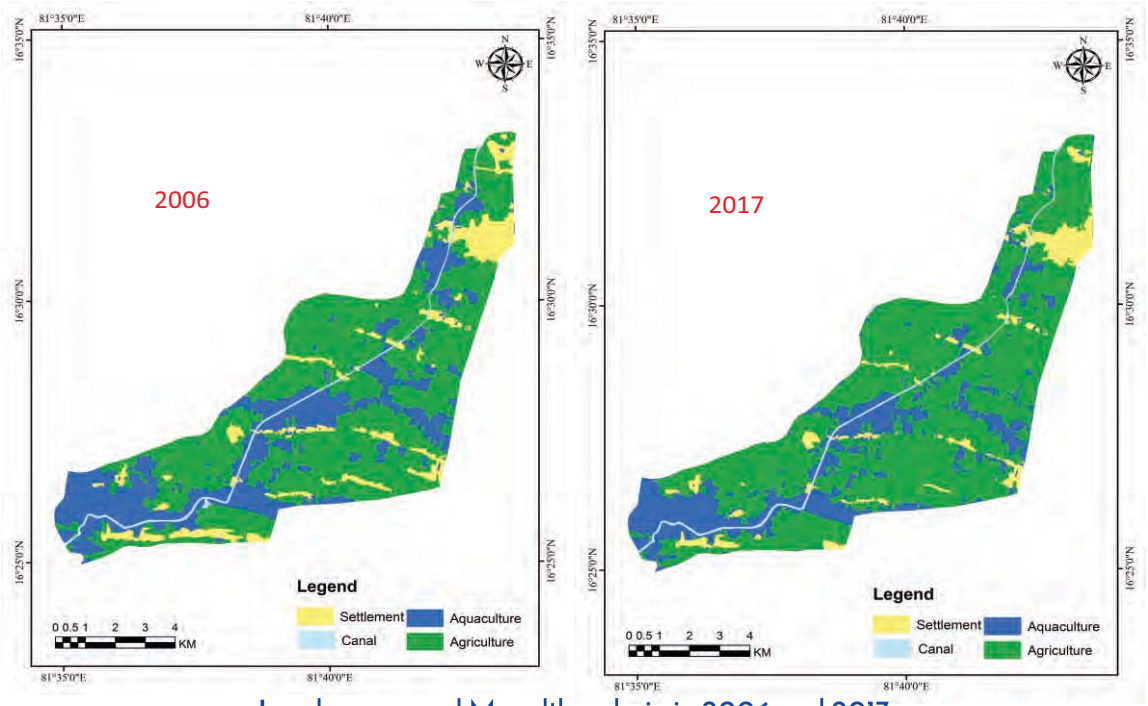




Seasonal changes in water quality parameters of Adyar creek and estuary

Comparison of carrying capacity estimations of brackishwater sources for *P. vannamei* and *P. monodon* farming

In West Godavari District, Andhra Pradesh, there was not much increase in vannamei farming area compared to earlier tiger shrimp farming, except for the intensification in brackishwater mandals, whereas the increase in area was enormous in freshwater mandals. Investigations were carried out to assess the carrying capacity of Mogalthur Drain, brackishwater source pertaining to vannamei farming and compared the earlier estimation for tiger shrimp (*P. monodon)* farming. The drain was divided into three zones and water samples were collected from 12 sampling stations on the drain shrimp culture ponds and water bodies. Based on bathymetry details of source waters and nutrients loading from both shrimp culture ponds and paddy fields into source waters, carrying capacity was estimated. An increase in shrimp farming area of 277 ha was observed in 2017 compared to 2006. The nitrogen loading into the drain was more than the carrying capacity and it is advised to reduce the stocking density in zone 3. The scope for increased area for vannamei is due to the scattered harvest over different months during the year unlike tiger shrimp, where maximum biomass harvest was in July and Nov/Dec months.



Land use around Mogalthur drain in 2006 and 2017

Environmental impact assessment (EIA) of crab farming and carrying capacity estimation of brackishwater creeks for crab farming in Sindhudurg District, Maharashtra

Environmental impact assessment and monitoring of water and soil quality from source water, crab culture pens and ponds, discharge water and receiving water body prior to culture, during culture period and harvest time for two crops in Malwan, Davgad and Vengurula taluks of Sindhudurg District showed no negative environmental impacts of crab farming on the receiving water bodies. There are no obvious sources of pollution nearby the crab farming sites which would negatively affect crab framing, either directly or indirectly. Virgin mangrove forest was not affected nor will regenerating mangrove forests be impacted to any significant degree. The probable impacts were identified and mitigation measures were recommended for sustainable crab farming in pond/pens.

Carrying capacity assessment of three water bodies in the district was estimated based on the bathymetry details of the creeks, nutrients concentration from crab ponds and pens and their load in water bodies. A maximum area of 256 ha on Mandavi creek in Vengurla, 471 ha on Achara creek in Malvan and 475 ha on Naringree creek in Devgad can be recommended for crab farming.

Pen structures installed near mangrove area for farming of crabs in Sindhudurg District, Maharashtra

Carrying capacity (CC) of creeks and area recommended for crab farming

Source water	CC of source water for N (Kg/day)	Total N load (kg/day)	N loading (kg/day) that can be accommodated	Area recommended for crab farming (ha)
Achara creek, Malvan	673	3.43	669	471
Mandavi creek, Vengurla	72	0.86	71	256
Naringree creek, Devgad	293	3.26	290	475

Soil and water health cards distribution for aquaculture farmers in Public Private Parternership (PPP) mode

Soil and water health cards (SWHCs) were prepared for aquaculture farms in coastal districts of Tamil Nadu and Andhra Pradesh and distributed to farmers in the programs organized by the Institute. As it is not possible to issue the SWHCs to a large no. of farmers throughout the country by the Institute, a working model in PPP mode was developed in collaboration with three private laboratories viz., Alpha Biologicals Pvt. Ltd., KCT Group and Blue Shell Aqua Analytical Lab and Fisheries College in Nellore District, Andhra Pradesh. Initially, Awareness was created among the farmers about the

importance of SWHC through media. About 190 and 37 SWHCs were distributed to aquafarmers from Kota Mandal and Allur Mandals, in Nellore District, AP and Elavur, Tamil Nadu respectively. The information provided in the cards is useful to farmers in understanding the nutrients status of the soils and water quality which will help in managing the pond soil and water parameters in optimum levels. The database from SWHCs captures the geographical variation and helps in framing

Greenhouse gases (GHGs) emission from cage culture systems

GHGs flux was collected from cage/pen culture systems and open water bodies of *L.calcarifer* (4 X 5 X 2 m), *C.chanos* (10 X 11 m) at Venangapattu, and *M.cephalus* (2 X 1 X 1 m) at Srinivasapuram with biomass of 80, 3.7 and 0.75 tons, respectively. GHGs emission in CO_2 eq. emission kg/ha was 341, 508 and 220, respectively from the three culture systems, whereas the emission from open waters from Venangapattu and Srinivasapuram was 623 and 853 respectively indicating the sustainability of cage aquaculture systems.

Collection of GHGs from Seabass cage culture systems installed in open waters at Venagapattu, Tamil Nadu

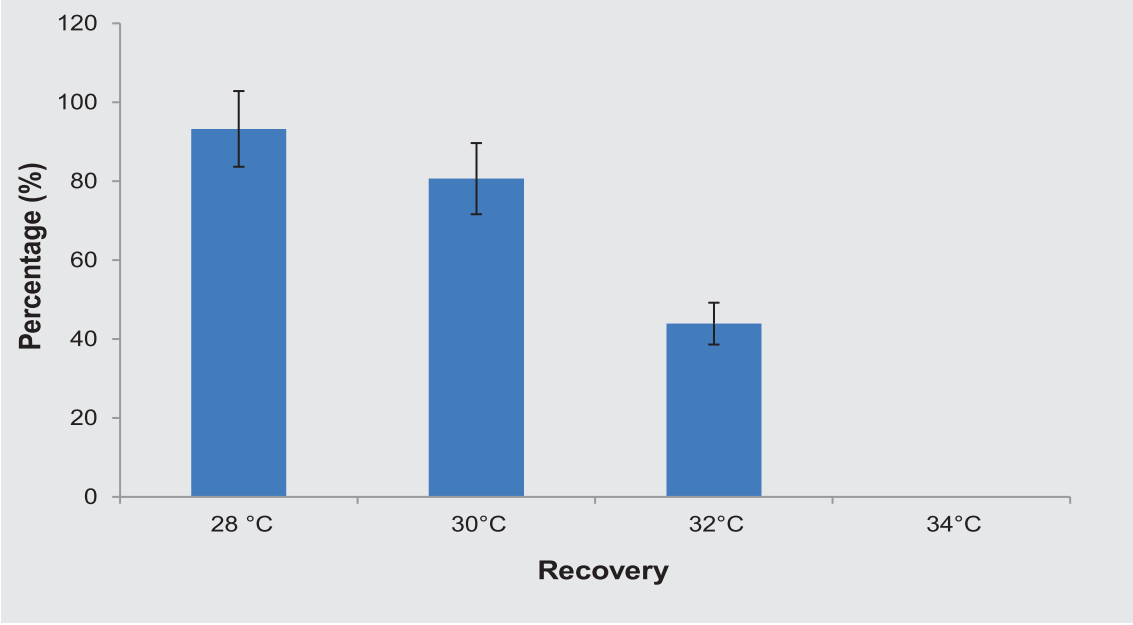
Influence of pond drying on greenhouse gases (GHG) emissions from shrimp ponds

GHGs flux was collected during a culture period of *P.vannamei* (56 to 60 nos./m^2) and *P.indicus* (36 to 54 nos./m^2), two days after harvest and, 30 and 46 days after drying from pond bottom sediment. The pond bottom emitted a higher amount of CO_2 during the drying process (2245 – 4142 g/ha/d), compared to the emission during culture period (640 – 2942 g/ha/d), whereas CH_4 emission was high during culture period, and N_2O emission trend was not significant.

Thermal stress experiments in seabass

Environmental manipulation unit for temperature controlled recirculation system was fabricated. Investigations on thermal stress tolerance on the recovery of Asian seabass fry (0.15 g body weight & 18- 22 mm length) showed that seabass fry could tolerate acute temperature stress for a period of 72 h till 30 °C with minimum mortality. Beyond 32°C water temperature, mortality was high and is not advisable for seabass nursery rearing. 24 h recovery was high in control temperature of 28 °C.

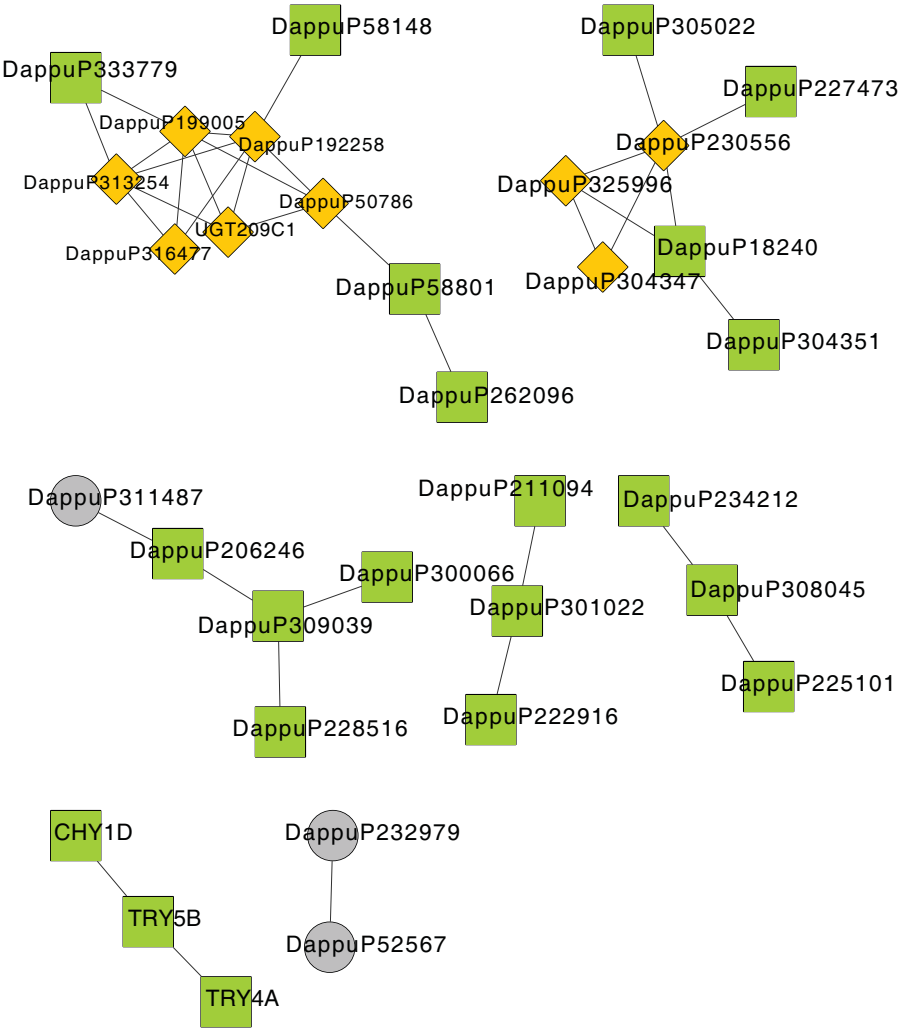
In situ environment manipulation unit



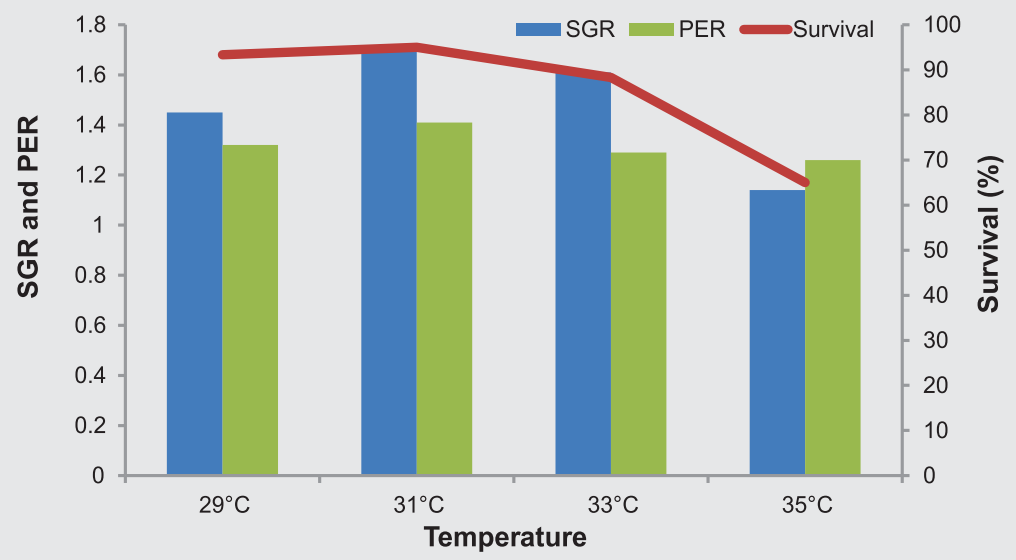
Percentage of recovery of Seabass after thermal stress

Effect of temperature stress on growth, fatty acids, stress indices and transcriptome profiling in *P. vannamei*

Effect of temperature (29, 31, 33 and 35 °C) on *P. vannamei* juveniles in thermostatically controlled RAS system showed better survival and growth of shrimp between 31 and 33 °C. Total lipid and fatty acid content increased in hepatopancreas shrimp reared in 31 and 33 but not at 35 °C. Transcript expression results (KEGG pathways) also indicated the increased fatty acid biosynthesis, pentose phosphate pathway and biotin metabolism at 31 and 33 °C and not at 35 °C. The hepatopancreas of shrimp was utilized for RNA-seq experiments and finding of differentially expressed transcripts in temperature-stressed shrimp. Out of the down-regulated transcripts at 33 °C, six interacting protein networks could be documented with searches made in STRING database and using cytoscape tool. One of the networks has enzymes involved in the breakdown of proteins which indicate that *P. vannamei* shrimp might lose the ability to digest protein at higher temperatures. Results led to the increased understanding on the preparation of functional feeds for temperature stress



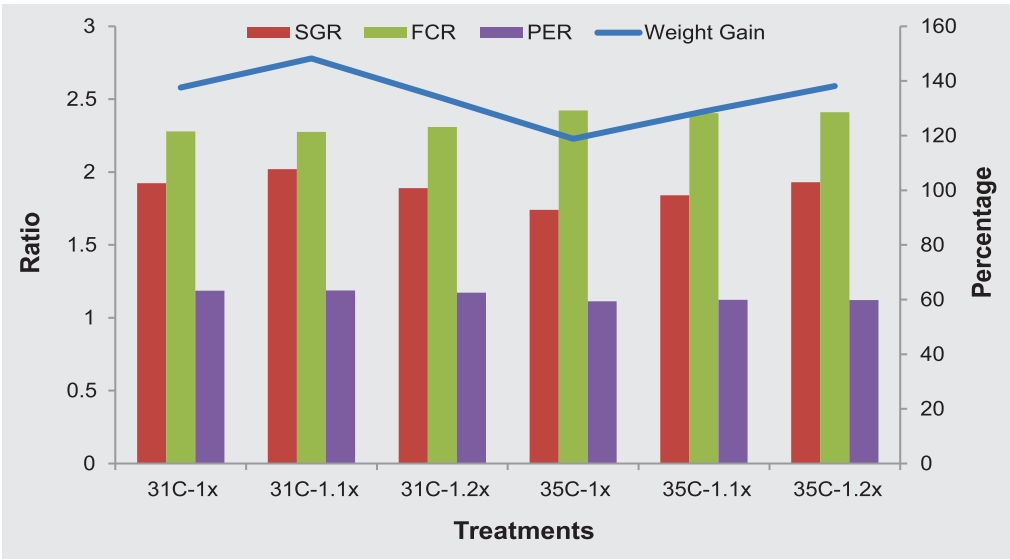
Interacting protein networks among down-regulated transcripts in temperature-stressed P. vannamei.



Growth, survival and immune parameters of *P. vannamei* reared in different temperatures

Effect of supplementation of fat-soluble vitamins for the amelioration of temperature stress in *P. vannamei*

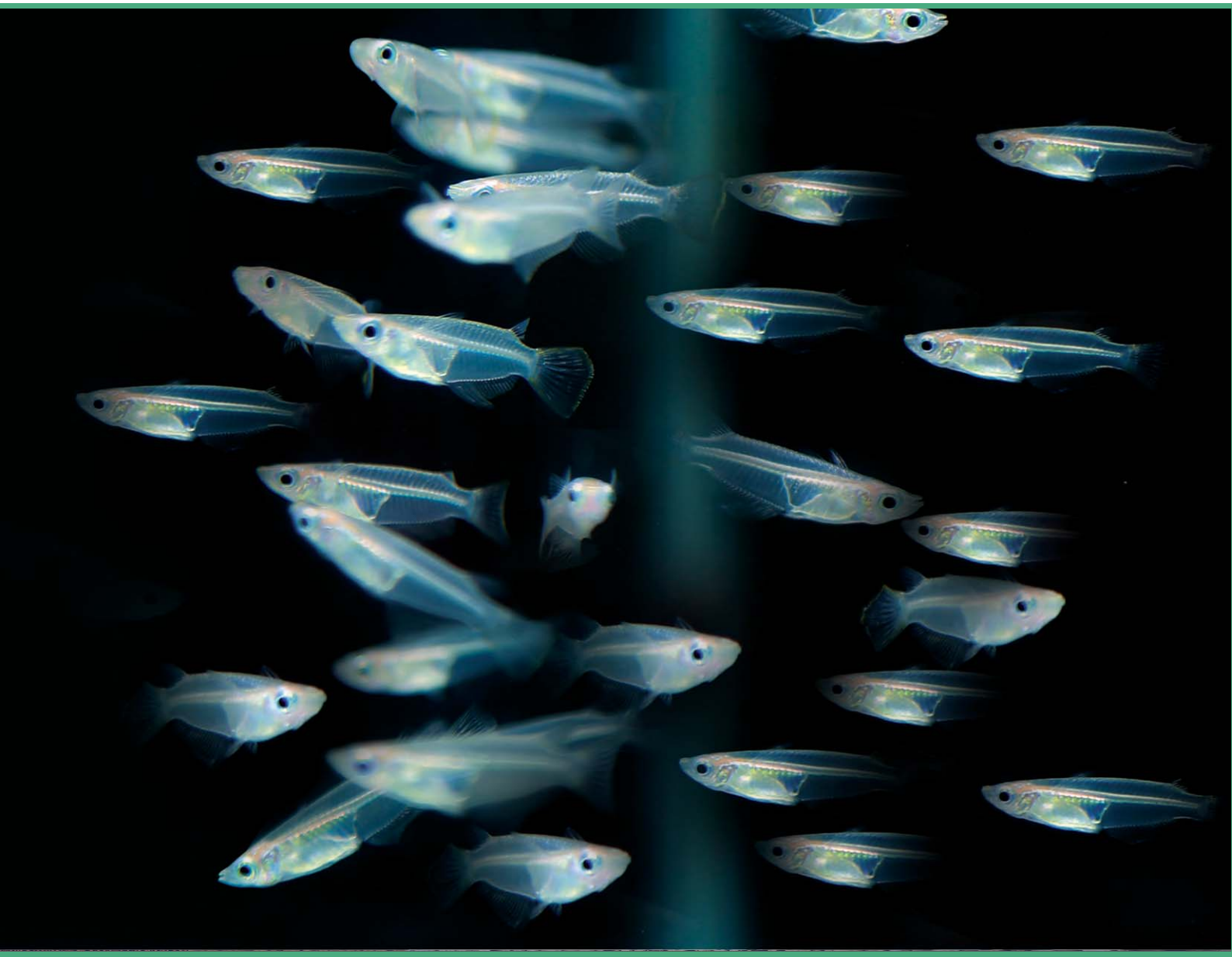
Based on the results of an experiment on the effect of temperature on growth and nutrient utilization the effect of supplementation of fat-soluble vitamins were studied at 31 and 35 °C. Three practical diets with varying levels of fat-soluble vitamins (1x, 1.1x and 1.2x) were prepared and tested in the juveniles (2.42±0.15 g) of *P. vannamei*. The results showed significant (P<0.05) increase in the weight gain at 31°C with10% higher supplementation of fat-soluble vitamins.



Effect of supplementation of fat-soluble vitamins for the amelioration of temperature stress in *P. vannamei* on growth and nutrient utilization

GENETICS & BIOTECHNOLOGY

Biology of aquatic organisms offer possibilities for rapid genetic improvement. CIBA focuses on wide range of genetic techniques that secure aquaculture production in future.



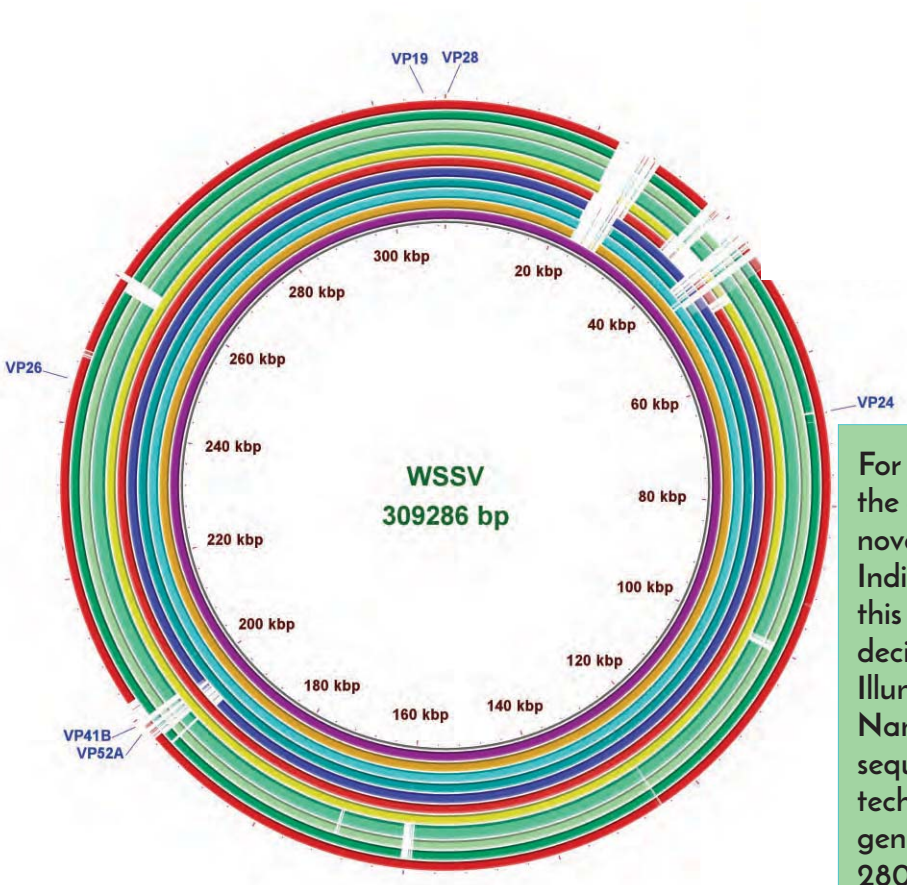
Orzias javanicus, an ornamental fish and a model organism for aquaculture research

Genetics & Biotechnology

First report on the complete genome of an Indian isolate of White Spot Syndrome Virus (WSSV)

White Spot Syndrome Virus is a major pathogen of shrimps causing economic loss to the aquaculture industry. For the first time, the complete *de novo* genome of an Indian isolate of this virus has been deciphered using Illumina and Nanopore sequencing technologies. The genome has 280,591 bp with 442 predicted coding genes.

An isolate of WSSV, IN_AP4RU was obtained from the pleopods of infected *Penaeus vannamei* samples that were collected from a shrimp culture pond located in Andhra Pradesh in 2014. The presence of virus was confirmed through PCR. Two sequencing technologies were used to build the complete genome of this virus. The assembly was principally built with long nanopore reads which were corrected for error bases using short Illumina reads. Initially, about 14 million Illumina and 170,475 Nanopore reads were separately aligned on to a WSSV



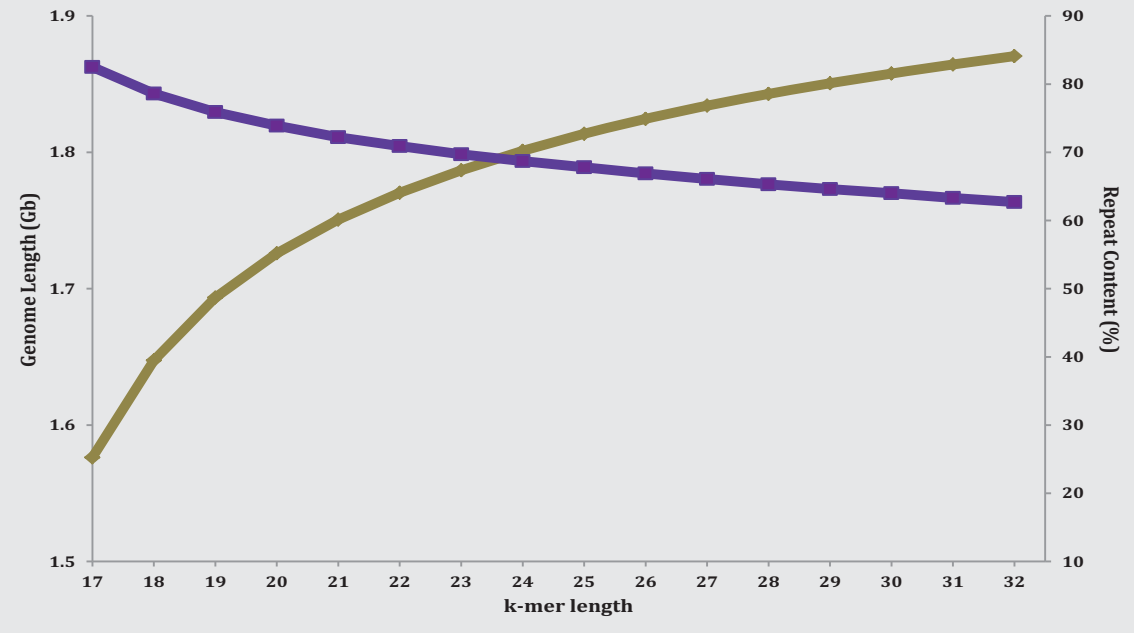
Comparative map of available WSSV genomes against the longest isolate of China, as the inner circle. Few envelope proteins missing in some genomes are also plotted

For the first time, the complete de novo genome of an Indian isolate of this virus has been deciphered using Illumina and Nanopore sequencing technologies. The genome has 280,591 bp with 442 predicted coding genes.

reference genome (GenBank accession KT995472) using BWA tool to separate out virus-specific DNA reads. About 771,852 Illumina paired reads were used to correct 27,883 Nanopore reads that originated from viral DNA. These nanopore reads were used for *de novo* assembly using CANU v1.1. The assembly generated a single contig of 280,591 bp. This is the smallest genome reported so far for WSSV and akin to a Chinese WSSV isolate of 281054 bp. The genome fragment was analyzed at Rapid Annotation using Sub-system Technology (RAST) server specifying 'Virus' domain which predicted about 442 coding sequences. The annotation of coding sequences was obtained through a local blast search against Uniprot Virus database using blast2go tool with an e-value of 1e-5. The complete genome sequence has been submitted to the GenBank database with the accession number, MG702567. The complete genome of Indian isolate was compared with genomes of other WSSV isolates available at GenBank to identify the missing regions in Indian isolate.

Genome size of *P. indicus* based on Jellyfish k-mers

Earlier, the DNA of Indian White Shrimp (IWS) had been sequenced on Illumina platform to generate about 2.66 billion reads. These sequence reads are to be used for building the complete genome of Indian White Shrimp. After performing quality control that involves removal of contaminating adapter content from reads, discarding poor quality reads, trimming of poor quality ends at 3' ends of reads and removal of shorter reads, about 1.97 billion reads of 225 Gb length were available. These good quality sequence reads were used to estimate the genome length of IWS based on Jellyfish k-mer principle. Different lengths of k-mer ranging from 17 and 32 were used to estimate the genome length and repeat content. The genome length varies between 1.57 to 1.87 Gb. The repeat content of the genome varied between 62.7 to 82.5 %. As the length of k-mer increased, there is an increase in estimated genome length and a decrease in estimated repeat content. This could be due to resolution of some repeat regions as the k-mer length increased.



Estimated genome length (primary Y-axis) and repeat content (secondary Y-axis) of *P. indicus* genome at different k-mer lengths (X-axis) of Illumina sequence data

Assembly of complete genome of *P. indicus*

The genome of *P. indicus* was built with three assemblers namely Soap *denovo*, CLC genomics workbench and Platanus using 1.97 billion Illumina sequence reads. A common observation with all three assemblers is that the assembly is broken to several fragments. This could be due to high repeat content of the shrimp genome and high heterozygosity of the specimen used. When the number of contigs assembled by various assemblers was examined, we find very high numbers to the tune of about 9 million. These several fragments would not indicate anything about the genome except for high repeat content and high heterozygosity. However, to extract useful information, we had also summarized the number of contigs that are equal to or longer than 1000 bp. These longer contigs are about 1.86 to 15.05 % of the total number of contigs and represent about 11 to 22 % of complete genome (assuming 2.47 Gb as genome size from flow cytometer reading). The efforts indicate that an assembly of shrimp genome cannot be built with short Illumina reads. It is planned to build the *P. indicus* genome with long sequence reads obtained on Pacbio sequencing platform.

Statistics of assembled genome of *P. indicus* based on short reads sequence data

	Soap denovo	CLC Genomics workbench	Platanus
No. of contigs,	7654919	2149684	9931046
No. of contigs, ≥1000 bp	212121	323453	185169
% of contigs of ≥1000 bp to the total no of contigs	2.77	15.05	1.86
Total length, bp	298 118 791	548 973 115	272 512 812
% of genome represented by contigs of ≥1000 bp	12.07	22.23	11.03
Longest contig, bp	12399	108009	22336
GC (%)	37.90	38.91	38.35
N50, bp	1346	1685	1421
L50	81460	107511	68592

Transcriptome profiling of WSSV infected *Penaeus vannamei*

P. vannamei shrimps (n=106) weighing between 15-20g were infected with WSSV virus by intramuscular injection. The gill samples from three individual shrimps were collected at 1.5, 3, 6, 9, 12, 18, 24, 30, 36, 48 and 56 hour time points post-challenge. The collected tissue samples were immediately frozen in liquid nitrogen and stored in a deep freezer. The infected samples tested positive for WSSV by PCR. The viral copy number at 11 different time points post-infection was calculated using qPCR and it was observed that there was a spike at 18 hours. Hence gill tissues collected from control and infected shrimp at 18 hour were taken up for RNA-seq to build transcriptome assembly and conduct differential gene expression studies.

A single assembly was made with RNA-seq data of six shrimp, 3 control and 3 infected in Trinity software. The assembly generated 7,92,385 transcripts with N50 of 493 bases. The transcripts were subjected to differential gene expression studies to document those transcripts that are up-regulated in infected shrimp based on read counts. The criteria used to find significantly up-regulated transcripts were log fold change of 4 and FDR value of less than 0.001. About 1987 transcripts were found to be up-regulated in infected shrimp. Out of these, 86 were mapped in 43 KEGG pathways. Efforts are in progress to unravel interactions among significantly up-regulated transcripts for documenting interacting protein networks.

Estimation of genome size of brackishwater fishes and shrimp by flow cytometry

Various fish and shellfish species are being cultured globally, amongst them brackishwater fishes and shrimp constitutes an important food resource. With the rapid advancement in NGS techniques, there is a concerted research effort worldwide to decipher whole genome sequence of various aquaculture fish and shellfish species including the non-model organisms to understand the organization and evolutionary pattern of their genomes. Prior estimation of the genome size is therefore essential in comprehending the genome content of the species. The genome size estimation was performed using BD Accuri™ C6 plus flow cytometer (BD Biosciences, USA) and was estimated with the corresponding mean value of the unknown and with the known genome size of chicken (*Gallus domesticus*). The mean estimated genome size from five individuals each of six fish species is shown in Table 2. On comparison, *Etroplus suratensis* showed the largest genome size of 1.71 ± 0.16 (pg) whereas *Lates calcarifer* showed the least genome size of 0.44 ± 0.02 (pg). The less genome size of *Lates calcarifer* (0.44 ± 0.02 pg) as compared to the reported larger size of this fish indicates variation due to distinct species found in the Indian subcontinent.

The estimated genome size from three individuals each of either sex of four shrimp species is shown in table below. Significant difference was observed in the genome size between male and female shrimp of all species except in *P. monodon*.

Estimated genome size for six fish species

Species	*Genome size (pg)*
Chanos chanos	0.72 ± 0.01
Lutjanus argentimaculatus	0.95 ± 0.10
Etroplus suratensis	1.71 ± 0.16
Scatophagus argus	0.79 ± 0.01
Liza macrolepis	0.87 ± 0.02
Lates calcarifer	0.44 ± 0.02

Estimated genome size of four shrimp species

Species	Genome size in male (pg)	Genome size in female (pg)
Penaeus monodon	2.86 ± 0.06	2.91 ± 0.03
*Penaeus japonicus**	2.30 ± 0.04	2.14 ± 0.02
*Penaeus vannamei**	2.32 ± 0.13	2.19 ± 0.03
*Penaeus indicus**	2.19 ± 0.02	2.47 ± 0.04

* The genome size varies significantly ($P < 0.05$) between sexes.

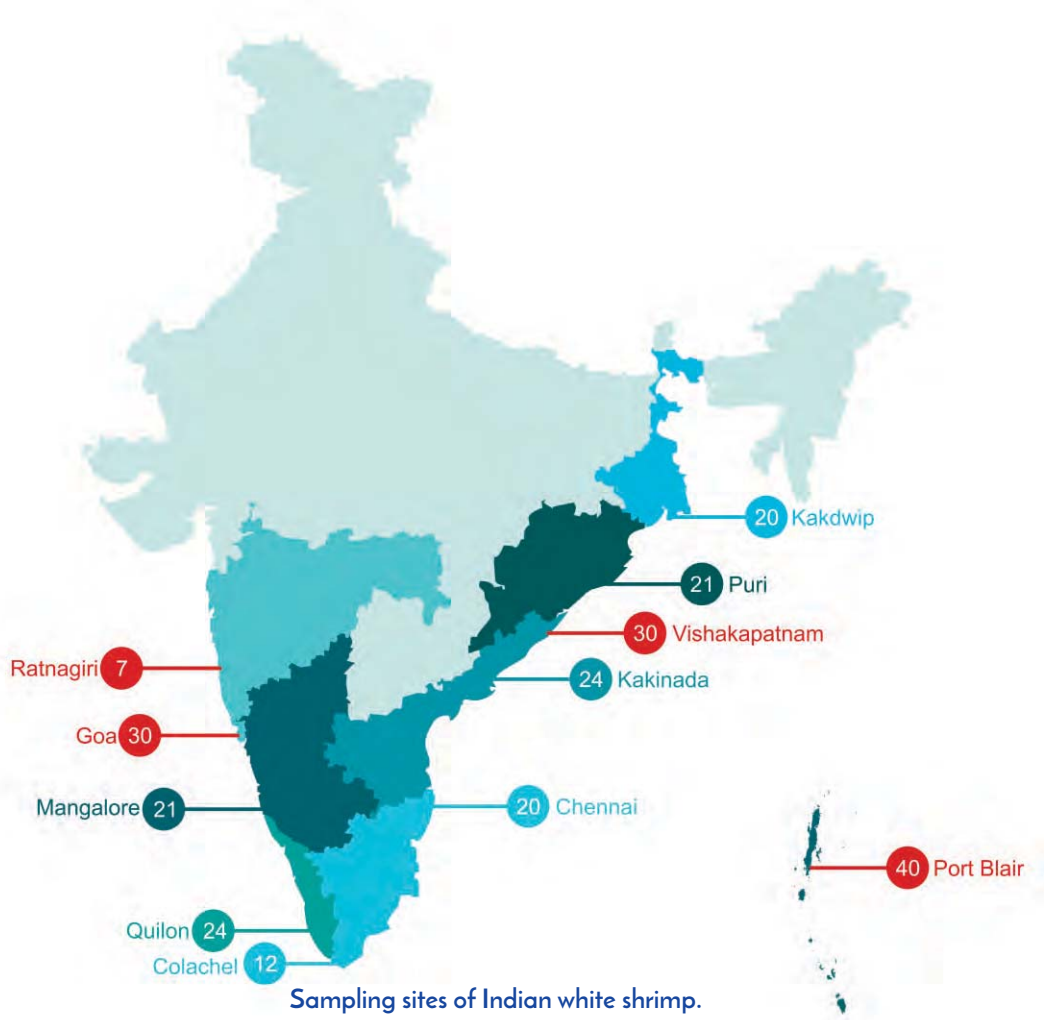
Population structure of Indian White shrimp

Penaeus indicus is a commercially important shrimp in our country after *Penaeus vannamei* and *Penaeus monodon*. Identification and evaluation of growth performance of these stocks of existing stocks in culture are preliminary steps for domestication and selective breeding. The genetic diversity, population structure and phylogenetics of *P. indicus* from the Indian coast using partial sequence data analysis of the 16S rRNA gene was carried out.

P. indicus samples from 11 locations along the coastal states of India *viz.* Kakdwip (20), Puri (21), Vishakapatnam (30), Kakinada (30), Chennai (30), Colachel (27), Kollam (24), Mangalore (21), Goa

(30), Ratnagiri (7) and Port Blair (40) were collected. The species of the samples was confirmed using COI gene sequences. Mitochondrial 16S rRNA gene sequence data was generated and 121 gene sequences were submitted in GENBANK with accession numbers MH094288-MH094408.

Sequence data analyses of mitochondrial 16S rRNA gene using Arlequin software revealed that there are only two different stocks of *P. indicus:* West Bengal (Kakdwip) stock and Rest of India (Mangalore, Kollam, Kanyakumari, Chennai, Kakinada and Puri) stock.



Sampling sites of Indian white shrimp.
Places in red indicate that samples did not conform to the species

Transgenic studies

Experiments were conducted to produce novel transgenic *Penaeus vannamei* with highly vivid fluorescent phenotype through transgenesis of a Green Fluorescent protein gene (GFP). Efforts were also taken to construct a green fluorescent protein (GFP) reporter construct regulated by an endogenous β-actin promoter in *P. vannamei*. The β-actin promote gene from *P. vannamei* was amplified using specific primers and sequenced for confirmation. The gene was strategically inserted into GFP vector to build a β-actin promoter-GFP gene construct for further studies. The gene construct was then cloned into a DH5-α strain of *Escherichia coli*. The β-actin-GFP plasmid was isolated and injected intramuscularly to *P. vannamei* juveniles to study the integration of transgene to muscle tissue. The injection was given at two different doses *viz.* 50 µg/mL and 100 µg/mL and reared in the laboratory to check for fluorescence along with control shrimp (un-injected). Further work is in the process of standardisation.

Population diversity of *Etroplus suratensis*

The populations or stocks of a species differ among them due to limited migration among the adjacent populations and continuous inter-breeding of the individuals of the same population. Further, the stocks have very well adapted to their local habitats too and therefore the existence of maximum level of genetic variation among the stocks is considered to be vital. Hence, documentation of the diversity of a species helps us to understand its genetic makeup as well as to construct the conservation strategies. Among the cichlids, Etroplus is the only genus endemic to India. *Etroplus suratensis* (pearlspot), an omnivorous fish widely distributed across brackish and fresh water sources of peninsular India. It is primarily of brackish-water fish which has naturally acclimatized to the freshwaters too. The delicacy of its meat fetches higher price in the market.

E. suratensis has the potential for both food and ornamental markets. Here, the genetic diversity of *E.suratensis* was estimated using ATPase 6/8, a mtDNA gene. The *E. suratensis* tissue samples were collected across the Indian coast from Chilika (19), Nagayalanka (10), Pulicat (32), Vellayani (17), Ashtamudi (8), Vembanad (40), Goa (19), Mangalore (19) and Ratnagiri (23). The total DNA was isolated from the tissue samples. About 930bp of ATPase 6/8 gene was amplified and sequenced. The consensus sequences were utilized to estimate the F_{ST} using arlequin 3.5.1.2 tool. The F_{ST} estimates revealed that the stocks Chilika Vs Nagayalanka; Vellayani Vs Ashtamudi; Mangalore Vs Vellayani & Ashtamudi did not differ. All other stocks differed significantly (P<0.01) among them.

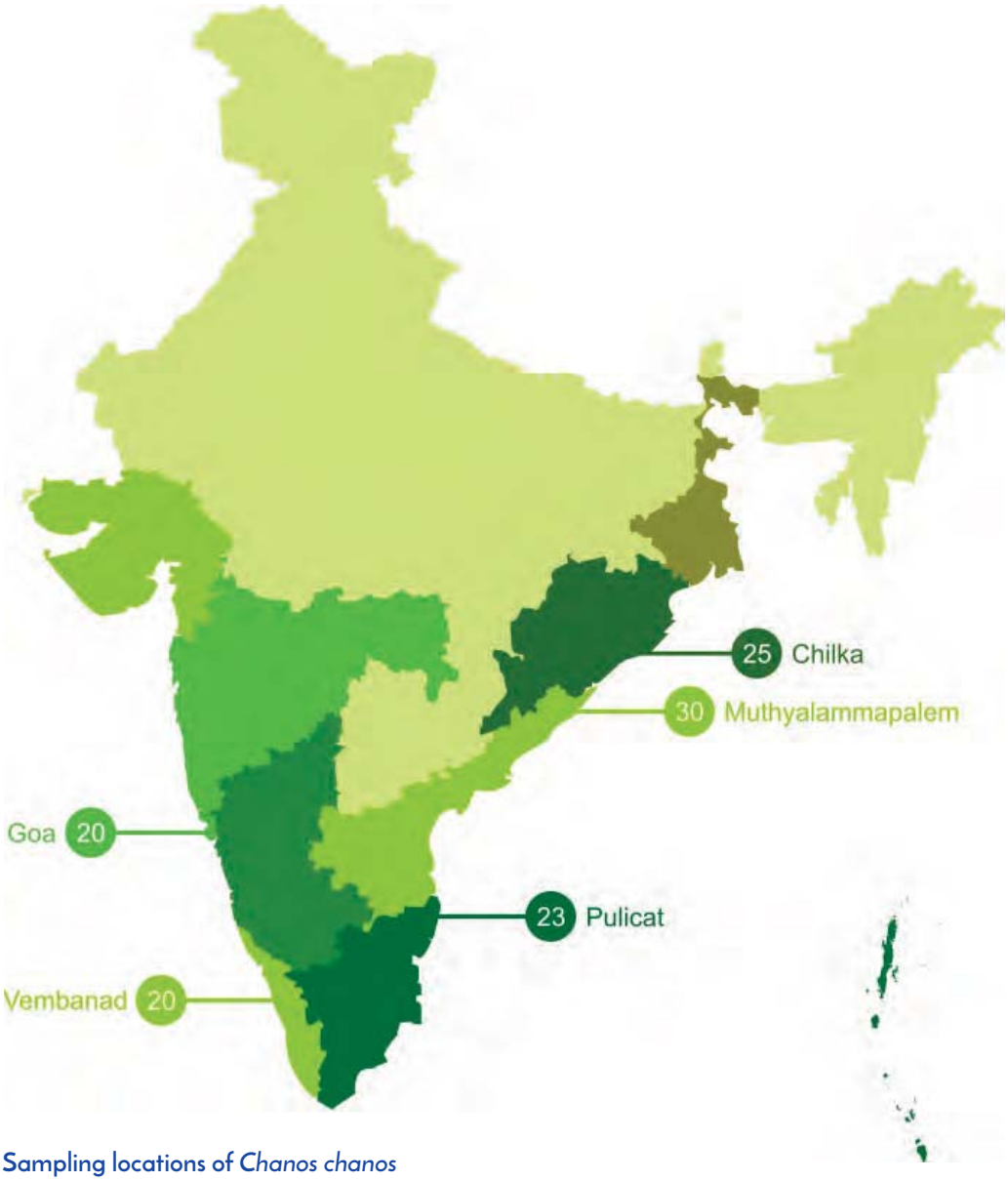
FST estimates between stocks of *Etroplus suratensis*

	Chilika (19)	Nagayalanka (10)	Pulicat (32)	Vellayani (17)	Ashtamudi (8)	Vembanad (40)	Goa (19)	Mangalore (19)	Ratnagiri (23)
Chilika (19)	_____								
Nagayalanka (10)	-0.04^{ns}	____							
Pulicat (32)	0.73**	0.74**	_____						
Vellayani (17)	0.60**	0.57**	0.50**	____					
Ashtamudi (8)	0.85**	0.89**	0.69**	0.12^{ns}	_____				
Vembanad (40)	0.30**	0.29**	0.46**	0.12**	0.20**	______			
Goa (19)	0.61**	0.59**	0.53**	0.30**	0.49**	0.32**	____		
Mangalore (19)	0.61**	0.59**	0.52**	0.07^{ns}	0.10^{ns}	0.14**	0.33**	_____	
Ratnagiri (23)	0.95**	1.00**	0.81**	0.68**	0.94**	0.59**	0.65**	0.69**	____

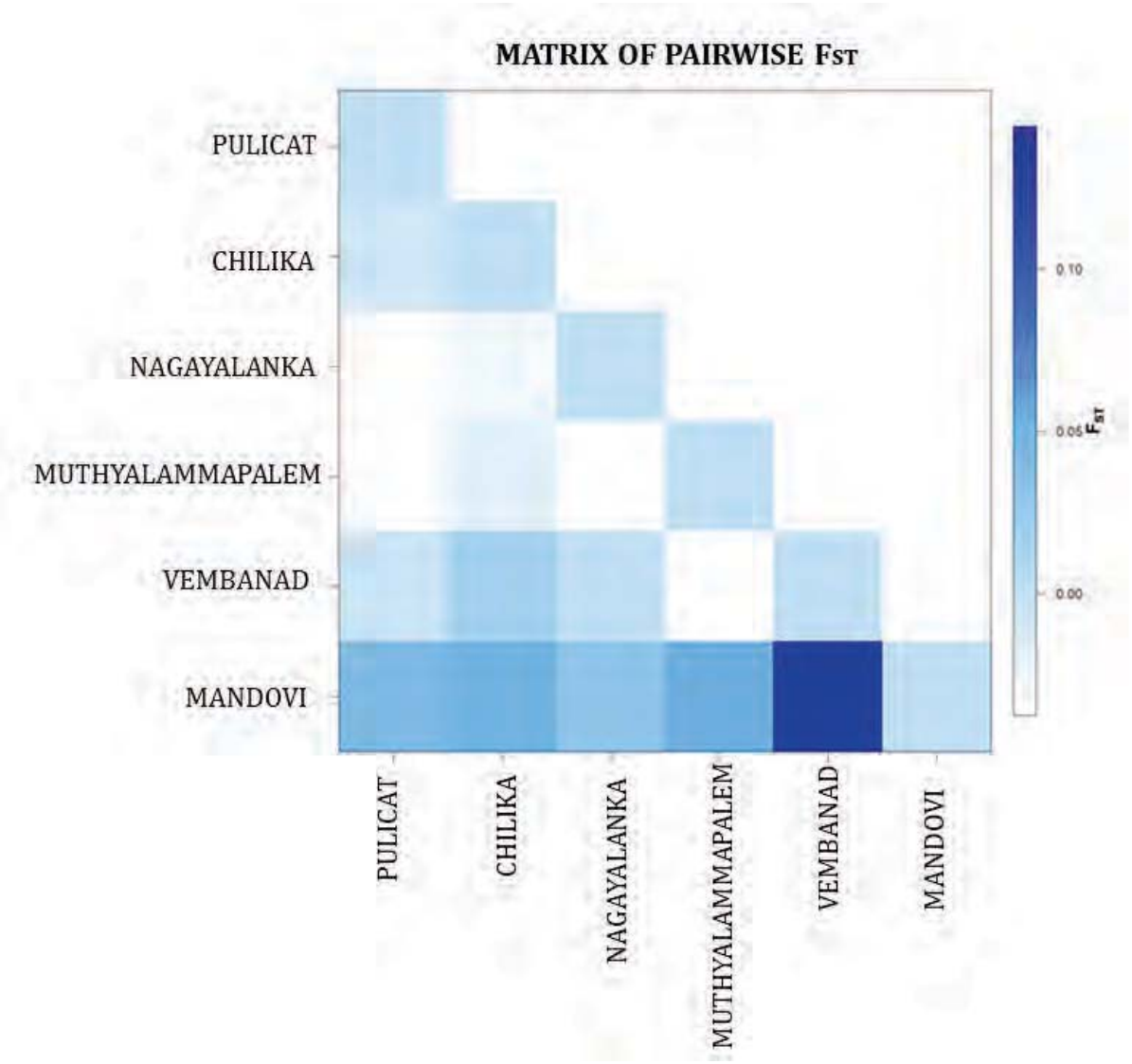
(significant P<0.01; ns – non-significant)**

Population structure of *Chanos chanos* using mitochondrial DNA

Milkfish samples were collected from the west coast (Goa:Mandovi river; Kerala: Vembanad river) and east coast (Tamil Nadu: Pulicat lake; Andhra Pradesh: Nagayalanka & Muthyalammapalem; and Odisha: Chilika lake) . The mitochondrial genes ATPase and CO I were amplified and sequenced in 98 and 111 individuals respectively. High haplotype diversity and low nucleotide diversity was observed in both sets of sequences. The analysis of ATPase sequences revealed 24 haplotypes out of 98 individuals with a haplotype diversity of 0.782 and nucleotide diversity of 0.002. The sequences of CO I revealed 17 haplotypes out of 111 individuals with a haplotype diversity value of 0.768 and nucleotide diversity value of 0.002. The most common haplotype was found in 44 individuals. Pair-wise F_{ST} analysis revealed significant genetic differentiation between the milkfish populations of Goa and Kerala. Milkfish from other regions in the east coast did not exhibit significant divergence.



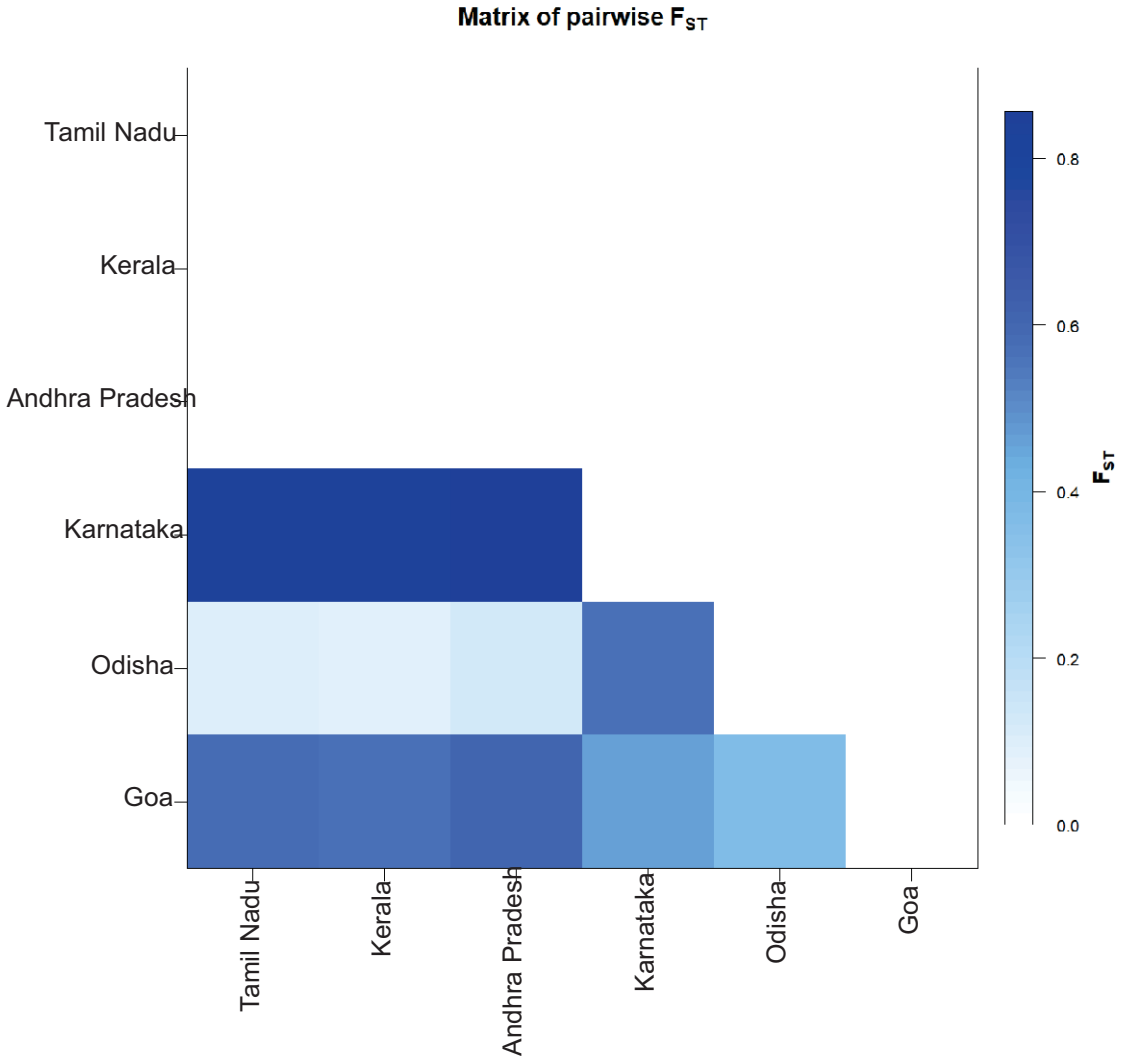
Sampling locations of *Chanos chanos*



Matrix of pair-wise F_{ST} values in milkfish

Population genetics study of *Mugil cephalus* based on mtDNA genes

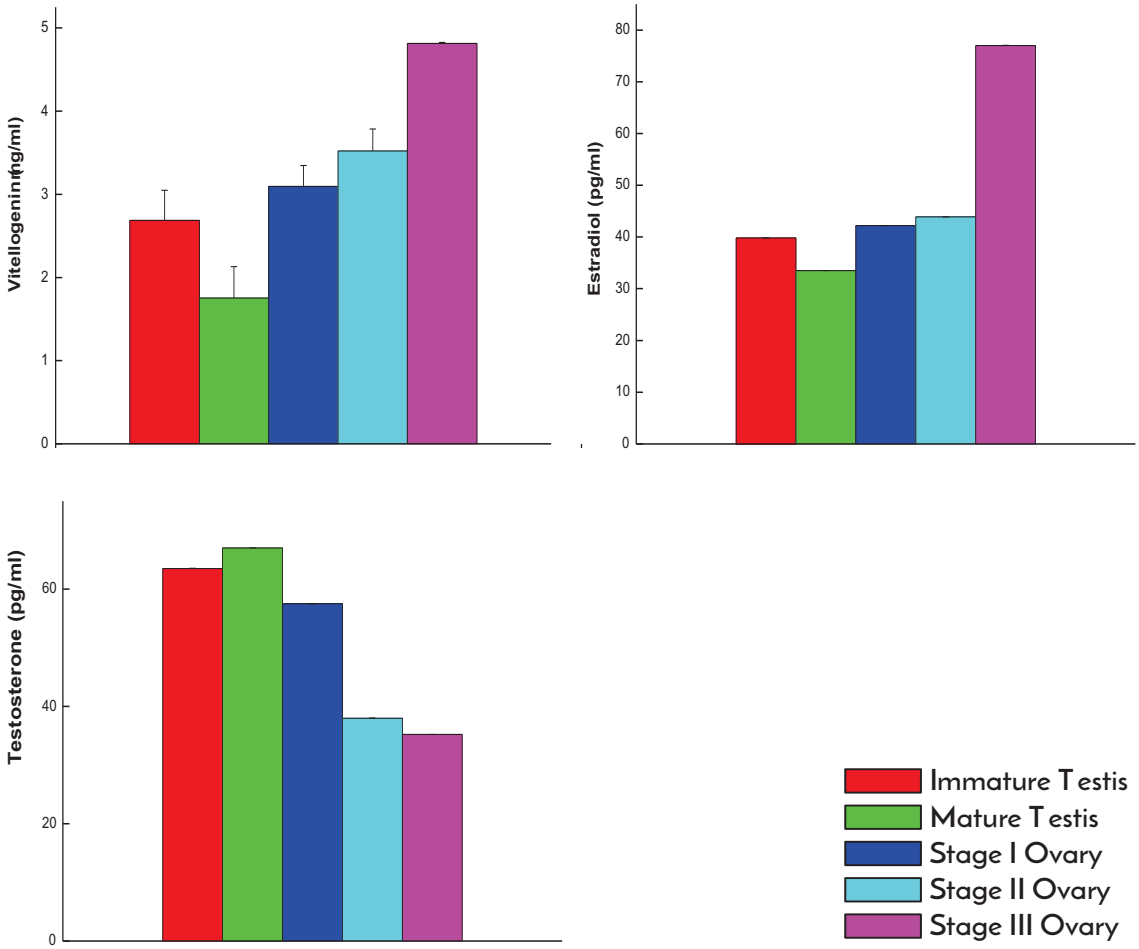
The genetic variation in natural populations of *Mugil cephalus* was analysed using ATPase 6/8 gene (842bp) of mitochondrial genome. Total DNA extracted from fin clips of grey mullet collected from Odisha, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka and Goa Coast. The ATPase 6/8 gene was amplified by PCR using universal Primers. Analysis of molecular variance (AMOVA) of sequence data revealed that stocks from Karnataka and Goa were divergent from the stocks of Tamil Nadu, Andhra Pradesh, Odisha and Kerala. A total of 10 haplotypes were identified among 110 samples collected. Overall, three distinct genetic stocks exist for grey mullet, Goa, Karnataka and the stocks from Kerala to Odisha.



The F_{ST} estimates between stocks of *Mugil cephalus*.

Plasma sex steroid hormone levels in *Mugil cephalus*

Sex steroid hormones play an important role in many physiological processes, particularly in the reproduction of vertebrates. The association of changes in gonadal development with plasma levels of gonadal steroids has proven to be a valuable tool for understanding the endocrine control of reproduction in teleosts. To analyse the changes in plasma sex steroid levels with maturation in grey mullets, adult females at different stages of gonadal development were collected from wild and were grouped into as immature or Stage I (ova diameter 30 – 110 Mm), Maturing or Stage II (ova diameter 120-180 Mm) and Mature or Stage III (ova diameter 180-650 Mm). Sera separated from the blood samples of five fishes of the same maturity stages, were pooled for analysis. The concentration of 17B-estradiol and testosterone in the plasma was determined by the enzyme-linked immunosorbent assay. Vitellogenin levels in the sera were also measured using anti-seabass vitellogenin with purified vitellogenin as standards. Higher levels of estradiol were observed in females compared to males while the levels of testosterone were higher in males. A positive correlation was observed between the serum estrogen levels, vitellogenin and growth of vitellogenic oocytes (ova diameter).

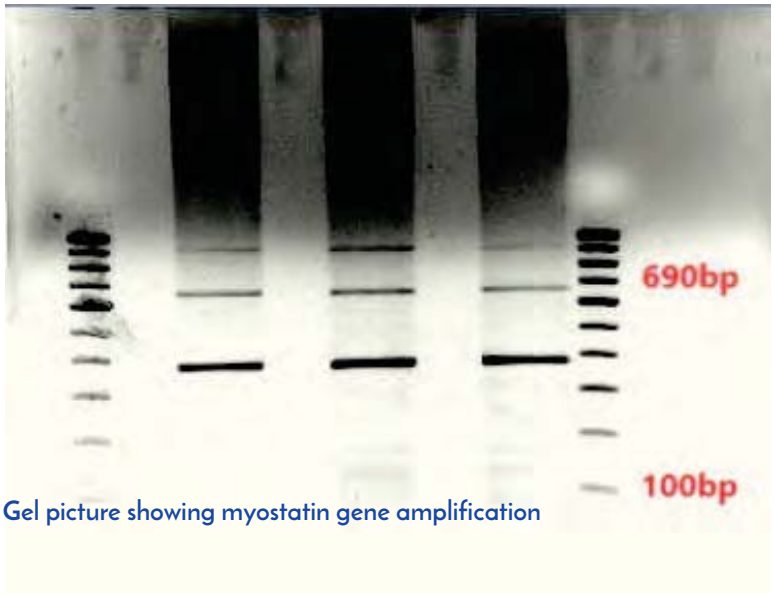


Vitellogenin, Estradiol and testosterone levels in grey mullets

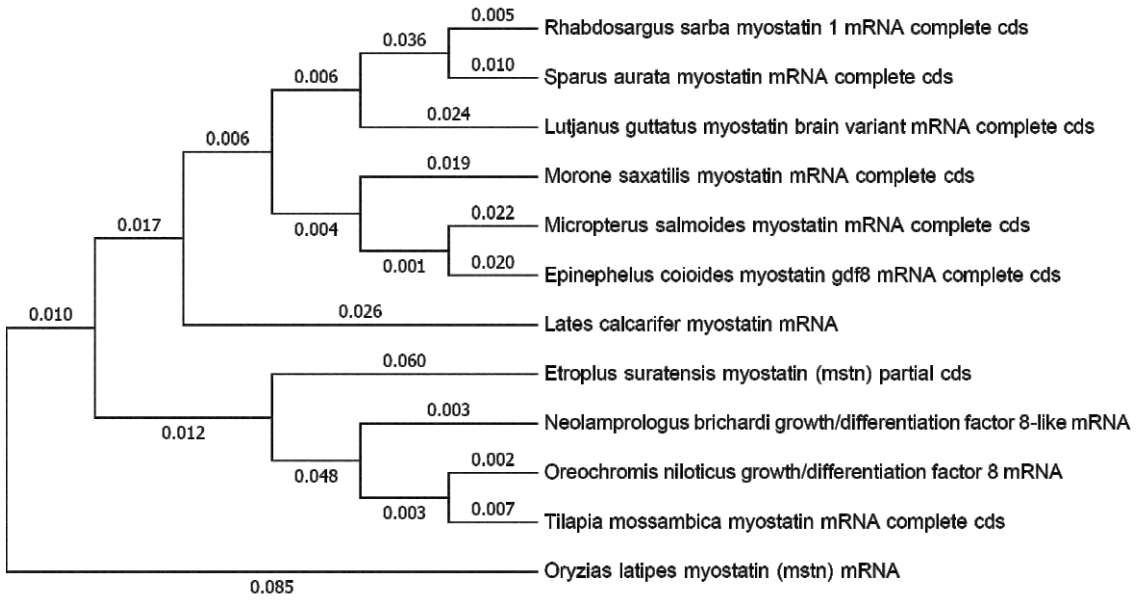
CRISPR/Cas9 mediated gene editing for growth improvement

CRISPR (clustered regularly interspaced palindromic repeats)/Cas9 (CRISPR-associated) system is a highly efficient gene editing technology, which has shown to specifically induce mutations in many aquaculture species. The engineered nuclease involved in CRISP-R generates permanent mutation by creating double-stranded breaks in the targeted gene. The intervention of CRISP-R for the improved growth of aquacultured species is reported recently. Pearlspot, *Etroplus suratensis*, is a regionally important farmed species; however aquaculture of this species is constrained due to its slow growth in the production system. Therefore, this species has been selected for the gene manipulation using CRISP-R. As the study aims at improving the muscle growth of fish, the genes controlling the muscle development took into consideration. Among the genes regulating the skeletal muscle development, myostatin gained importance. Myostatin is one of the members of transforming growth factor beta (TGF-β) superfamily which functions as a negative regulator of skeletal muscle growth and development by inhibiting production and differentiation of myogenic cells. For the characterization of the gene,

appropriate primers designed and PCR conditions were optimized for the amplification of the myostatin gene (GDF-8), of *Etroplus suratensis*. Expression of myostatin was confirmed by the PCR amplification of the partial coding sequence of the gene utilizing cDNA templates generated from the mRNA of the muscle tissue using specific sets of primers, which generated an amplicon of 690bp. A 20 bp target sequence ends with PAM (Protospacer Adjacent Motif) sequence were identified from the exon and transcribed to generate sgRNA. Stop codon cassette also designed and synthesized to include in the CRISP-R construct for the microinjection to the fish egg at the one-cell stage.



Gel picture showing myostatin gene amplification



Maximum likelihood tree showing phylogenetic relationships of *Etroplus suratensis* MSTN sequences with the sequences of other fish species

SOCIAL SCIENCES AND DEVELOPMENT

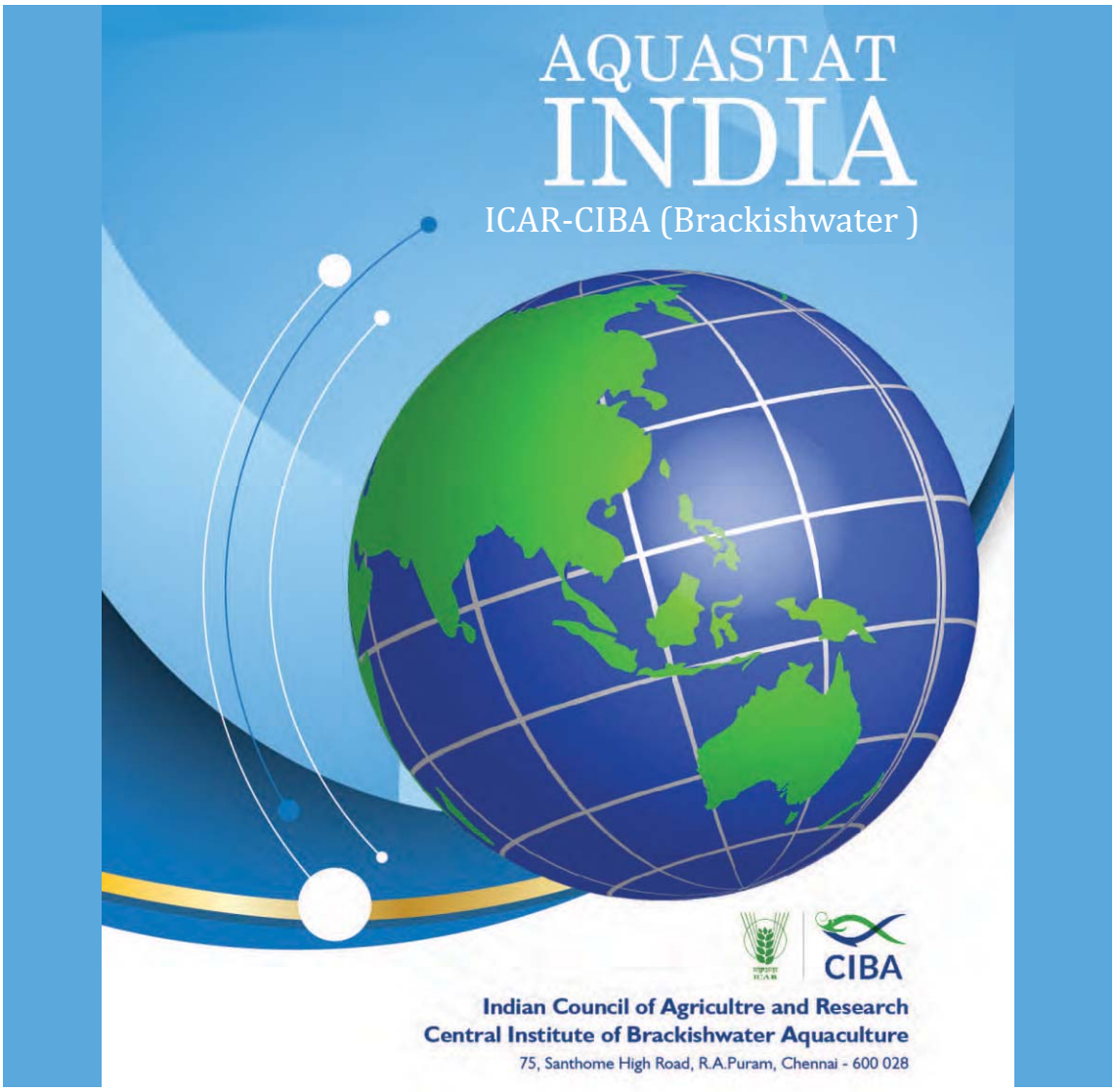
Social science has been an integral part of the aquaculture research. CIBA addresses the research issues at social context

Brackishwater aquaculture in open water is an alternate livelihood for coastal fisherman

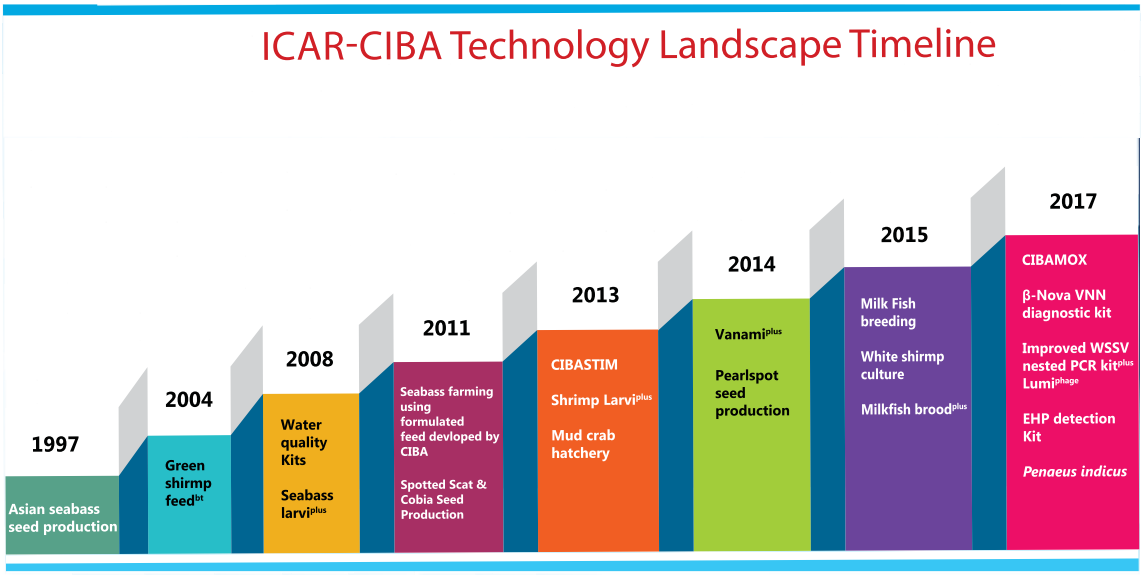
Social Sciences and Development

Aquastat India: A statistical compendium on Indian brackish water aquaculture scenario (under development)

ICAR-CIBA took the initiative to prepare "Aquastat India ", the first comprehensive database on the global and Indian scenario of brackishwater aquaculture. This compendium consists of resources, production and trade statistics of aquaculture from 1991 to 2016. Also, it includes information on technical aspects of the brackishwater aquaculture and their economic impact and infographics on technology transfer to various clients, etc.



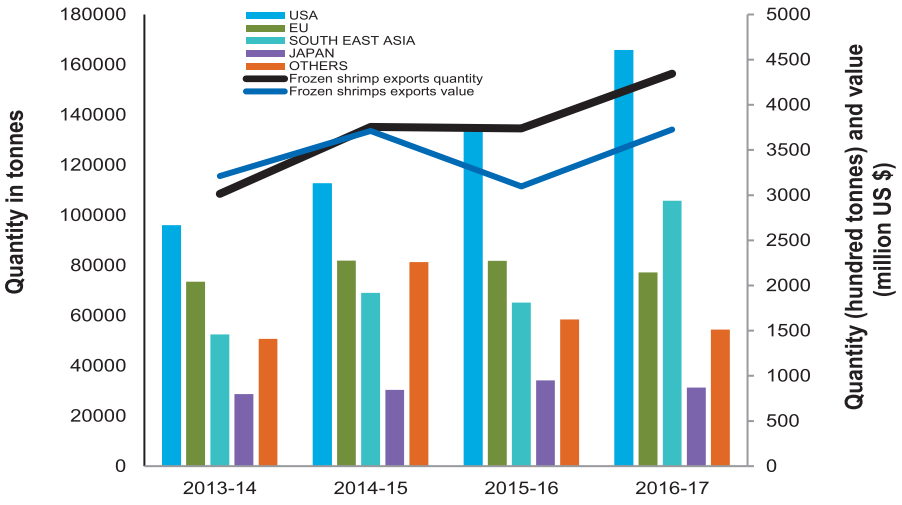
Aquastat : Infographics on CIBA seed



Technologies developed and transferred to the stakeholders of the brackishwater sector

Indian shrimp export scenario

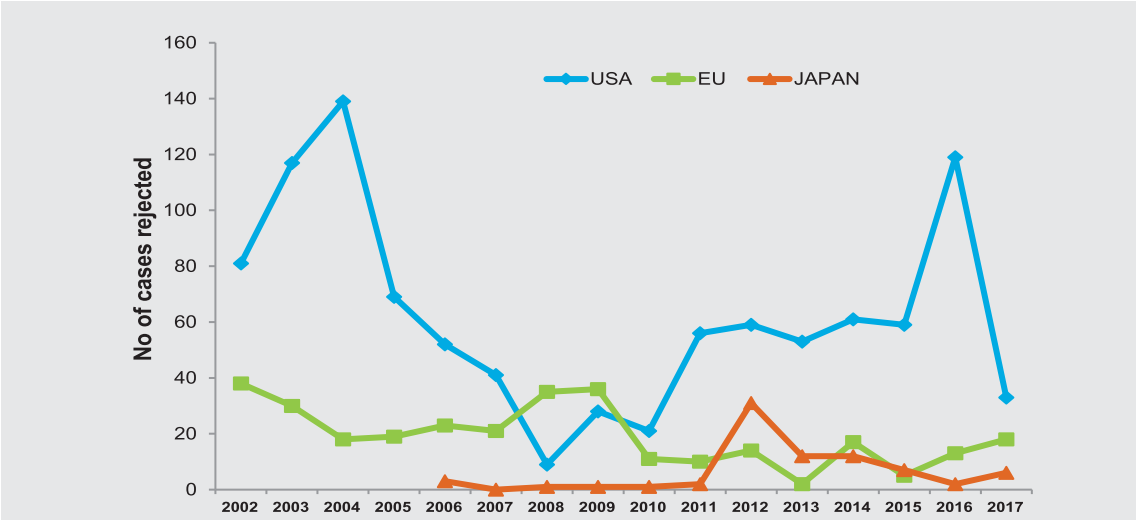
Shrimp is the world's most important commodity, accounting for about 15.3 percent of the international seafood trade. India ranked first in shrimp exports to the global market in 2016 with 14.5% growth over the previous year (FAO, 2016). India's shrimp export volume reached 4.38 lakh tonnes during 2016-17. During the same period, frozen shrimp maintained its position as the top item of fisheries export, accounting for 38.28% in quantity and 64.50% of the total earnings in USD. Shrimp exports increased by 16.21% in quantum and 20.33% in USD. Farmed shrimp alone contributed about 3.7 billion USD, which is more than half of the fish and fishery export from India. The increase in export quantity and value attributable to the introduction of *P.vannamei* in India and the decrease in international trading from competing nations such as South-East Asian countries due to disease problems. India's major shrimp exporters in 2016 were USA (38%), South-East Asia (24%), the EU (18%) and Japan (7%).



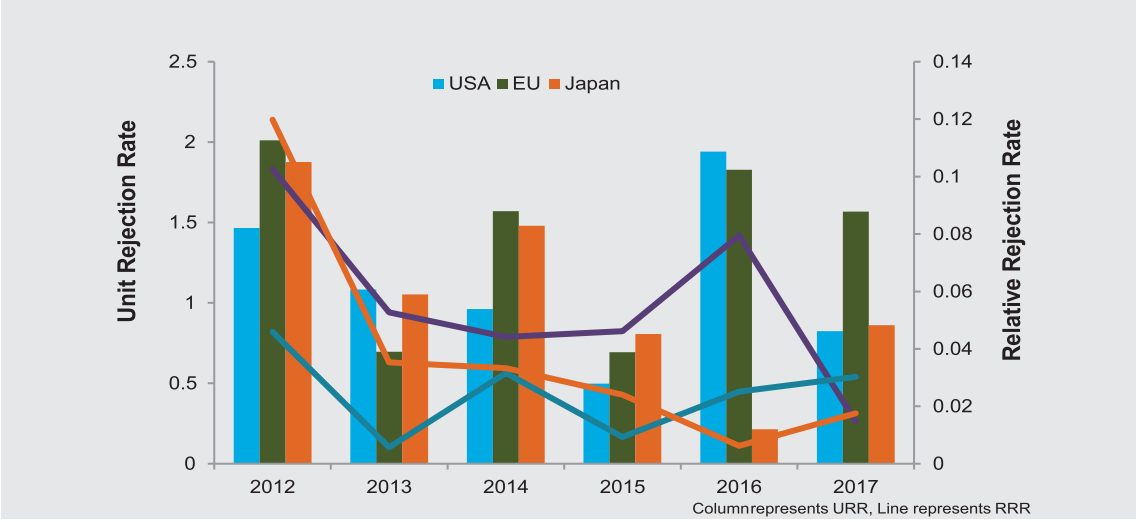
Frozen shrimp exporters of India

Trend in Indian shrimp exports rejection by USA, EU, and Japan

Among the exported aquaculture products, shrimp being a high valued item and produced mostly from aquaculture farms, the import denial due to the antibiotic residue is a matter of concern for all the stakeholders' including R&D agencies, development agencies, exports promotion arm, and policymakers. Secondary data analysis indicated that from 2002 to 2017, a total of 997, 310 and 78 Indian shrimp consignments denied entry by the US, EU, and Japan, respectively. Unit Rejection Rate (The number of rejections per million US$ exports) reflected the reducing trend of shrimp rejection by USA and EU due to the adoption of BMS in farms, HACCP protocols in the processing units and National Residue Control Plan (NRCP) by export authorities. But in case of Japan, it indicated a reducing trend except during 2012 due to the presence of chemicals Viz., furazolidone and ethoxyquin. Relative Rejection Rate (Ratio of country's share of total rejections in one market to its share of all import in that market) was meager (0.8) for US and Japan, whereas it was 1.57 for EU during 2017 and significantly declined over the years.



Rejection frequency of India's shrimp exports by USA, EU, and Japan



Unit Rejection Rate and Relative Rejection Rate of India's shrimp exports

Economic loss of Indian shrimp exports rejection

The share of economic loss to the value of exports was 0.3% for USA and Japan whereas it was 0.7% for EU during 2017. The results indicated that the loss was less than 1% of shrimp exports value. Filth and salmonella (83%) was the major cause of rejection by USA which can be easily prevented by further effective implementation of BMP at farms and HACCP protocols at processing level in future. Awareness and regulations in input use at farms and improved infrastructure facilities at farms would also help reduce rejection in future.

Impact analysis of brackishwater aquaculture technologies

Economic impacts of three select aquaculture technologies viz., WSSV kit (2002-2009), Introduction of *Penaeus vannamei* (2009-2016) and the product CIBASTIM (2012-2016) were estimated using impact assessment methodology of 'Input-Output time series intervention model.' The total economic benefits that accrued to the national exchequer cumulatively from 2002 to 2016 was evaluated to Rs. 34,413 crores, from three select technologies/policy support interventions attributable to the work of ICAR-CIBA. The returns to the investment made on brackishwater aquaculture research estimated were huge though only these three technologies were considered.

Brackishwater aquaculture and doubling of farmers income

Scientific production and management of shrimp and finfishes yield high income to the farmers within a short span of time, which are four-fold increase than the traditional practices. Production of shrimp species like Pacific white shrimp (*Penaeus vannamei*), milkfish (*Chanos chanos*), Asian Sea Bass (*Lates calcarifer*), Cobia (*Rachycentron canadum*) and mud crab (*Scylla serrata*) are the dominant species which would fetch higher income within short to medium time span.

Under farmers field conditions in Kozhikode district of Kerala (n=5), cultivation of seabass, milkfish and pearlspot resulted a higher level of profit to the tune of Rs.1.70 lakh/crop, 1.47 lakh/crop, and 0.70 lakh/ha respectively. The Benefit-Cost Ratio range is 1.29, 1.38 and 1.41 respectively in case of seabass, milkfish and pearlspot.

Economics of the culture of brackishwater species under optimum management conditions

S. No.	Particulars	Pacific White shrimp	Milk Fish	Asian Sea Bass	Pearl Spot
01	Culture duration in months	4	6-8	6-8	6-8
02	Stocking density in number/ha	500000	8000-10000	5000	2000
03	Yield in kg/ ha	8000-10000	4000-5000	3500-4000	2000-3000
04	Market price in Rs./kg	220	140-150	300-350	300-350
05	Gross Return in Rs. lakh/ha	22.00	6.00	12.00	9.00
06	Gross Cost in Rs. lakh/ha	15.00	3.6	8.00	7.00
07	Net Return in Rs. lakh/ha	7.00	2.40	4.00	2.00
08	Cost of Production in Rs/kg	150-180	72-80	200-250	230-250
09	Benefit Cost Ratio	1.47	1.67	1.5	1.29

Based on 2015-16 market prices in Southern India

Aquaculture Extension

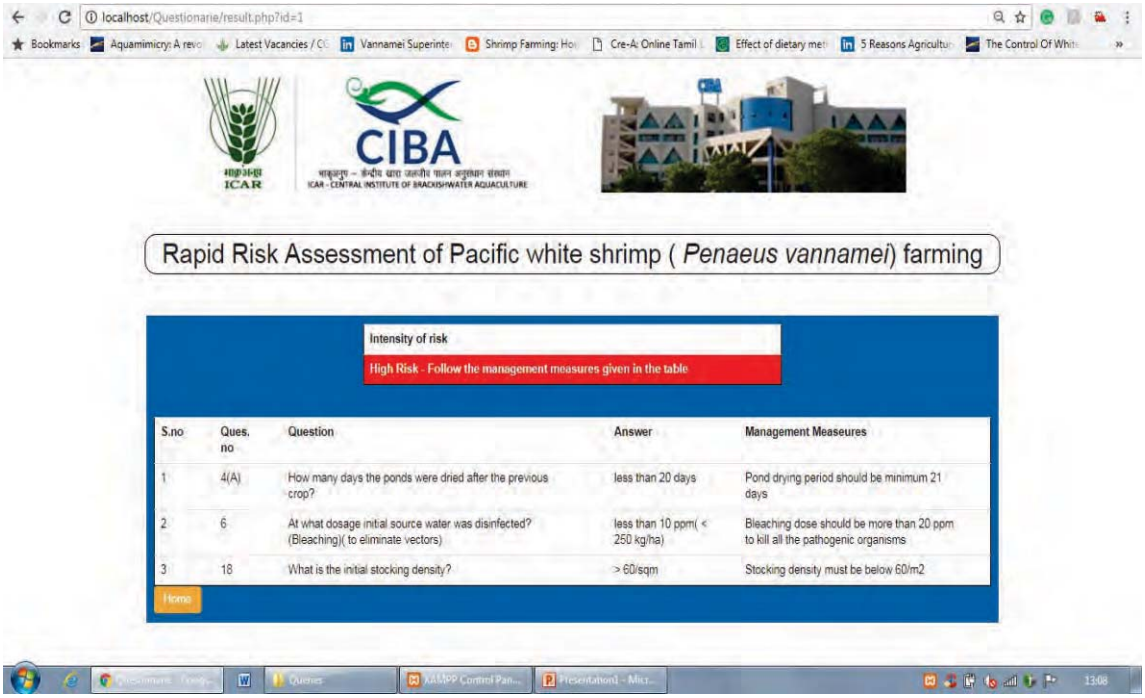
Extension and developmental interventions for sustainable brackishwater aquaculture production systems

The technology package for a three-tier model of cage farming of Asian seabass (*Lates calcarifer*) in open brackishwater comprises of nursery rearing, pre-grow out and grow out phases was validated in partnership with the NIOT Chennai and fisher youth group at Vennangupattu village cluster in Kancheepuram district, Tamil Nadu. The farming cycle began with the stocking of fish fry (2cm size) initially in the nursery cages, they were grown to fingerlings size in 45-60 days (7-8 cm size), transferred from nurseries to the pre-grow-out cage and then 90-100g juveniles from pre-grow out were transferred to grow out cages @12 kg per/m^3 for further rearing. The fishes were fed with CIBA's formulated indigenous feed (*Seebass*^{Plus} @ Rs80/kg). The average Feed Conversion Ratio (FCR) was 1.85. The juveniles were grown to a marketable size of 900 g - 1.25 kg in 6 months. The productivity of 460 kg was realized in two partial harvests in one cycle. With proper planning, two cycles of production are possible in a year. The production cost was worked out to be Rs.190 per kg of fish and sale price was Rs.380 per kg with a BCR of 2.0. A person is spending 2 hours per day in the nursery rearing, pre-grow out and grow out phases get a monthly income of Rs.6000, Rs.5000 and Rs.8500, respectively. The fish producers were linked to Tamil Nadu Fisheries Development Corporation a state government body which procures fishes from producers giving farm gate price and sale to the consumers through its outlets. This model is being replicated in Puducherry UT, Kerala and Maharashtra states.

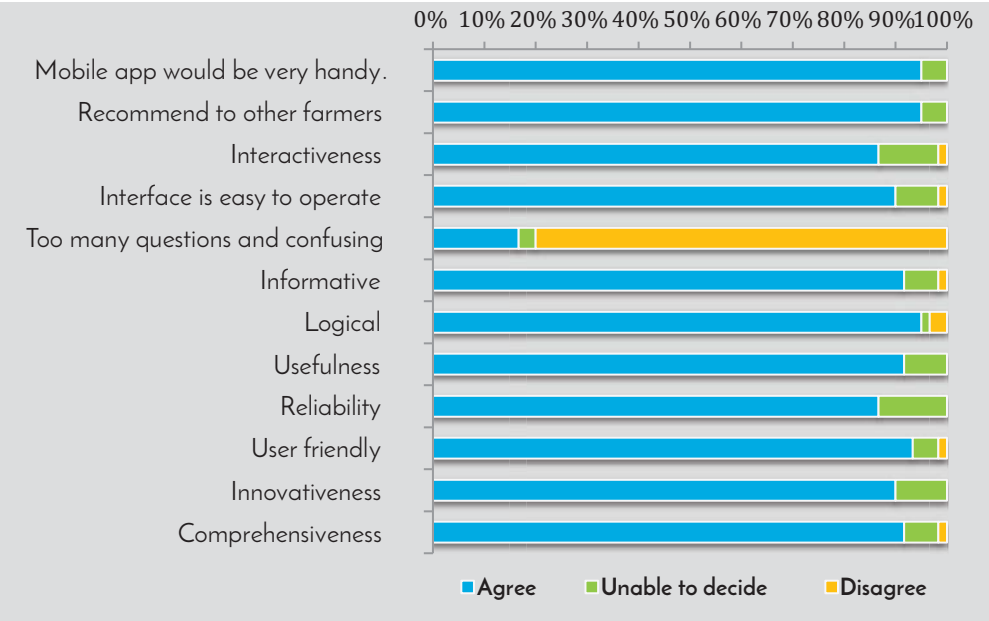
Three-tier model of cage farming in open brackishwater

Development and validation of an online 'probabilistic risk diagnosis module' for Pacific white shrimp farming and evaluate its utility

A questionnaire-based *on-farm risk assessment module* for vannamei farming was developed. The module contains three distinct categories viz., phase1: Up to 40 Days of Culture (DOC); phase2: 40-80 DOC and phase3: above 80 DOC. On completion of this questionnaire, the results will indicate the risk level of the farm, practices need immediate attention to minimize the risk levels. This tool was validated with a sample size of 60 shrimp farmers in TN and AP, and the farmers felt that the tool was comprehensive, educative, reliable and highly useful to the farming community.



Final page of the module with results



Perception of farmers on the module

Technology dissemination through mobile phone: Updation of *Vanami Shrimpapp* with additional modules

Vanami Shrimpapp is the first mobile app on shrimp farming and has been regularly followed by more than 7500 stakeholders (farmers and extension workers) across the globe (India, Indonesia, Vietnam, Brazil, Peru, Mexico, Ecuador, and the USA). The app is comprehensive and updated with several modules recently.

Farmer receiving response to his query through Vanami Shrimpapp mobile app

Preparation of farmer friendly publication

A farmer friendly publication *Penaeus vannamei Ginga Palan Ke Bara Mae Akshar Poochae Janaevalae Prashna (in the Hindi language), (Vannamei Shrimp Farming: Farmers Frequently Asked Questions (FAQs) and Explanations), was prepared and published.*

The value chain of family participation in aquaculture sectors

A value chain study was conducted among 50 coastal farmers to identify and measure the family involvement in aquaculture value chains, and significance of both women and men roles in the aquaculture sectors at coastal villages of Kancheepuram, Nagappatinam, Villupuram , Thiruvallur districts of Tamil Nadu, and Kozhikode district of Kerala.SEAGA analysis indicated that women and their families had supported men in aquaculture sector (50%), have now adopted new techniques in fish farming practices (20%), entered into new markets and more profitable enterprises (20%) and both men and women play a significant role in the aquaculture and fishery value chain (60%) and decision making practices (60%) in value chain of fish and shrimp farming. The modern and diverse fishery value chains have opened up new avenues for resource-rich groups (40%) while resource poor and weaker groups (60%) remain in low-value nodes of the value chain.

Assessment and transfer of brackishwater aquaculture technologies among tribals of Tamil Nadu (under TSP)

Under the CIBA-TSP sub-plan, an assessment was made on tribal participation in aquaculture sectors, and awareness was created on dissemination and adoption of CIBA technologies among 50 coastal irular tribal aqua farmers of Nagapattinam and Thiruvallur districts of Tamil Nadu. The socio-economic status of the tribals and resource availability in the coastal tribal villages was studied for dissemination and adoption of fish farming as an alternate livelihood option among the tribal communities. Fishing, wild shrimp collection, and crab collection was their major occupation (90%). Majority of the beneficiaries (70%) earned monthly income ranged from Rs.4001-10,000/- followed by Rs.1000- 4000/- (20%) and Rs. 10,001 - 15,000/- (10%).

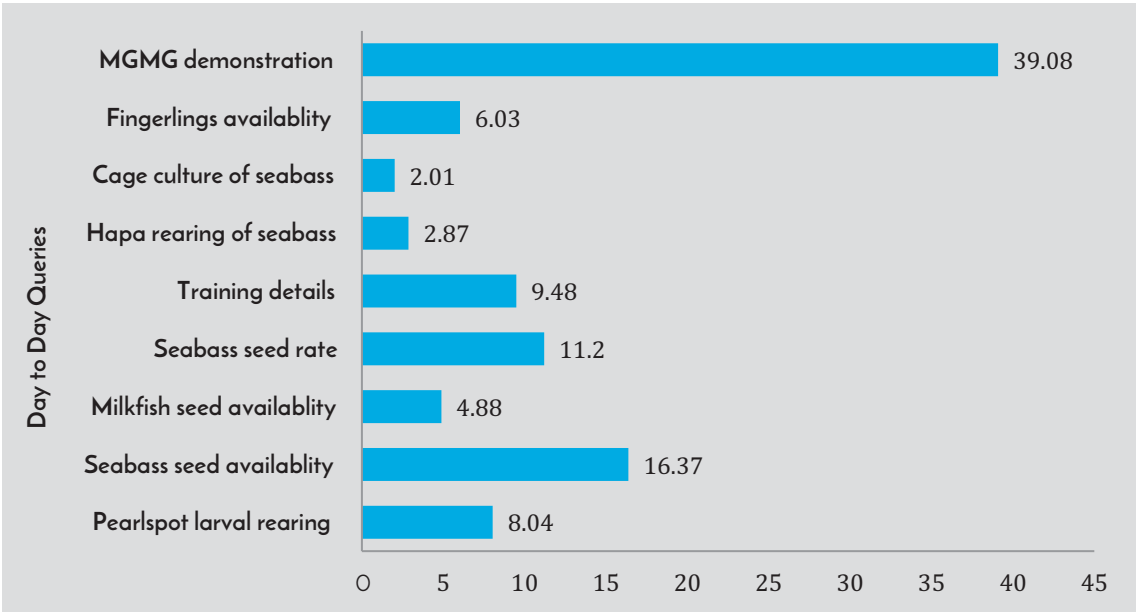
Scientist conducting a awareness meeting with the tribal farmers of Thiruvallur district Tamil Nadu

Nursery rearing of seabass (*Lates calcarifer*) by adidravida families as a livelihood activity at Keelarkollai village, Kanchipuram District, Tamil Nadu

The suitability of Keelarkollai water source in Kancheepuram district of Tamil Nadu was assessed for nursery rearing of seabass in hapas, mobilizing four Adidravida families in partnership mode. A nursery rearing unit comprised ten hapas (2x1x1m size) with a total volume of 120 m^2 was developed in open waters and seabass fish fry of size 1.2-1.8 cm were stocked @ 500 no/hapa. The nursery rearing duration was 57 days. The survival realized was 35.80%. A production of 1820 fingerlings of size 3-9.5 cm was realized. On an average one member spent two hours in the for feeding the fry twice and monitoring. The net income per cycle was Rs.28, 000 and each family got an income of Rs.7000/- per head. This could be a model for earning extra income through job-sharing employment which could be taken up throughout the year as a livelihood activity.

Evaluation and execution of extension programmes for sustainable brackishwater aquaculture

One hundred and thirteen frequently asked questions (FAQs) about seabass culture and its farm management along with answers under 12 heads have been prepared in the Tamil language. The 12 heads include; 1.Hatchery Management 2.Nursery Rearing of seabass in Hapas.3 Nursery Rearing of seabass in ponds.4 Cage culture.5. Grow-out culture 6.Management of seabass 7.Soil and water Management.8.Feed Management and Feeding 9.Health Management.10.Integrated Management 11.Harvest and 12. Production and Marketing. Development of Android-based Mobile app for Seabass culture and farm management is in progress.The need assessment for mobile connectivity regarding the day to day queries showed that the fish farmers approached CIBA regarding MGMG demonstration (39.08%), seabass fingerlings availability(6.03%),cage culture activities (2.01%), nursery rearing of seabass in hapas (2.87%),training details (9.48%),seabass seed rate (11.2%), milkfish seed availability(4.88%), seabass fry availability (16.37%) and Pearlspot larval rearing (8.04%). It was also observed that localization and native language of farmers need to be considered for incorporation into the systems.



Response of stakeholders for the various extension activities of CIBA

Demonstration of mud crab culture in pen and floating boxes in the open water system at Adyar creek water bodies

Trials were conducted to standardize the culture of mud crab adopting different systems in Adyar creek water bodies. Under pen culture system, total 50 crabs (9.6 kg; body weight range 95-250 g) were stocked in 100 m^2 pen structure. Crabs were fed trash fish @ 10% body weight daily in two times. After 40 DOC, 30 crabs (body weight range 168-627 g) with total biomass of 10.27kg were collected through partial harvesting and an amount of Rs. 16405/- were realized as interim profit. Under cage culture system, twenty crabs (Av. body weight 109.9 g) were stocked individually in 20 floating boxes. Crabs were fed with trash fish @ 10% body weight daily in two times. After 40 DOC, crabs attained average body weight of 212.81g and profit of Rs. 2380/- were realized.

Mud crabs obtained from cages on a harvested from Partial harvest of mud crab at Adyar creek

Demonstration of milkfish culture in pen at Adyar creek water bodies

Based on the experimental trial conducted at Adyar creek during 2016-17 for identifying the suitable brackishwater species for cultural practices, demonstration of milkfish culture in pen was initiated at Adyar creek water. A total of 280 milkfish fry (avg. wt - 4.8 g; avg total length 6.7 cm) was stocked in 100 m^2 pen structure. Fishes were supplied with the formulated feed prepared by ICAR-CIBA @ 5% body weight daily in two times. After 55 DOC, milkfish attained average weight of 52.5 g and average length of 20.2 cm. The adopted ten nos. of fisher folks (5 families; 2 nos. from each family) were trained with cage and pen installation and maintenance, feeding to animals, handling of crabs, and sampling, etc.

Customized low volume cages installed at Adyar creek

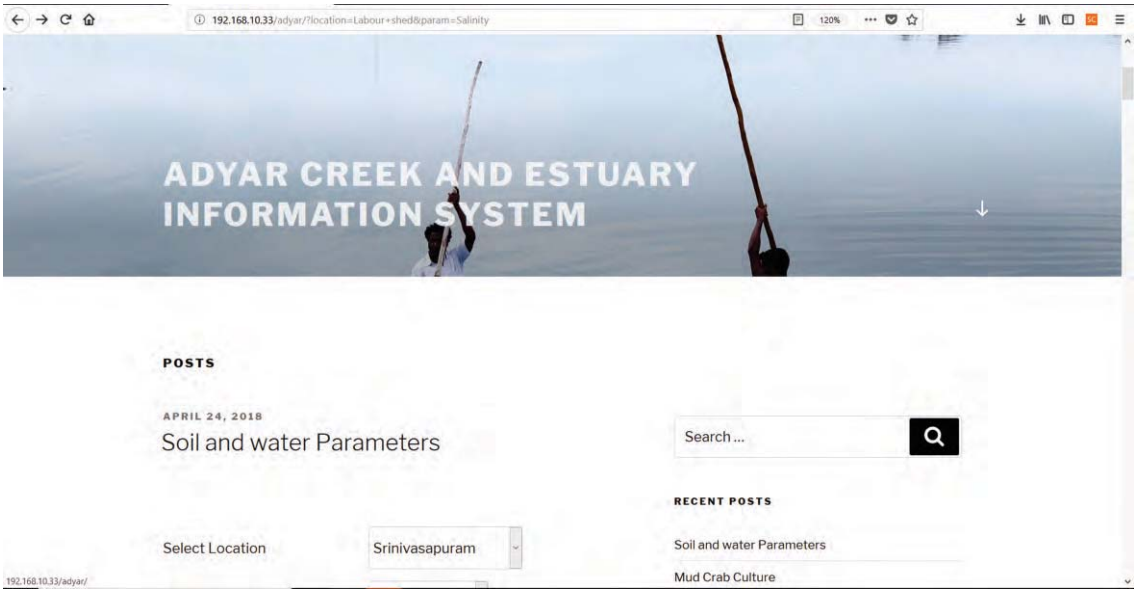
Computer Applications

Web-based knowledge centre in brackishwater aquaculture

Web-based knowledge centre in brackishwater aquaculture was designed based on the ADDIE model of Instructional System Design (ISD), including Analysis, Design, Development, Implementation, and Evaluation. Needs assessment of 110 stakeholders, users of ICT projects of Village Knowledge Centre of MSSRF, Tamil Nadu, and Aquachoupal, Andhra Pradesh (50 nos); aqua/tribal farmers of Gujarat (50 nos.) and students (10 nos.)was completed. The required information was designed into eight categories viz., Overview of brackishwater aquaculture; Details of Shrimp; Details of fish; Details of Crab; Fisheries institutions; Aquaculture statistics; Fisheries policies; ICT tools and Important links. Each category has many sub-categories for highlighting the information about the topic. Before designing the web-based centre, content was processed and evaluated. The evaluation results revealed that the items related to materials produced, visual design, accessibility and presentation style had good responses. Knowledge centre in brackishwater aquaculture was developed using Drupal content management software (CMS). This system is built-up with PHP and MySQL for the design of pages and database respectively.

Adyar Creek and Estuary Information System (ACEIS-Aqua) for aquaculture development

Adyar Creek and Estuary Information System (ACEIS-Aqua) was developed using MySQL database management system and PHP scripting language for the development of aquaculture in the water bodies. This web-based system describes the database/search modules that permit end users 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 these water bodies for the development of brackishwater aquaculture. The home page of this system was designed into eight modules namely, about Adyar creek and estuary, system needs and objectives, Sample location, water parameters, soil parameters, phytoplankton, zooplankton, culture practices, and contacts. In the system, search module is used to search and retrieve information based on users' keywords in the form of season wise, location-wise, month-wise, year-wise, salinity-wise, phytoplankton class/genies-wise and zooplankton group-wise. 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.



Home page of Adyar Creek and Estuary Information System (ACEIS-Aqua)

Human Resource Development (HRD) Trainings, Capacity Building and Skill Development

Trainings attended by individuals

International

1. Dr. P.K. Patil, Principal Scientist attended the training programme on "Methods of determination for drug residues in fish, meat and poultry", Joint Institute for Food Safety and Applied Nutrition, during 10-14th April 2017 at Maryland USA.

National

2. Smt. V. Usharani, Asst. Administrative officer, Shri. P. Srikanth, Junior Accounts Officer attended the Training Programme on "FMS" organized by IASRI at New Delhi from 17-19th April 2017.

3. Ms. Misha Soman, Scientist attended the training programme on "Molecular Biology and Biotechnology for Fisheries Professionals" organized by ICAR- CMFRI, at Kochi from 15th February 2017 to 14th May 2017.

4. Dr. Prem Kumar, Scientist attended the training programme on "Techniques pertaining to molecular biology and reproductive endocrinology" organized by Department of Animal Biology, School of Life Sciences, University of Hyderabad, from 8-28th June 2017.

5. Shri R. Aravind, Scientist attended the training programme on "Taxonomic Identification of Coastal and Oceanic Copepods (TICOC-2017)" organized by Marine Planktonology & Aquaculture Laboratory, Department of Marine Science, Bharathidasan University, at Tiruchirappalli, from 12-14th July 2017.

6. Dr. D. Deboral Vimala, Principal Scientist attended the training programme on "Digital Media Innovations in Extension" organized by National Institute of Agricultural Extension Management, at Hyderabad, from 26-28th July 2017.

7. Christina Lalramachhani, Scientist attended the training programme on "Analysis of experimental data" Organized by ICAR National Academy of Agricultural Research Management, at Hyderabad, from 3– 9th August, 2017.

8. Dr. Sujeet Kumar, Scientist attended the training programme on "Good Aquaculture Practices & Food Safety Preventive controls for Aquaculture Farms" organized The Marine Products Export Development Authority (MPEDA) in Association with United States Food and Drug Administration, at Sirkali, from 13-14th November 2017.

9. Dr. M. Makesh, Principal Scientist attended the training programme on "Management Development Programme on Leadership Development" organized by ICAR National Academy of Agricultural Research Management at Hyderabad from 12-23rd December 2017.

10. Shri. R. Elankovan, Chief Technical Officer attended the training programme on "KOHA for Library staff of ICAR organized by ICAR-NAARM, at Hyderabad, from 5 – 9th February 2018.

11. Dr. Raymond Jani Angel, Scientist attended the training programme on "Genomics and Proteomics-2018" organized by Department of Biotechnology, Alagappa University, at Karaikudi, from 14 -16th February 2018.

12. Dr. M. Kumaran, Principal Scientist attended the Training Programme on Competency Enhancement Programme for Effective Implementation of Training Functions by HRD Nodal Officers of ICAR, organized by ICAR-NAARM at Hyderabad from 15 - 17th February 2018.

13. Dr. N. Lalitha, Scientist attended the training programme on Vetinformatics, organized by Bioinformatics Centre & ARIS Cell, Madras Veterinary College at Chennai, from 12-16th March 2018.

14. Mr. Joseph Sahayarajan, Senior Technical Officer attended the training programme on Antimicrobial Resistance & Alternative to Antibiotic use in Aquaculture, organized by ICAR – CIFA at Bhubaneswar, from 12- 13th March 2018.

Trainings Programs Organised

Headquarters

Sl. No	Name of the Training /FGD	Duration	No. of participants
1.	Training Programme on "Innovative and evolving brackishwater crustacean aquaculture"	15 -21 April 2017	8
2.	Training Programme on "Grow-out cage farming of finfish in open brackishwaters" at Kottaikadu village, Kanchipuram Dist.	12 -13 May 2017	12
3.	Training Programme on "Innovative and evolving brackishwater crustacean aquaculture"	22 -27 May 2017	3
4.	Hands-on training programme on "Recent advances in soil and water management in brackishwater aquaculture"	20-24 June 2017	21
5.	Skill development programme for the fisher youths and aquaculture graduates on "Crafting low volume cages and farming of brackishwater fishes in cages"	11-14 July 2017	19
6.	Training Programme on "Innovative and evolving brackish water crustacean aquaculture"	17 -22 July 2017	9
7.	Training Programme on "Seed production and culture of brackishwater finfishes"	2-11 August 2017	1
8.	Sensitization Training programme on DNA based diagnostic "Polymerase Chain Reaction (PCR) detection of Enterocytozoon hepatopenaei (EHP) in shrimp" for the stakeholders of shrimp-farming sector	17-18 August 2017	14
9.	Training Programme on Hatchery Production and farming of milk fish and grey mullet	22-26 August 2017	10
10.	Training Programme on "Seed Production and culture of brackishwater finfishes"	12-16 September 2017	3
11.	On-farm training cum demonstration of Seabass nursery rearing in hapas to the youth and families at Kovalam, Kanchipuram Dist	7, 10, 13 & 19 October 2017	10
12.	Nursery rearing of seabass fry in hapas for tribals at Kezhar Kollai village, Koovathur, Kanchipuram Dist.	1, 6, 15 & 20 October 2017	5
13.	Training Programme on Seed production and culture of brackishwater finfishes"	9 – 13 October 2017	2
14.	National Training Programme on "Advances in shrimp aquaculture and biofloc based farming technology"	6-10 November 2017	10

Sl. No	Name of the Training /FGD	Duration	No. of participants
15.	Nursery rearing of seabass and rearing of milkfish to tribals at Kezhar Kollai village, Koovathur, Kanchipuram Dist.	8 December 2017	30
16.	Brackishwater aquaculture in the changing climatic scenario and distribution of soil and water health cards to aqua farmers (Kota, Gudur Division, Nellore Dist., Andhra Pradesh) -FGD	21 December 2017	222
17.	Brackishwater aquaculture in the changing climatic scenario and distribution of soil and water health cards to aqua farmers (Allur, Kavali Division, Nellore Dist., AP)-FGD	22 December 2017	225
18.	Profitable technologies in brackishwater aquaculture for doubling farmers' income	29 January 2018	6
19.	National Training Workshop on "Aquaculture Nutrition and Feed Technology"	3-12 January 2018	20
20.	Customized Training on "Shrimp feed preparation and quality control" during	13-17 February 2018	2
21.	Training on Proximate Analysis of feeds and feed ingredients	13-14 February 2018	2
22.	A three day training programme on "Science and agricultural careers after School Education"	28-31 March 2018	25
	KRC, Kakdwip		
23.	Training Progrmme on "Feed formulation and feed management in brackishwater aquaculture"	19-24 June 2017	5
24.	Training programme on "Advances in Brackishwater Aquaculture Practices"	17-22 July 2017	12
25.	Training Programme on "Scientific management practices for sustainable shrimp and crab culture"	21-26 August 2017	12
26.	Training Programme on "Diagnosis and control of brackishwater finfish and shellfish diseases with special reference to emerging diseases"	13 – 18 November 2017	13

Workshops/Seminars/Meetings

CIBA-Foundation Day celebrated as OPEN DAY for school students

The 30th "Foundation Day" of CIBA was observed on 4th Apr 2017 as an "Open Day" to create awareness among school children about the importance of agriculture and allied subjects, including fisheries and aquaculture and their career prospects. About 300 students and 18 teachers from schools in and around Chennai visited the facilities and gained knowledge of aquaculture. Dr. K. K. Vijayan, Director, ICAR-CIBA stressed the importance of fish production through aquaculture as nutrition security to common people and as livelihood option for the fisherfolk. A mobile application on pacific white shrimp farming known as "Vannamei Shrimp App" developed by ICAR-CIBA along with 14 posters on ICAR-CIBA technologies were released during the occasion for the benefit of farmers and stakeholders.

Workshop on Revitalizing Fisheries and Aquaculture in Tamil Nadu for Doubling Farmers' Income by March 2022

ICAR-CIBA and Federation of India Chamber of Commerce and Industry (FICCI) along with Tamil Nadu Fisheries University, Nagapattinam and Coastal Aquaculture Authority (CAA), Chennai jointly organized a "Workshop on Revitalizing Fisheries and Aquaculture in Tamil Nadu – Doubling income by March 2022-"on 30th May 2017 at ICAR-CIBA, Chennai. In his inaugural address, Dr K.K.Vijayan, Director, ICAR CIBA Chennai stated that Fisheries and Aquaculture Sector is a 'Sleeping Giant' in Indian Economy and its true strength is yet to be fully conceived by the planners and policy makers. The speakers stressed on the potential of aquaculture for the Indian economy and the scope for expansion of aquaculture in Tamil Nadu in a safe and sustainable manner.

Training programme on "Recent advances in soil and water management in brackishwater aquaculture"

A five-day hands-on training programme on "Recent advances in soil and water management in brackishwater aquaculture" was conducted during 20th -24th June 2017. 21 participants comprising of farmers, technicians, academicians, students and entrepreneurs participated in the training programme and gained hands-on training on soil and water quality testing and BMPs.

Third International Yoga Day celebration

A week long training programme by a renowned yoga guru Mr. K. Nanjapathi was organised in ICAR-CIBA to commemorate the third international day of yoga from 15th to 21st June 2017. Speaking on the occasion, Dr. K.K. VIjayan, Director, ICAR-CIBA highlighted the significance of yoga and emphasized its relevance in today's lifestyle and the need to maintain a healthy body for a sound mind. Guest speaker Dr. Raji Velmurugan, life style expert from MIOT hospital delivered a lecture on "Life style modifications for lifelong good health.

Farmers' Interaction Meet at Uttar Chandanpiri, Namkhana, West Bengal

Farmer's Meet was organized at Uttar Chandanpiri, Namkhana, South 24 Parganas., West Bengal on 29 June 2017. To provide technical support to the aqua farmers and vegetable growers of this village, scientists from ICAR-CIBA and subject matter specialists from Ramakrishna Ashram Krishi Vigyan Kendra, Nimpith, West Bengal delivered lectures in scientific session. Total 100 progressive farmers participated in the meet.

National Fish Farmers Day celebration at Kokilamedu,Kanchipuram District, Tamil Nadu

National Fish Farmers Day was celebrated on 10th July, 2017 with shrimp farmers, fishers and womenfolk at Kokkilamedu village, Kanchipuram district, Tamilnadu with the theme on "Doubling fish farmers" income. Initiatives taken by CIBA for alternative income generation of farmers/fishers through nursery rearing of fin fishes in open waters and ornamental fish farming in household tanks in the Kokkilamedu village were explained to the participants. Success story of "Ornamental fish farming unit" of the womenfolk of Thiruvidanthai village using the technology developed by CIBA was shared with the participants.

Skill development programme on "Crafting low volume cages and farming of brackishwater fishes in cages"

A skill development programme was organized for the fisher youths and aquaculture graduates on "Crafting low volume cages and farming of brackishwater fishes in cages" during 11-14th July, 2017. 19 trainees participated in the training. Resource persons from NIOT provided hands-on training on cage fabrication and deployment at Vennangupattu village where ICAR-CIBA is demonstrating cage farming. The brackishwater fish species suitable for cage farming, seed availability, optimum seed size, seed transportation, acclimatization, stocking density for different cages and sampling procedures were demonstrated to the trainees.

ICAR Foundation Day

The 89th foundation day of ICAR was celebrated at ICAR-CIBA on 17th Jul, 2017. Ms. Swapna Sundar, IP Strategist & Patent Agent and CEO, IP Dome Strategy Advisors, Pvt. Ltd. Chennai presented on the "Recent developments in IPR and science policy issues.

Harvest cum interaction meet on Cage Farming of Seabass Fish as Alternate Livelihood Support of Coastal Population

Farming of brackishwater fishes in locally crafted cages suitable for estuaries, creeks, backwaters and lagoons is an emerging innovative and viable technology for the production of valuable finfish such as seabass. The

technology is efficient in utilizing the vast stretches of brackishwater resources along the costal India for increased fish production, employment creation and income generation, falls under the vision of Indian Govt. under the blue revolution. In this direction, ICAR-CIBA, has successfully demonstrated cage farming of Asian seabass fish (*Lates calcarifer*) in the Buckingham canal waters at Vennangupattu coastal village in Kancheepuram District of Tamil Nadu. A novel three tier model comprising nursery rearing, pre-grow out and grow out cages were taken up in a phased manner. Asian seabass (*Lates calcarifer*) fish was chosen as culture species due to its growth potential, availability of seed and feed and higher market value. A harvest cum interaction meet on cage farming of Asian seabass was organised at Vennangupattu village, on 4th Aug, 2017. About 120 fishers including fisherwomen and school children participated in the event and witnessed the harvest. Dr.K.K.Vijayan, Director, ICAR-CIBA handed over the revenue generated to the group.

National workshop on "Farming technology and propagation of indigenous Indian white shrimp for diversification of shrimp farming industry"

A national workshop on "Farming technology and propagation of indigenous Indian white shrimp for diversification of shrimp farming industry" was conducted at ICAR-CIBA, Chennai on 3rd Aug 2017 to demonstrate and disseminate P. indicus culture. 150 farmers from various coastal states participated and benefited from the workshop. Addressing the large gathering, V.P. Thandapani, I.A.S, DOF,Govt. of TamilNadu and Dr.K.K. Vijayan, Director, CIBA emphasised the urgent need to promote native indigenous species along with exotic vannamei as the backup for sustainable aquaculture

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Sensitization training programme on DNA based diagnostic "Polymerase Chain Reaction (PCR) detection of *Enterocytozoon hepatopenaei* (EHP) in shrimp"

ICAR-CIBA reported the cause of growth retardation problem due to presence of microsporidian parasite, *Enterocytozoon hepatopenaei* or EHP for the first time in the country. ICAR-CIBA conducted a hands-on training programme on "Polymerase Chain Reaction (PCR) detection of *Enterocytozoon hepatopenaei* (EHP) in shrimp" in collaboration with CAA and MPEDA on 17th and 18th Aug, 2017 to train 14 hatchery personnel, colleges and government laboratory representatives for screening larval samples from the hatcheries and artemia. Mr. S.Chandrasekar, President, SAP, Chennai, inaugurated the training, expressed his concern about the grim scenario emerging in the shrimp culture industry in India, especially with new pathogens and related crop failures.

Farmers Conclave and National Workshop on Sustainable Livelihood Options in Aquaculture for Rural Population for Doubling Aquafarmers Income

ICAR-CIBA in association with the Fisheries Technocrats Forum (FTF), Chennai conducted a farmers' conclave cum workshop on "Sustainable Livelihood Options in Aquaculture for Rural Population" at Nagapattinam on 19th August, 2017 to emphasise the Government of India initiative to double the farmers' income by 2022 and the role aquaculture can play in achieving this objective. About 100 participants including farmers, rural youth, scientists, scholars and officials from RGCA, NIOT, TNFU and Department of Fisheries attended the conclave

CIBA Annual Day-2017 and family get-together

ICAR-CIBA celebrated its annual day 2017 and family get-together on 26th Aug 2017 organised jointly with SCAFi. CIBA staff and retired employees attended the annual day with their families. An exhibition of technologies, recent publications of the institute, and aquarium of brackishwater candidate species were also displayed

Society of Coastal Aquaculture and Fisheries (SCAFi) was inaugurated

The newly formed society at ICAR-CIBA for promotion of coastal aquaculture and fisheries (SCAFi) was inaugurated by Dr. E.G. Silas. He also unveiled the logo of SCAFi and launched the thematic logo of the society, he addressed the gathering by briefing about the history of CIBA formation and appreciated the activities of CIBA and formation of SCAFi..Director of CIBA, Dr. K K Vijayan underlined the need and proactive role of SCAFi in bringing R&D from the institution to benefit the society.

Interaction meet on "Role of Media in Dissemination of Brackishwater Aquaculture Information to the Stakeholders and Public"

ICAR-CIBA organised a Scientists-Media interaction meet on 15th Sep 2017 to discuss the means for increased engagement with the media for disseminating technology innovations, success stories and development initiatives to farmers, policy makers and stakeholders. Correspondents from press, visual and digital media, agriculture magazines, media students and scientists participated in the programme. The speakers highlighted the necessity of constant interaction between the research institutions and media to understand the needs of the society and bringing technologies to the common man.

CIBA participated in Aqua Aquaria India 2017 conducted at Mangalore

ICAR-CIBA actively participated in the Aqua Aquaria India 2017 with the theme "Diversification in Sustainable Aquaculture" organised by MPEDA at Mangalore during 14-16th May 2017. Posters, aquarium and specimen related to rearing, feed and disease management technologies for shrimp, Asian sea bass, milk fish, pearl spot, etc. were displayed. About 3,000 stakeholders visited the CIBA stall and interacted with the scientists.

ICAR-CIBA participated in the India International Science Festival

ICAR-CIBA participated and acted as the nodal institute for ICAR in the 3rd India International ICAR-CIBA showcased novel technologies developed at "Aqua Goa Fish Festival" organized by Government of Goa at Panaji during 7th to 10th Dec 2017. Smt. Mridula Sinha, Hon'ble Governor of Goa, Shri. Manohar Parikar, Chief Minister of Goa and Shri. Radha Mohan Singh, Hon'ble Union Minister of Agriculture and Farmers Welfare visited the CIBA stall and interacted with CIBA scientists. He appreciated the research efforts undertaken by CIBA in the direction of 'Make in India' in brackishwater aquaculture and advised the scientists to further take it up to greater heights.

Attracting and Retaining Youth in Agriculture (ARYA) Programme

ICAR-CIBA conceived a 'Student project module on brackishwater aquaculture' to expose school students to farming systems and technologies to kindle interest among them. A group of nine students from Kendriya Vidyalaya School, Chennai participated in the programme held for seven weeks during Sep – Oct 2017. The students learned the basics of aquaculture and completed short-term projects to study brackishwater resources and aquaculture.

Partnership farming of *Penaeus vannamei* in inland low saline water for doubling of farmers income

With the objective of doubling farmers' income, ICAR-CIBA took the initiative to demonstrate pacific white shrimp (*Penaeus vannamei)* farming in inland low saline water in South western Punjab where farmers used to earn an income of around Rs. 30,000 to Rs. 50,000 per acre from crop based activities. Under the ARYA program, two young engineers were trained in CIBA and were provided with support in terms of technology and specially formulated feed for the region. The farmers realised around Rs. 2 lakhs per acre from aquaculture income.

Harvest of pacific white shrimp (*Penaeus vannamei)* from inland low saline water in South western Punjab

World Fisheries Day celebrations at Koovathur Village, Kancheepuram District, Tamil Nadu

World Fisheries Day was celebrated on 21st November 2017 at Keelarkollai village in Koovathur Panchayat of Kancheepuram district of Tamil Nadu in convergence with about 120 villagers including fishers, tribals, rural youth and local leaders. The CIBA team disseminated the aquaculture technologies to the villagers, which can provide alternate livelihood opportunities, to increase their income. Dr. V. Selvam, Executive Director, MSSRF, Chennai, Chief guest of the function, distributed the hatchery produced milk fish (*Chanos chanos*) seeds from CIBA finfish hatchery, to the farmers of Koovathur village, which were released for pen culture operation.

Agricultural Education Day celebrated at Muttukadu

Agricultural Education Day was organized on 4th December, 2017 to educate the school students on various facets of brackishwater aquaculture and inspire them to develop interest in agriculture. About 250 higher secondary students and 17 school teachers from leading schools of Chennai participated in the programme held at Muttukadu Experimental Station of CIBA.

Farmers interaction meet and harvest mela of Indian white shrimp (*Penaeus indicus*) in Kerala and Tamil Nadu

Multi-location culture demonstration of *Penaeus indicus* were carried out along different coastal states by ICAR-CIBA with an objective of propagating indigenous 'Desi' shrimp culture with support of NFDB. A partnership farming model of Indian white shrimp *P. indicus* were taken up in Tamil Nadu and Kerala for the performance evaluation. At both the demonstration sites the results were encouraging and the performance were on par with Pacific white shrimp, farms in the adjacent ponds with respect to ABW, production and profitability. This present culture demonstrations were successful in terms of sustainability and profitability as the produced shrimps were sold at a rate of Rs.300-350/- per kg against a production cost of Rs.210-225/- per Kg. Farmers interaction meet and Harvest Mela were organized on 27th Aug 2017 at Kannur Kerala and on 30th November, 2017 at Shirkhali, Nagapattanam Tamil Nadu near the demonstration site.

Distribution of "Soil and Water Heath Cards" – PPP model to scale up

ICAR-CIBA is the first institute initiated the distribution of soil and water health cards (SWHC) in fisheries sector. The Institute has distributed about 705 SWHCs since 2015.In 2017, CIBA developed a working model to issue a SWHC through Public Private Partnership mode by impressing upon the fisheries colleges and private aquaculture laboratories existing in a particular district to analyze the samples at free of cost. In which the technical backstop and validation for the analysis was provided by CIBA. This model was tested in Nellore District, Andhra Pradesh and was appreciated by the farmers. In this regard, Brackishwater Aquaculture Farmers Meetings were organized by ICAR-CIBA in Nellore District, Andhra Pradesh on 21st and 22nd December 2017 at Kota and Allur, respectively under NICRA Project.

ICAR-CIBA partnered in the national seminar 'Aquaculture Kerala 2018 – A Blue Revolution Initiative

ICAR-CIBA, Chennai partnered in the 'Aquaculture Kerala 2018-A Blue Revolution Initiative' organized by Kerala Aqua Farmers Federation at Kannur in Kerala State during 10th to 12th February 2018. It was inaugurated by Shri Pinarayi Vijayan, Honourable Chief Minister, Government of Kerala. Chief Minister in his address stated that Government of Kerala will give support for promotion of aquaculture in Kerala through relevant policy including the leasing of public water resources and planning. Dr K K Vijayan Director CIBA Chennai in his key note address on "Brackishwater and Marine Aquaculture" stated that CIBA has several technically feasible, environment friendly and economically viable technologies in shellfish and finfish culture and the same need to be scaled-up through strategic planning and implementation of development schemes in convergence with State Government, aqua farmers and other stakeholders. Scientific adoption and scaling up of these technologies would definitely double the farmers income in a span of one to two years itself considering short crop period in aquafarming.

Women empowerment through brackishwater aquaculture

ICAR-CIBA, Chennai celebrated World Women's Day at Keezar Kollai in Koovathur village of Kancheepuram district in Tamil Nadu on 8th March 2018 with the theme on "Empowering farm women through brackishwater aquaculture" in consonance with the global theme of "Transformation of Women through empowerment." CIBA scientists showcased successful Pearl Spot seed rearing and 'Brackishwater Ornamental Aquariculture' technologies. Smt Pushpa, a tribal woman from Thiruvidanthai village in Kancheepuram district, who has already taken up ornamental rearing, shared her experiences, and presented economic benefits gained from ornamental fish culture with the technical support of ICAR-CIBA, in a period of six months.

National workshop on 'Strategic Approach in Fisheries Sector on the Potential and Viability of Culturing Endemic and Exotic Species in India'

One day national workshop on "Studying the potential and viability of culturing endemic and exotic species for aquaculture" was organized by CIBA on 29th December 2017. Dr. B. Meenakumari, Chairperson, NBA inaugurated the workshop and emphasised the importance of cataloguing of exotic fish species in India and stressed the co-ordination among the national bodies to create region wise quarantine facilities in order to address the biosecurity concerns in Indian context. In the Presidential Address, Dr. K.K. Vijayan, Director, ICAR-CIBA emphasized the importance of identifying the endemic fish species with economic importance, and put a mechanism in place to analyse positive and negative aspects of exotic species already introduced in India. He also stressed to create awareness among aquaculture farmers on the management of these species, through cataloguing and familiarisation.

National workshop on "Aquaculture Nutrition and Feed Technology"

The national workshop on "Aquaculture Nutrition and Feed Technology" was inaugurated by the CEO, Shri Ramakanth V. Akula of The Waterbase Ltd., a leading shrimp feed manufacturer in India on 3rd January, 2018 at ICAR - CIBA, Chennai. He recorded his appreciation on the achievements of ICAR-CIBA in developing indigenous feed technologies and its subsequent commercialization for the benefit of brackishwater farmers in the country. Dr K.K Vijayan, Director, ICAR-CIBA stressed the need for joint ventures of research institutes and industries in PPP mode in scaling up of the technologies for sustainable development of the sector and for increasing profitability of farmers using the desi technologies. Farmers, technicians, academicians, research scholars, scientists and entrepreneurs from Punjab, Haryana, U.P, Gujarat, West Bengal, Andhra Pradesh, Telangana, Tamil Nadu and Kerala were participated in this workshop.

Krishi Unnati Mela

ICAR-CIBA organized a Farmers-Scientists meet on the occasion of 'Krsihi Unnathi Mela' and Prime ministers address, along with the project workshop on "Poverty alleviation through prevention and future control of the two major socioeconomically important diseases in Asian aquaculture' on 17th of March, 2018 at Elavoor Village in Thiruvallur district of Tamil Nadu". On that occasion live streaming of Honourable Prime Minister of India Shri

Narendra Modi addressing to the farming community was webcasted. Dr Chris Hauton, Scientist from University of Southampton, United Kingdom and Dr.Salam from Bangladesh Agricultural University, shared their experiences on management of aquaculture diseases and interacted with the farmers. They emphasized that disease surveillance and Best Management Practices would help to reduce the risks in shrimp culture and able to maintain the sustainability.

Society of Coastal Aquaculture and Fisheries, CIBA (SCAFi-CIBA) Lecture Series

Invited talk by Dr. K. Vijayakumaran, Principal Scientist, CMFRI, Chennai

ICAR-CIBA, CMFRI and the SCAFi jointly observed the World Environment Day and World Oceans Day at CIBA on 7th June, 2017 with the theme on "Life Systems in the Ocean Environment with reference to Fisheries and Aquaculture". Dr. K.Vijayakumaran, Principal Scientist, CMFRI, Chennai gave a presentation on "Sustaining the Living Systems in the Oceans" and explained the importance of oceans and its life forms in keeping the planet as a place suitable for life.

Invited talk by Shri. N. Vasudevan, Additional Principal Chief Conservator of Forests, Mangrove Cell, Mumbai, Maharashtra

Under the collaborative initiatives between Mangrove cell of Maharashtra Government and ICAR-CIBA, Shri. N. Vasudevan, Additional Principal Chief Conservator of Forests delivered an invited talk on "Mangrove ecosystems and its relevance to coastal development and blue economy" on 16th June, 2017. He stressed the need for conservation of mangroves and options for a sustainable livelihood from mangrove ecosystems, such as eco-friendly brackishwater aquafarming, eco-tourism, etc.

Invited talk on Entrepreneurship Development by Dr.K.Narayana Gowda, Formerly V.C, UAS, Bengaluru

A lecture programme was organized by Agri-Business Incubator (ABI) and SCAFi on 29th August 2017 at Chennai. Dr.K.Narayana Gowda, Formerly Vice-chancellor, UAS, Bengaluru delivered the invited talk on "Entrepreneurship development for attracting youth to agriculture". In his talk, he briefed the importance of fish and milk for nutritional security.

Invited talk by Dr. Mruthyunjaya, former National Director, NAIP, ICAR

SCAFi, CIBA organised a lecture on "Challenges in the Indian Agricultural Research and Planning – a way forward" delivered by Dr. Mruthyunjaya, former National Director, NAIP, ICAR on 20th March 2018. He insisted Agricultural Science and Technology Innovations need to be quipped to meet the emerging food safety challenges of India, hence need to be 3-times rich in the R&D content in the days to come.

Awards and Recognitions

CIBA received ICAR Hindi Magazine award

CIBA Hindi magazine Jal Tarang got the best magazine award for the year 2016-17. This award has been presented to the Director CIBA and Nodal Officer of CIBA Hindi Cell at 89th Foundation Day celebrations of ICAR on 16th July 2017.

CIBA was recognised and appreciated by Govt. of Andhra Pradesh for its efforts in promotion of native Indian White Shrimp

CIBA and its team were appreciated for its effort for native shrimp species promotion at the Andhra Pradesh Agri Tech Summit 2017 organized by Andhra Pradesh Government in association with Bill and Melinda foundation during 15-17 November, 2017 at Visakhapatnam. As a token of appreciation Dr A. Panigraghi, Principal Scienitist of CIBA received a memento from Mr Chandra Mohan Reddy, Honourable Agriculture Minister, Govt of Andhra Pradesh.

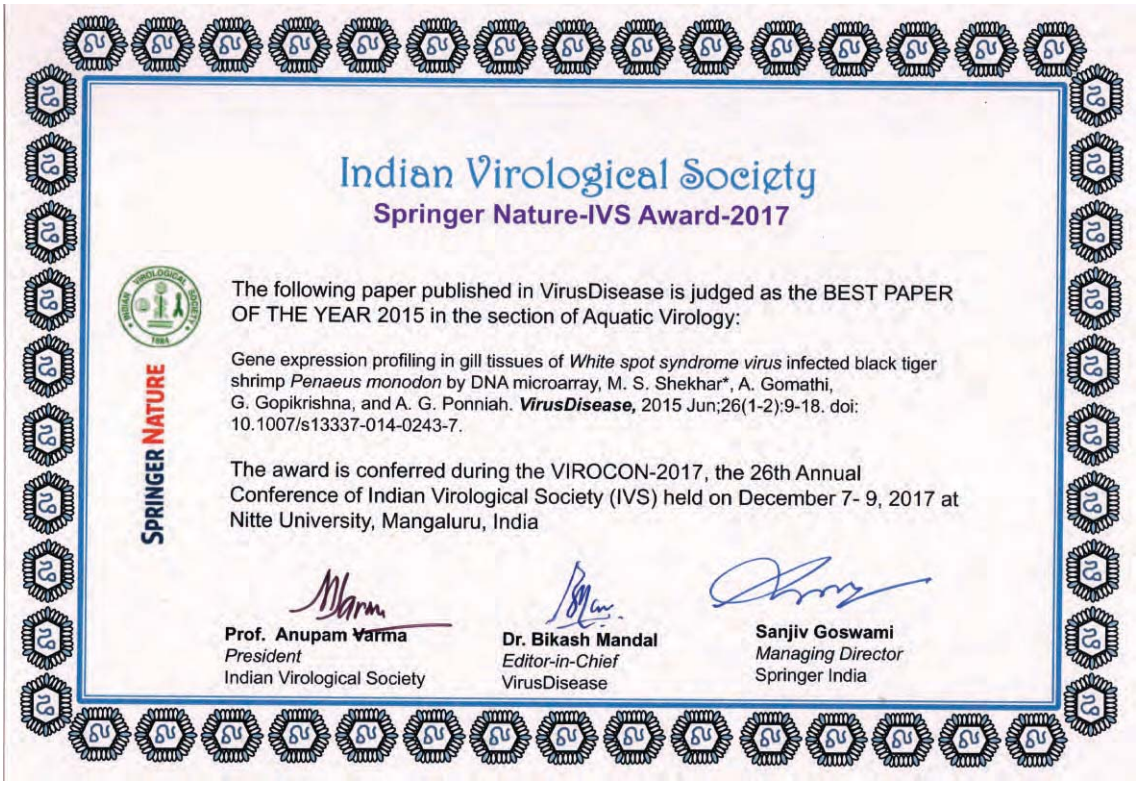
Dr A. Panigraghi, Principal Scienitist of CIBA was appreciated by Honourable Chief Ministe of Andhra Pradesh

Dr. T. Sathish Kumar receiving the award in aquatic animal health from the moderator

- Dr. T. Sathish Kumar awarded with best poster presentation in the International Symposium on "Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture" held during April 20-21, 2017 at NBFGR Lucknow for the poster with the title "Development and validation of Loop mediated isothermal amplification (LAMP) for the detection of Enterocytozoon hepatopenaei (EHP)"

- Dr. M. Kumaran received Letter of Appreciation from the Founder Chancellor and President Vel Tech Rangarajan Dr.Sagunthala R & D Institute of Science and Technology, Deemed University, Avadi, Chennai for being an expert Jury for the "VISAI 2018-8th International Project Competition and Exhibition" held during 23-24th February, 2018, Avadi, Chennai.

- Dr. R.Ananda Raja, Scientist was conferred with the "certificate of outstanding contribution in reviewing" from the Editors of "Fish and Shellfish Immunology" and "Microbial Pathogenesis ", Elsevier, Amsterdam, The Netherlands.



Indian Virological Society

Springer Nature-IVS Award-2017

SPRINGER NATURE

The following paper published in VirusDisease is judged as the BEST PAPER OF THE YEAR 2015 in the section of Aquatic Virology:

Gene expression profiling in gill tissues of *White spot syndrome virus* infected black tiger shrimp *Penaeus monodon* by DNA microarray, M. S. Shekhar*, A. Gomathi, G. Gopikrishna, and A. G. Ponniah. ***VirusDisease,*** 2015 Jun;26(1-2):9-18. doi: 10.1007/s13337-014-0243-7.

The award is conferred during the VIROCON-2017, the 26th Annual Conference of Indian Virological Society (IVS) held on December 7- 9, 2017 at Nitte University, Mangaluru, India

Prof. Anupam Varma
President
Indian Virological Society

Dr. Bikash Mandal
Editor-in-Chief
VirusDisease

Sanjiv Goswami
Managing Director
Springer India

- **Springer Nature-IVS Award 2017**
  Publication by M.S.Shekhar, et al., 2015 appeared in Virus Disease, 2015 Jun 26 (1-2): 9-18, won the best paper of the year in the section of Aquatic Virology.

Ph. D. Obtained during 2017-18

Name	Title of thesis	Date
 Shri. R. Vijayakumar	Identification and immunoproteomic analysis of outer membrane proteins (OMPS) of Vibrio anguillarum as potential vaccine candidates **Supervisor :** Dr. T.C. Santiago, Principal Scientist (Retired) ICAR-CIBA, Chennai	21 st April 2017
 Shri. S. Elangeshwaren	Reproductive biology of Cobia Rachycentron canadum around Chennai coast **Supervisor :** Dr. A.R. Thirunavukkarasu, Principal Scientist (Retired) ICAR-CIBA, Chennai	30 th May 2017
 Mrs. A. Gomathi	Studies on Sequential pathogenesis and immune expression analysis of WSSV infection in Penaeus mondon **Supervisor :** Dr. M. Shashi Shekhar, Principal Scientist, ICAR-CIBA, Chennai	7 th September 2017
 Mr. R. Jannathulla	Nutrient utilization of fermented plant protein sources in the diet of shrimp **Supervisor :** Dr. J. Syama Dayal,Principal Scientist, ICAR-CIBA, Chennai	7 th February 2018
 Dr. Sujeet Kumar	Quorum Sensing and Virulence Mechanism in Vibrio and Clostridium Species **Supervisor :** Dr. K.N Viswas, Professor ICAR-IVRI, Izatnagar - Bareilly (UP)	February, 2018

Linkages and Collaborations

The Institute maintained linkages with the following national and international organizations

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 Technology, 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, 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 Unit (ITMU)

Institute Technology Management Unit and Agri Business Incubator are 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 addition, CIBA also made parternership 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 2017-18

Technologies transferred / commercialized

Desi shrimp feed technology Vanami ^{Plus} transfered to Sri Sathvika Aqua Agro Industries

MoU was signed with Mr. E. Sudhakar, Sri Sathvika Aqua Agro Industries Private Limited, Prakasam District, Ongole, Andhra Pradesh for setting up of shrimp feed mill and Vanami ^{Plus} technology.

Polyculture feed (Poly^{Plus}) technology was transferred to NRG Feeds, West Bengal

CIBA has developed cost effective and quality feed using indigenous feed ingredients for multispecies aquaculture, and the feed is promoted as the 'Poly ^{Plus}'. The polyculture feed technology has been transferred to NRG Feeds at Hooghly, West Bengal by signing MoU on 6th March 2018 for up scaling and commercial production on non-exclusive basis.

M/s Aura Biotechnologies Private Limited signed an agreement for cost-effective White Spot Syndrome (WSSV) diagnostic kit

A technology of DNA based nested-Polymerase Chain Reaction (PCR) diagnostic kit for the detection of lethal shrimp pathogen White Spot Syndrome Virus (WSSV) was transferred to M/s Aura Biotechnologies Private Limited, Chennai on 11th May 2017

Agency for Development of Aquaculture, Kerala (ADAK), signed an MoU comprehensive technology for fish/shrimp feed processing

Technology of Fish/Shrimp Feed processing and production was transferred to Agency for Development of Aquaculture, Kerala (ADAK), Trivandrum on 22nd of November 2017.

Promotion of milkfish and seabass farming in West Bengal towards augmenting the blue economy

ICAR-CIBA signed MoU with Shri Amalesh Chatterjee and Shri Saifulla Mandal, farmers from South 24 parganas district of West Bengal on 3rd July 2017 to provide technical assistance for milkfish and seabass farming and low cost feed production technology.

"CIBAMOX"- water probiotic technology was transferred to New Biosciences, Mysore

CIBAMOX"- water probiotic technology was transferred to New Biosciences, Mysore on 23rd February 2018 on non-exclusive basis.

CIBAMOX- water probiotic technology was transferred to Sharat Industries, Chennai

CIBAMOX- water probiotic technology was transferred to Sri. Mohan Anjaneya Reddy, Sharat Industries, Chennai on 6th March 2018 on non-exclusive basis.

Partnership with institutions

Initiation of responsible aquaculture development in and around Kutch region of Gujarat

To initiate responsible aquaculture development in and around Kutch region of Gujarat, Gujarat Institute of Desert Ecology (*GUIDE*) proposed collaborative research with ICAR-CIBA for aquaculture research development and extension in the region. On 4th April 2017 Dr.K.K.Vijayan, Director, ICAR-CIBA, Chennai and Dr. V. Vijay Kumar, Director, GUIDE, Bhuj signed MoU to initiate joint work programmes on aquaculture activities.

Mangrove Foundation of Maharashtra government for development of brackishwater aquaculture livelihood options in mangrove areas of Maharashtra

An MoU for collaborative research and development work was signed with CIBA and mangrove foundation on 17th June 2017 in a function organised at CIBA, Chennai.

TNFU join hands with CIBA for sustainable development of aquaculture

Tamil Nadu Fisheries University, (TNFU) Nagappatinam joining hands for undertaking collaborative programmes in research, teaching, and extension in the areas of brackishwater aquaculture by signing a MoU on 25th September 2017 at CIBA Chennai.

TANUVAS inks with CIBA for collaborative research programme

Tamil Nadu Veterinary and Animal Sciences University, Chennai Joined hands with CIBA, Chennai for undertaking collaborative programmes in research, teaching, and extension in the areas of fisheries and animal sciences on 13th February 2018 at TANUVAS, Chennai.

Technology for hatchery production of Asian seabass was transferred to Golden Eye Hatcheries, Chennai

CIBA signed a MoU under public-private partnership (PPP) mode for hatchery technology of Asian Seabass Seed Production with Golden Eye hatcheries on 30th December 2017 at ICAR-CIBA, Chennai.

Venkateswara farms, Andhra Pradesh signed a agreement with CIBA for knowledge partnership on development of ecofriendly and innovative penaeid shrimp production

Venkateswara farms, East Godavari, Andhra Pradesh partnered with CIBA for knowledge partnership for development of ecofriendly and innovative penaeid shrimp production technology on 6th January 2018.

Partnership with Farmers

Collaboration with Seven sea aqua farms and exports Ltd., Vishakhapatnam

Collaboration for partnership farming in brackishwater aquaculture was done with Seven seas aqua farms and exports Ltd., Vishakhapatnam on 5 October 2017.

Shri.Nishanth Reddy partnered with CIBA for commercial operation of seabass nursery

Shri.Nishanth Reddy, a software professional from Nellore, signed Memorandum of Agreement (MoA) for commercial operation of Seabass nursery on 17 April 2017. He also shared the revenue generated from this programme this year after the successful crop.

M/s Blancas Aqua took technological assistance for shrimp farming in inland saline areas of Bhatinda, Punjab

A MoU was signed between ICAR-CIBA and M/s Blancas Aqua, Gurthari road, Sangat Kalan, Bathinda, Punjab-151401 on 3rd June 2017 for shrimp farming in inland saline. This MoU is first of its kind on shrimp farming in inland saline areas of state of Punjab.

Periyar Integrated hatchery partnered with CIBA for establishing commercial scale mud crab hatchery at CIBA-Muttukadu Experimental Station

Memorandum of understanding was signed with Sri. V.G Eraniappan, Periyar Integrated hatchery for upscaling of Mud crab hatchery at Muttukadu Experimental Station (MES) to commercial scale on 25th September 2017 using broodstock and technical assistance of CIBA.

Cluster of farmers across the coastal states of India partnered with CIBA for popularization of Indian white shrimp

Ten MoUs were signed between CIBA and the farmer groups and their representative from different states to promote *P.indicus* culture. Under this agreement ICAR-CIBA is being partnered with the farmer to provide technical guidance with respect to providing quality seed and feed for undertaking *P.indicus* culture.

Shri. Keerthiram, a farmer signed aggreement with CIBA for technical support and partnership farming of pearlspot seed production

Providing Technical Support and Partnership farming for Adoption of modular System of Pearlspot seed production and Nursery Rearing Models to Sri.Keerthiram, a farmer from Kerala on 26th March 2018.

Partnership in pond based broodstock development and breeding

Memorandum of understanding was signed with Pancham aquaculture farms ltd. (PAFL), Mumbai for partnership in pond based broodstock development, breeding and nursery rearing of grey mullet in west coast at PAFL Ltd., farm at Jalsar on 10th of October 2017.

Revenue generated during 2017-18

The revenue earned from different types of activities and revenue from one time payment and royalty/revenue share obtained in the total revenue generated.

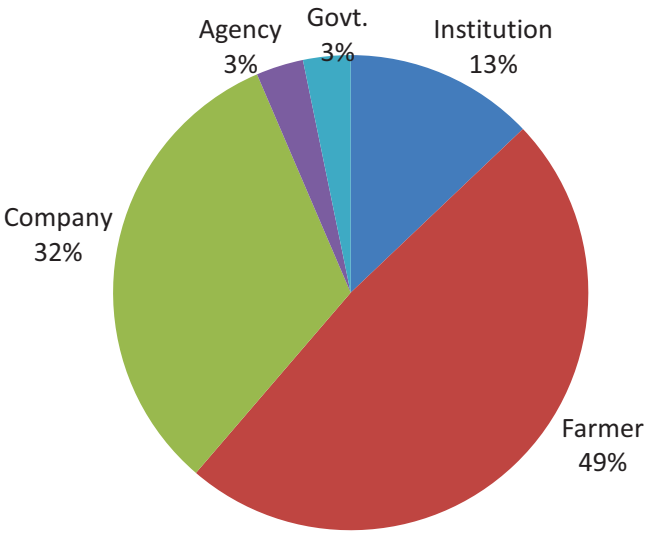
Revenue generated

Client name	Revenue generated
Sathvika Aqua, AP	690000
Royalty from Sai aqua, Bapatla	60000
Aura Biotech	143750
Revenue share from Sri.Sudhakaran, Anjan Dandapat & Ms.Girija	210000
Revenue share from, Anjan Dandapat	199200
Golden Eye, Chennai	200000
Venkateswara farms	59000
ADAK, Kerala	118000
New Bioscience, Mysore	118000
Revenue share from Nishanth Reddy, Nellore	2,52,800
NRG seeds, West Bengal	1,18,000
Sharat industries, Chennai	2,36,000
Revenue share from Sri. AsheshGiri, West Bengal	80,000
Total	**24,84,750 (inclusive of tax)**

CIBA's MoU with different stakeholders

ICAR-CIBA has strengthened relationships with other Govt. institutions and departments, Govt. agencies, companies and farmers through signing of MoUs. The farmers MoUs occupied 49% of total MoUs signed. Private companies were also eager to sign MoUs with ICAR-CIBA which was evidenced by 32% of MoUs being signed with ICAR-CIBA in the year 2017-18.

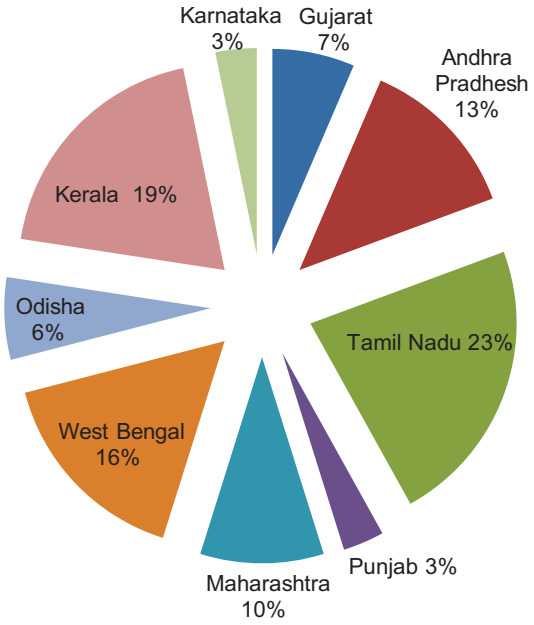
The constraints experienced in working with private firms are exclusive ownership demanded by private companies and focuses interest on ealuation for field testing of their products. The institute has been firm on joint ownership of IP with a nominal royalty payment from the companies. ICAR-CIBA has also signed MoUs with state Govt. agencies, other Govt. institutions.



Nature of organizations which signed MoU with ICAR-CIBA

Interaction with different states of the country

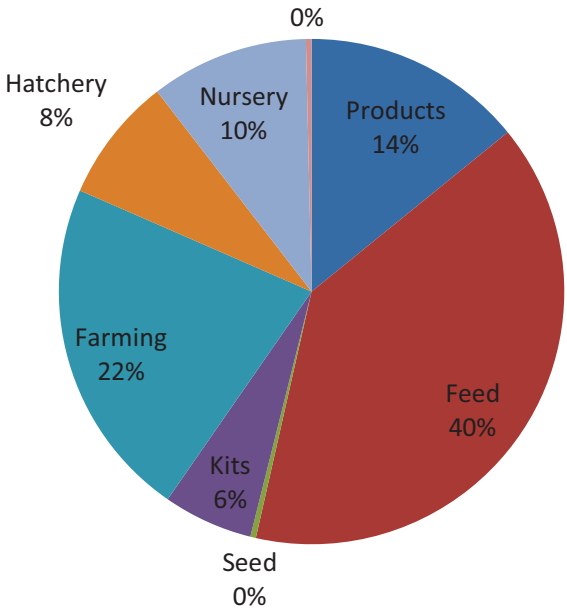
Statewise interaction and presence of the institute is important to have a image of national institute. This year except Goa all the coastal states of India had MoUs with ICAR-CIBA for public private partnership activities. Notably Punjab representing inland saline soils has also signed an MoU with ICAR-CIBA this year.



State - wise

Mou Signed for different purpose

The number of MoUs signed for different purpose is another indicator on the technical strength of ICAR-CIBA. Farming related MoUs were Sixteen in number during 2017-18. It is a proof of the strength of institute supporting farming community for undertaking novel farming methods. Hatchery and nursery MoUs were Three in number along with Four MoUs for feed technologies. One MoU was signed for commercialisation of diagnostic kit along with Four MoUs for collaborative research programme. Two products were also commercialised through MoUs.



Collaborative Research Programme

Research & Administrative Meetings

RESEARCH ADVISORY COMMITTEE (RAC)

The Research Advisory Committee of CIBA was constituted by ICAR (Council's order F.No.18-03/2016 -ASR-I dated 06.12.2016) for a period of three years with effect from 01.01.2017 to 31.12.2019.

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 23rd Research Advisory Committee (RAC) meeting of CIBA was held on 27th February 2018 at CIBA Headquarters, CIBA, Chennai.

INSTITUTE RESEARCH COUNCIL

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. Gopal Dr. S.V. Alavandi Dr. G. Gopikrishna Dr. M. Kailasam Dr. V.S. Chandrasekaran Dr. M. Muralidhar Dr. K. Ambasankar Principal Investigators of all the projects
Member Secretary	Dr. Subhendu Kumar Otta

The 34th IRC Meeting was held on 17-19th May 2017 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**

Members

Dr. Pravin Puthra, ADG (M.Fy.), ICAR
Dr. K. Ashok Kumar, PS, ICAR- CIFT, Cochin (upto 12.05.2018)
Dr. Bindu R. Pillai, PS & Head, ICAR- CIFA, Bhubaneswar (upto 12.05.2018)
Dr. Vijaya Gopal, PS, ICAR- CMFRI, Kochi (upto 12.05.2018)
Dr. Joe Kizhakudan, PS, ICAR- CMFRI, Chennai (upto 12.05.2018)
Commissioner of Fisheries, Govt. of Tamil Nadu, Chennai
Commissioner of Fisheries, Govt. of Gujarat, Gandhi Nagar
The Dean, FCRI, TANUVAS, Thoothukudi

Co-opted Members

Member Secretary
Sh. K.V.S. Satyanarayana, Administrative Officer

Members
Dr. T. Ravisankar, Principal Scientist & Head of Office
Dr. M. Kumaran, Finance & Accounts Officer (I/c)
Dr. M. Jayanthi, PS & OIC (Engg. Cell)
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 49th IMC meeting held on 28th October 2017.

INSTITUTE JOINT STAFF COUNCIL (IJSC)

The composition of the Institute Joint Staff Council (reconstituted by CIBA for a period of three years w.e.f 29.03.2016 to 28.03.2019 vide Office Order F.No.13-1/2012-Admn.
Dated 02.04.2016) is as follows:

Official Side

Chairman	**Dr. K.K. Vijayan**
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. K.V.S. Satyanarayana, A.O.

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

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**
Elected Members	
Scientific Member	Dr. J. Syma Dayal, P.S & Dr. Nila Rekha, P.S
Technical Member	Dr. A. Nagavel, Senior Technical Officer
Administrative Member	Mrs. Usha Rani, A.A.O & Shri P. Srikanth, J.A.O Shri. A. Manoharan, Assistant
Staff Member	Shri. M. Pichandi, Skilled Support Staff

WOMEN COMPLIANT COMMITTEE

Women Complaint Committee has been constituted as follows:

Chairman	**Dr. R. Saraswathy**
Members	Dr. Prasanna Kumar Patil Dr. Sherly Tomy Dr. Vinaya Kumar Katneni Shri. S. Nagarajan Smt. E. Mary Desouza
External Member	Dr. Lita Sunder, Madras Christian College

WOMEN'S CELL

Women Cell has been constituted as follows:

Chairman	**Dr. D. Deboral Vimala**
Member	Dr. R. Saraswathy Smt. B. Amudavalli Smt. K. Subhashini Smt. M. Mathuramuthubala
Member Secretary	Shri. R. Kandamani

Services and Assignments

Services in Committees

Dr. K.K. Vijayan, Director

Member, Executive Committee and Governing Body, Rajiv Gandhi Centre for Aquaculture (MPEDA), Mayiladuthurai.

Member, ICAR Regional Committee No.VIII

Executive Committee Member, National Centre for Sustainable Aquaculture (NaCSA)

Member, Coastal Aquaculture Authority

Member, Scientific Advisory Committee, Krishi Vigyan Kendra, Tiruvallur

Member, Scientific Advisory Committee for Dr. Perumal Krishi Vigyan Kendra

Member, State Level Committee on Animal Genetic Resources (SLCAnGR), constituted by Department of Animal Husbandry & Veterinary Services, Government of Tamil Nadu, Chennai

Member, Board of Management of Tamil Nadu Fisheries University, Nagapattinam

Member, Board of Management of Tamil Nadu Veterinary and Animal Sciences University, Chennai

Member, Academic Council of Central Institute of Fisheries Education, Mumbai.

Member, Board of Management of Central Institute of Fisheries Education, Mumbai

Member, 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

Member, Advisory Committee on Hilsa Conservation and Research

Member, Governing Body of State Fisheries Resource Management Society (FIRMA), Thiruvananthapuram

Member, Advisory Board for Fisheries Sector Development, constituted by Special Chief Secretary (Planning), Planning Department, Govt. of Andhra Pradesh.

Member, Society of Coastal Aquaculture and Fisheries

Member, Society for Fisheries Technologists

Member, Marine Biological Association of India

Member, 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.

Member, 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).

Member, Selection Committee - Tamilnadu Scientist Award (TANSA) constituted by Tamil Nadu State Council for Science and Technology), Kochi.

Member, 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.

Member, Selection Committee for the selection of the University Officers of the Tamil Nadu Dr J Jayalalitha Fisheries University, Nagapattinam

Member, State-wise Coordination Committees for doubling Farmer's Income by March, 2022, constituted by Secretary, DARE & Director General, ICAR, New Delhi.

Member, Kerala State Council for Science Technology and Environment, Thiruvananthapuram.

Member, Expert committee to study on Vembanad, Astamudi and Sasthamkotta lakes, constituted by Office of the Director of Fisheries, Govt. of Kerala, Thiruvananthapuram.

Member, National Steering Committee of 11th Indian Fisheries and Aquaculture Forum.

Member, Scientific Committee of the International Conference on Climate Change and Sustainable development, Annai Fathima College of Arts and Science, Madurai.

Member, National Organizing Committee for "Second international symposium on societal applications in fisheries and aquaculture using remote sensing imagery", CMFRI, Kochi.

Member, Steering Committee for the Asian Pacific Aquaculture 2019 (APA 2019), Chennai.

Other Staffs of CIBA

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.

Member, Editorial Board for Menba Journal of Fisheries Faculty, Kastamonu University, Turkey – Dr.Gouranga Biswas.

Member, Inspection Committee, Coastal Aquaculture Authority, Ministry of Agriculture and Farmers Welfare, Government of India – Dr.S. Kannappan, Dr. M.Makesh and Dr. M. Poornima

Associate Editor, Journal of Fisheries and Life Sciences, Mangaluru, India - Dr. Gouranga Biswas.

Member, Committee for Regulation and Monitoring of Aquaculture Inputs in India, constituted by the Secretary, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Farmers Welfare, Govt. India, New Delhi – Dr. P.K.Patil.

Member, Fish, Fisheries and Aquaculture sectional committee FAD12 and Aquaculture subcommittee FAD12.1- Dr. K. Ambasankar.

Member, Expert Committee to 'Study possible side effects of unauthorised use of oxytocin on animal and human health' at the Office of the Drugs Controller General (India), Directorate of General of Health Services, Ministry of Health and Family Welfare, Govt. India, New Delhi – Dr. P.K.Patil.

Member, committee for "Scrutiny of Application received for the post of faculty positions" organized by IIFPT Institute on 10th January 2018 - Dr. K.P. Jithendran.

Expert, to the interview of Technical Consultants for Coastal Aquaculture Authority, on 12th January 2018.- Dr. S.K. Otta.

Expert, for the Scientific Panels in the Food Safety and standards Authority of India on 16th March 2018 at New Delhi - Dr. P.K. Patil.

Expert Faculty Member, working on Application of Artificial intelligence in Agriculture, organized by ICAR-Indian Institute of Water Management at Bhubaneswar on 30th March 2018 - Shri. Ashok Kumar Jangam.

Observer for the ARS – 2006 (Preliminary) and NET (I)-2017 Examination held at Chennai on 15.5.2017 - Dr. B. Shanthi.

Advisory services and technical guidance for establishment of fish feed mill unit bt TN state fisheries Department at Sengipatti, Achampatti in Thanjauvur district of Tamil Nadu

Feed mill operated by Department of Fisheries under Tamil Nadu State Government in Thanjavur with technical guidamce of ICBA-CIBA

Inside view of feed mill opened at Thanjavur

ARYA (Attracting and Retaining Youth in Agriculture) : an initiative to attract youth to brackishwater aquaculture

Farming in land or water is the noble occupation and farmers consider it as their way of life. As on day, India is self-sufficient and self-reliant in food production and also exporting food grains. But, the majority of the farmers don't want their next generation to continue with their traditional profession, because of low income from agriculture and poor quality of life in rural areas. Youth minds are creative and socially networked, and they are capable of handling risk factors such as monsoon management, climatic change adaptation and poverty in an efficient way, using various technologies. Therefore, the government has taken a number of schemed to make youth to enter into agriculture. The new scheme ARYA has recently been launched by the ICAR.

Exposing the school students to farming systems and farming technologies is the first step to create awareness and interest among them in food production. CIBA has taken initiatives to motivate and attract the student in to brackishwater aquaculture. CIBA has conceived a 'student project module on brackishwater aquaculture' and provided an opportunity to a group of nine higher secondary students from the Kendriya Vidyalaya School, island grounds, Chennai for a period of 7 weeks during September-October, 2017. The students learnt the basics of brackishwater aquaculture initially and were subsequently given short-term projects to study the brackishwater resources and aquaculture in brackishwater. The students, with the guidance of scientist mentors, were imparted the hands-on skills and technological inputs, followed by experimental set up to rear the fishes to have aquaculture production

A brief interaction meeting was held on 27 October 2017 at CIBA wherein the students presented their project findings. The students gladly said that the internship gave them the 'attitudinal change' towards farming and expressed that it has provided awareness on farming and its prospects.

Mera Gaon Mera Gaurav

The "Mera Gaon Mera Gaurav" has been conceptualized in which scientists of ICAR and Agricultural Universities will identify villages in the vicinity of the Institutions for providing advisories and consultations to farmers for increasing farm productivity and production.

Under this program ICAR-CIBA has adopted twelve nearby villages namely Srinivasapuram, Thenchennai Mullikuppam, Mullimanagar, Vennagupattu, Kottaikadu, T. Kulathur, Thangalperumpulum, Kattur, Thonirevu, Karikattukuppam, Pattipulam, Kokilamedu under the MGMG programme and carrying our scientific interventions in helping the rural youth for self-employment. Under this programme, cage culture, ornamental fish culture, crab fattening, feed preparation etc are demonstrated. Partnership farming module initiates are regarded as new models.

Conducted farmers meeting at Kanathur, Reddikuppam in relation with Mera Gaon Mera Gaurav (MGMG) on 19th August 2017 and also organized the Swachhta Pakhwada "Cleanliness Fortnight" at Thiruvidanthai (adopted MGMG village), Kancheepuram district, Tamil Nadu, on 25th May 2017.

Swachh Bharat Mission Programmes

In response to the noble call, Swachh Bharat Mission, the following Swachhta Pakhwada and Swachhta Hi Seva programmes were conducted by ICAR-CIBA, Chennai and Kakdwip Research Centre (KRC) of CIBA, Kakdwip, West Bengal, with due gravity and purposefulness during 16-31 May 2017 and 15 September to 2 October 2017 respectively.

1. Awareness and cleanliness programme at Kakdwip Research Centre of ICAR-CIBA on 22nd May, 2017.
2. Awareness cum Cleanliness programme at Thiruvidanthai village, Tamil Nadu, with participation of local people on 25th May 2017.
3. Awareness cum Cleanliness programme at Kottaikadu village, Tamil Nadu, on 26th May 2017 in Anganvadi School, Kottaikadu village (adopted by ICAR-CIBA for MGMG programme), Kanchipuram District, Tamil Nadu.


केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान
काकद्वीप शोध केन्द्र
CIBA
KAKDWIP RESEARCH CENTRE
(Indian Council of Agricultural Research)
Kakdwip, South 24 Parganas, West Bengal - 743347

4. Hands-on Training on "Waste to Wealth" at Adyar creek and estuary on 27th May, 2017 at Srinivasapuram, Mullikuppam, Mullimanagar villages cluster.
5. Hands-on demonstration on fish silage making Awareness cum cleaning programme at Gangadharpur, West Bengal, on 29th May 2017.
6. Swachhta Hi Seva was observed at Kakdwip Research Centre of ICAR-CIBA, Kakdwip, West Bengal on 17th September, 2017.
7. Swachhta Hi Seva was conducted at Srinivasapuram, Chennai, Tamil Nadu on 24th September 2017 by CIBA team with participation of local village Panchayat representatives.
8. Organized the cleaning, Sarwatra Swachhta, programme of public pathways at Adyar Creek areas, Chennai, Tamil Nadu, on 25th September 2017.

   Muttukadu beach areas nearby Muttukadu Experimental Station of CIBA, Tamil Nadu were cleaned with active participation of CIBA team as part of Swachhta Hi Seva on 1st October 2017.

Distinguished Visitors

Headquarters, CIBA, Chennai		
S.No.	**Details of visitors**	**Date of visit**
1.	Shri.Baburaj V.Nair, the Chief Human Resources Officer of 'The Hindu' newspaper group	4th April 2017
2.	Mr. E. Sudhakar, Sri Sathvika Aqua Agro Industries Private Limited	4th May 2017
3.	Shri Sunil Kumar Singh, Financial Advisor and Additional Secretary, DARE/ICAR	5th May 2017
4.	Dr. Dhinakar Raj G, Project Director, Translational Research Platform for Veterinary Biologicals (TRPVB), CAHS, TANUVAS, Madhavaram Milk Colony, Ch ennai & Dr. Pazhanimuthu Annamali, 'Aura Biotechnologies Limited	11th May 2017
5.	Mr. P. Murari, IAS (Retd) Adviser to FICCI and Former Adviser to President of India	30th May 2017
6.	Mr. Manish Goyal and Mr. Vineet Verma from Bathinda, Punjab	3rd June 2017
7.	Shri. N. Vasudevan, Additional Principal Chief Conservator of Forests, Mangrove Foundation, Mumbai, Maharashtra	16th June, 2017
8.	Dr. N.K. Ambujam, Professor and Director, Centre for Water Resources, Anna University	20th June 2017
9.	Yoga Guru Mr. K. N anjapathi	21st June 2017
10.	Shri Amalesh Chatterjee and Shri Saifulla Mandal farmers from South 24 parganas district of West Bengal	3rd July 2017
11.	Ms. Swapna Sundar, IP Strategist & Patent Agent and CEO, IP DOME Strategy Advisors Pvt Ltd., Chennai	17th July 2017
12.	Shri.P.Parthiban IAS, Secretary Fisheries Government of Puducherry and Director of Fisheries, Government of Puducherry and his technical team comprising of Shri.V.Jayanand, Joint Director of Fisheries, Shri.J.Nadarajan, Deputy Director of Fisheries	21st July 2017
13.	Shri V.P. Thandapani, I.A.S, Director DOF, Govt. of TamilNadu	3rd August 2017
	Dr.Suresh	
14.	Dr.Trilochan Mohapatra, Director General, ICAR and Secretary, DARE and Dr.Joykrushna Jena, Deputy Director General (Fisheries)	6-7th August 2017

	Details of visitors	Date of visit
15.	Mr. S. Chandrasekar, President, Society of Aquaculture Professionals (SAP), Chennai and Dr. Anup Mandal, representative from MPEDA	17th August 2017
16.	Dr. A.K.Panda, Project Manager of Aquatic Quarantine Facility (AQF) of MPEDA	18th August 2017
17.	Dr. E.G. Silas, Founder Director CIBA & Former Vice Chancellor, Kerala Agricultural University	26th August 2017
18.	Dr.K.Narayana Gowda, Former Vice -chancellor, UAS, Bengaluru	29th August 2017
19.	Shri M.Annadurai, IAS, Director, Directorate of Field Publicity (DFP), Ministry of Information and Broadcasting, Govt. of India	15th September 2017
20.	Dr G. Jeyasekaran, Director of Research, TNFU in the presence of Dr S. Felix, Hon. Vice Chancellor of TNFU	25th September 2017
21.	Dr. C. Suvarna, Commissioner of Fisheries, Te langana State	18th December 2017
22.	Dr. B. Meenakumari, Chairperson, National Biodiversity Authority, Dr. J.K. Sundaray, Director, ICAR -CIFA, Dr. Shubhadeep Ghosh, Senior scientist CMFRI, Dr. T.T. Ajith Kumar, Senior Scientist, NBFGR and Ms. M.C. Ramany, P roject manager RGCA -MPEDA	29th December 2017
23.	Mr. E. M. Senthil Kumar of Golden Eye	30th December 2017
24.	Shri Ramakanth V. Akula CEO, The Waterbase Ltd.	3rd January, 2018
25.	Dr. T.J.Harikrishnan, Registrar, TANUVAS, Chennai	13th February 2018
26.	Dr.K.Gopaku mar, former DDG, Fisheries. Distinguished members of RAC	27th February 2018
27.	Mr. Kajal Kumar Roy, NRG Feeds, Joyrampur, Arambagh, Hooghly, West Bengal	6th March 2018
28.	Dr. Mruthyunjaya, Former National Director, NAIP, ICAR	20th March 2018
	KRC, Kakdwip	
29.	Ms. Seema Chopra, Director, Raj Bhasa, ICAR	25th May 2017

Dr. Trilochan Mohapatra, Director General ICAR and Secretary, DARE visited ICAR-CIBA, Chennai

Dr.Trilochan Mohapatra, the Director General, Indian Council of Agricultural Research and Secretary, Department of Agricultural Research and Education visited the ICAR-CIBA, Chennai on 6th and 7th August 2017 and had interactions with the scientists and staff. He visited the research facilities at Muttukadu Experimental Station of CIBA and interacted with the scientists on the ongoing research programmes on breeding and seed production of finfishes, shrimps and mudcrab, nutrition and feed development. He had in depth discussion regarding the genetic stocks, breeding protocols, prioritized programmes and the requirement of the developmental needs of the brackishwater sector. He distributed hatchery produced seabass fish seeds to farmers from Andhra Pradesh, Kerala and Women SHGs from Tamil Nadu. He witnessed the formulated pelletized feed making process in the CIBA's experimental feed mill. The DG released a DNA based diagnostic kit for the screening of EHP disease in shrimp, books on CIBA Technologies and FAQs on Shrimp farming in Hindi language.

Secretary Fisheries, Union Territory of Puducherry visited ICAR-CIBA, Chennai

Shri.P. Parthiban IAS, Secretary Fisheries and Director of Fisheries, Government of Puducherry and his technical team comprising of Joint Director of Fisheries, Deputy Director of Fisheries and other officials visited cage farming programme taken up by ICAR-CIBA at Adyar creek on 21st July 2017.

Fisheries Commissioner Telangana State visited ICAR-CIBA, Chennai

In order to explore the feasibility of *P. vannamei* farming in low saline waters of land locked state of Telangana, Dr. C. Suvarna, Commissioner of Fisheries, Telangana State along with Fisheries Department officials visited ICAR-CIBA on 18th December,2017. Commissioner and team visited all the research facilities at Head Quarters and Muttukadu Experimental Station of CIBA.

Personnel

Director: Dr. K. K. Vijayan

Headquarters

Head of Divisions
Dr. C. Gopal, Crustacean Culture Division (VRS on 23.10.2017)
Dr. G. Gopikrishna, Nutrition, Genetics & Biotechnology Division
Dr. S. V. Alavandi, Aquatic Animal Health & Environment Division

Principal Scientists
Dr. K. P. Jithendran
Dr. V. S. Chandrasekaran (Superannuation on 30.11.2017)
Dr. C.V. Sairam
Dr. T. Ravisankar
Dr. M. Muralidhar
Dr. (Mrs.) M. Jayanthi
Dr. (Mrs.) B. Shanthi
Dr. C. P. Balasubramanian
Dr. M. Kailasam
Dr. (Mrs.) D. Deboral Vimala
Dr. M. Shashi Shekhar
Dr. S. Kannappan
Dr. (Mrs.) P. Nila Rekha
Dr. K. Ambasankar
Dr. J. Syama Dayal
Dr. Akshya Panigrahi
Dr. M. Kumaran
Dr. Debasis De
Dr. (Mrs.) M. Poornima
Dr. (Mrs.) R. Saraswathy
Dr. M. Makesh
Dr. Prasanna Kumar Patil
Dr. (Mrs.) Sherly Tomy
Dr. Subhendu Kumar Otta
Dr. (Mrs.) P. Mahalakshmi

Senior Scientists
Dr. K. P. Kumaraguru vasagam
Dr. Satyanarayan Sethi

Scientist (Senior Scale)
Shri. Ashok Kumar Jangam

Scientists
Dr. K. Vinaya Kumar
Dr. R. Ananda Raja
Dr. (Mrs.) Krishna Sukumaran
Dr. (Mrs.) P. Ezhil Praveena
Dr. Sujeet Kumar
Dr. (Mrs.) P. S. Shyne Anand
Dr. (Mrs.) T. Bhuvaneswari
Dr. (Mrs.) N. Lalitha
Dr. P. Kumararaja
Dr. B. Sivamani
Dr. (Smt).R. Geetha
Dr. (Mrs.) Vidya Rajendran
Dr. Satheesha Avunje
Shri K. P. Sandeep
Mrs. M. U. Rekha
Ms. Babita
Shri. Aritra Bera
Shri. T. Sathish Kumar
Shri. R. Aravind
Shri. Tanveer Hussain
Ms. Suvana Sukumaran
Dr. N.S. Sudheer
Mrs. Neethu.K.C.
Ms. Misha Soman
Shri. Jose Antony
Ms. Leesa Priyadarsani
Shri. Dani Thomas
Shri. Biju.J.E.
Smt. Mary Lini
Dr. J. Raymond Jani Angel
Shri. T. Sivaramakrishnan
Dr. Vinay Tharabenahalli Nagaraju
Shri. Pankaj Amrut Patil

Chief Technical Officer
Shri. R. Elankovan

Assistant Chief Technical Officers
Dr. S. Sivagnanam
Shri. D. Raja Babu
Shri. M. Shenbagakumar
Shri. R. Puthiavan
Mrs. K. Jacquline

Senior Technical Officers
Dr. Joseph Sahayarajan
Shri. S. Stanline (Expired on 29.07.2017)
Dr. A. Nagavel
Shri. R. Subburaj
Shri. S. Nagarajan
Shri. S. Rajamanickam

Technical Officers
Shri. N. Ramesh
Shri. S. Saminathan
Shri. N. Jagan Mohan Raj
Shri. R. Balakumaran (Driver) (Superannuation 31st May, 2017)

Senior Technical Assistant
Shri. D. M. Ramesh Babu
Shri. G. Thiagarajan
Shri. K. Paranthaman (Driver)

Technical Assistant
Shri. K. Karaian

Senior Technician
Shri. K. V. Delli Rao

Administrative Officer
Shri. K. V. S. Satyanarayana

Finance & Accounts Officer
Vacant from 17.05.2015

Assistant Administrative Officers
Shri. R. Kandamani
Mrs. V. Usharani
Shri. S. Pari (Promoted w.e.f. 01.04.2017)

Junior Accounts Officer
Shri. P. Srikanth,

Personal Assistants
Mrs. S. Nalini
Shri. K. G. Gopala Krishna Murthy

Assistants
Shri. A. Manoharan
Mrs. E. Amudhavalli
Shri. A. Sekar
Shri. K. Raghavendra (Joined on 28.07.2017)
Smt. E. Mary Desouza (Promoted w.e.f. 13.10.2017)

Stenographer Gr. III
Mrs. K. Hemalatha
Mrs. K. Subhashini

Upper Division Clerks
Mrs. R. Vetrichelvi
Mrs. M. Mathuramuthu Bala

Lower Division Clerks
Shri. B. Palanivelmurugan
Mrs. B. Prasanna Devi
Shri. R. Kumaresan
Shri. A. Paul Peter

Skilled Support Staff
Shri. V. Jeevanandam
Shri. K. Nithyanandam
Shri. V. M. Dhanapal
Shri. V. Kumar
Shri. E. Manoharan
Shri. C. Saravanan
Shri. S. Kuppan
Shri. M. Pichandi
Shri. S. Selvababu
Shri. D. Senthil Kumaran
Shri. C. Ragu
Shri. P. G. Samuvel
Shri. M. Sakthivel
Shri. R. Mathivanan
Shri. R. Indra Kumar
Shri. G. Dayalan
Shri. Kanaka Prasad
Smt. S. Premavathy
Shri. J. Murugan
Shri. V. Kisor kumar (Joined on 31.05.2017)

Kakdwip Research Centre

Principal Scientists
Dr. T. K. Ghoshal
Dr. Sanjoy Das

Scientists
Dr. Gouranga Biswas
Dr. Prem kumar
Ms. Christina Lalramchhani
Ms. Leesa Priyadarsani

Technical Officer
Shri. P. S. Samanta

Senior Technical Assistant
Mrs. Chhanda Mazumder

Administrative Staff
Private Secretary
Shri. S. K. Halder (Superannuation on 31.01.2018)

Assistant
Shri. S. K. Bindu

Skilled Support Staff
Shri. N. N. Jana
Shri. K. P. Naskar
Shri. Purna Chandra Das
Mrs. L. R. Bhuiya
Shri. U. K.Santra
Shri. Sanjoy Some (Joined on 30.05.2017)

Redeployed Staff from PRC of CIBA, Puri to CIFA, Bhubaneswar

Technical Assistant
Shri. P. C. Mohanty

Skilled Support Staff
Shri. Premananda Bisoi
Shri. Maharaga Majhi
(Superannuation on 31.08.2017)

OBITUARY

Mr. S. Stanline
Senior Technical Officer

Mr. S. Stanline, 48 years, Senior Technical Officer, at Headquarters of CIBA passed away on July 28, 2018, as a result of injuries and illness sustained due to road accident he met earlier in May 2018. His untimely death left a tremendous rift in the lives of his family, friends and colleagues of CIBA. Born in Kanyakumari district of Tamil Nadu on July 11, 1969, had his diploma in mechanical engineering in nearby hometown and joined in CIBA in 1997. Later he acquired a bachelor degree in Mechanical Engineering from prestigious Anna University. His enthusiasm, sincerity and scientific curiosity played a significant role in bringing up the pilot scale feed mill a state of art facility in CIBA at its Muttukadu Experimental Station. At a more personal level, he will always be remembered for his truthfulness, gentlemanliness, and humble behaviour. Mr Stanline is survived by his wife, Mrs S. Sobhi, daughter, S. Stebhi Isabel, son, S. Solin Igneshius and several friends and colleagues who had the privilege of his friendship

Infrastructure Development for the year 2017-18

1. Construction of compound wall at CIBA Head Quarters, Chennai.
2. Construction of Aquaculture laboratory for climate change works over the existing health laboratory at CIBA Head Quarters, Chennai.
3. Replacement of the mosaic flooring with vitrified tiles in Ground floor corridor at CIBA Head Quarters, Chennai.
4. Construction of semi-permanent shed over the parking area at CIBA, Head Quarters, Chennai.
5. Construction of laboratory buildings at CIBA, Head Quarters, Chennai.
6. Supply, Installation, Testing & Commission of 1 No. 320 KVA Diesel Generator at CIBA Head Quarters, Chennai.
7. Conversion of existing 11 KV Overhead 4 pole Structure and HT Metering cubicle in to 11 KV outdoor type compact RMG with metering at CIBA Head Quarters, Chennai
8. Replacement of Faulty neon sign board to LED signs board at CIBA Head Quarters, Chennai
9. Providing 1 No 315 KVA Outdoor Transformer at CIBA Head Quarters, Chennai
10. Conversion to LED lighting system in the Video Conference hall, Auditorium, Library and common area at CIBA Head Quarters, Chennai.
11. Replacement of the poly carbonite roofing sheet in the court yard area at CIBA Head Quarters, Chennai.
12. Construction of platform with lean roof sheet at Muttukadu Experimental Station of CIBA, Muttukadu.
13. Renovation of shrimp hatchery, Fish hatchery and Crab hatchery at Muttukadu Experimental Station of CIBA, Muttukadu.
14. Farmer facilitation centre at Muttukadu Experimental Station of CIBA, Muttukadu.
15. Replacement of electrical earthing system at Muttukadu Experimental Station of CIBA, Muttukadu.
16. Construction of first floor over the existing wet laboratory building at Regional centre of CIBA, Kakdwip.
17. Enhancement of power load from 50 KVA to 200 KVA at Regional centre of CIBA, Kakdwip.
18. Renovation of existing electrical supply to pumps, aerators, water supply systems of KRC of CIBA, Kakdwip
19. Renovation of challenge shed at Regional centre of CIBA, Kakdwip.
20. Desilting of ponds and laying brick pitched road around C- sector farm Regional centre of CIBA, Kakdwip.
21. Construction of Trainee's hostel at Regional centre of CIBA, Kakdwip.

Farmer facilitation centre at Muttukadu

Library and Documentation

a. Library holdings
CIBA Library procured 60 new books including official language books during this period 2017-18 and currently holds 2,731books, international and national journals at headquarters, Chennai and Kakdwip Research Centre of CIBA in West Bengal. The details of Library holdings as on 31.03. 2018 are provided in the diagram below.

b. Library and e-Resource Centre
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 academicians from Universities, Colleges and Institutes. The timing of the facility has been extended till 6 p.m. to enable students to use it effectively

c. Digital Repository
Under this initiative, all institute publications and the individual scientists publications have been digitized and uploaded in the Krishi ICAR website. It will be further uploaded in the Eprints (open sources software) and linked to the international databases to facilitate visibility of CIBA research achievements across the globe.

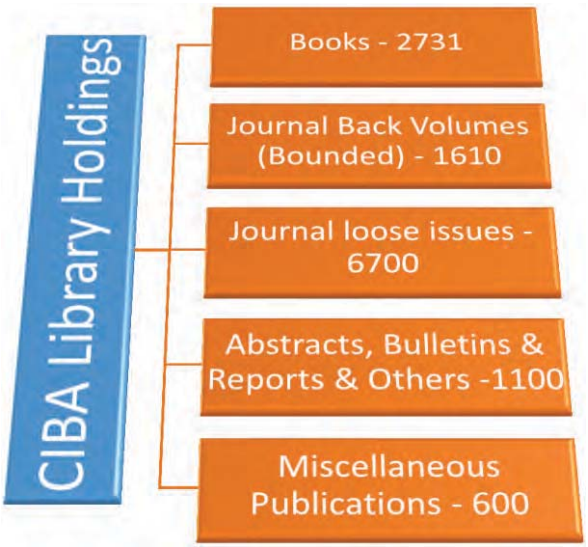
d. Online access to the CIBA Subscribed & CeRA journals and Document delivery services:
CIBA has access to e-books and journals published by Springer, John Wiley and Elsevier through ICAR- CeRA resource sharing platform. The library has listed all the full content accessible online journals with their access links in CIBA web portal for the benefit of users of the library. 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 national and international organizations working on fisheries and aquaculture on mutual interest. The library maintained the free mailing of institute's annual report and other Institute publications to various research organizations, universities and other agencies to give greater to 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, academicians, university/ college students, research scholars, stakeholders and other related visitors. The library provided Photocopying service to the users on nominal payment basis.

g. Utilization of funds
During this year, there is Rs. 15.00 lakhs funds were utilized towards the procurement of new books for Headquarters and KRC library of CIBA, procurement of Servers, Scanner and Grammarly Software for the library users, Scientists & Staff.

h. ISBN Numbers
CIBA has obtained 50 ISBN numbers for five years from the Ministry of Human Resources Development for its publications. Eight books have been allotted ISBN numbers as of March 2018.



CIBA - Library Holdings

Publication, Particpation in Conferences,Meetings, Workshops, Symposia

Institute Publication list

Annual Report 2016-17

Training Calendar 2017-18

CIBA News 2015-16

CIBA News Jan-Jun 2017

CIBA News Special Issue

Jal Tarang Vol.3 Sep 2017
(Hindi magazine)

CIBA Extension Series

- Managing hepatopancreatic Microsporidiosis, An emerging threat to shrimp farming. CIBA extension series No. 49. (Telugu).
- Acute hepatopancreatic necrosis disease/early mortality syndrome (AHPND/EMS). CIBA Extension Series No. 50. (Telugu).
- Prevention and management of white spot disease of shrimp. CIBA Extension Series No. 51. (Telugu).
- Seed production and grow-out culture technology of brackishwater catfish, *Mystus gulio*. CIBA extension series No. 60.
- Nona tengra machher chara utpadon o chas paddhoti (Bengali) - Seed production and grow-out culture technology of brackishwater catfish, *Mystus gulio.* CIBA Extension Series No. 60
- Lumiphage (Malayalam).
- CIBAMOX (Malayalam).

CIBA Technology Series

- Etro Brood^{Plus} – A functional feed broodstock feed for Pearlspot (*Etroplus suratensis*). ICAR-CIBA Technology Series No. 14.
- Poly ^{plus} – a cost effective feed for brackishwater polyculture. CIBA Technology Series 15.
- Cage farming of Asian Seabass in open brackishwaters using formulated feed in tailormade cages. ICAR-CIBA Technology Series No. 16.

CIBA Special Publication

- Revised Handbook on Biofloc Technology: Concepts, Benefits and Application in Aquaculture. CIBA Special Publication No.82.

CIBA Training Manuals

- Training Manual on Recent Advances in Soil and Water Management in Brackishwater Aquaculture. CIBA TM Series 2017 No. 8.
- Training Manual on Polymerase Chain Reaction (PCR) detection of *Enterocytozoon hepatopenaei* (EHP) in shrimp. CIBA TM series 2017 No. 9.
- Innovative and evolving Brackishwater Crustacean Aquaculture. CIBA TM Series 2107 No. 5.

Books by CIBA

- *Penaeus Vannamei Ginga Palan Ke Bara Mae Akshar Poochae Janaevalae Prashna* (in Hindi), (Vannamei Shrimp Farming: Farmers Frequently Asked Questions -FAQs and Explanations), ICAR-CIBA, Chennai, ISBN No: 978-81-932937-6-8, 48p
- Compendium on prophylaxis in Aquaculture. ISBN No. 978-81-932937-7-5.

Reports by CIBA

- Environmental impact assessment of (EIA) of mangrove crab (*Scylla serrata*) farming in the coastal villages of Sindhudurg District, Maharashtra and carrying capacity assessment of creeks for crab farming. Published by ICAR-Central Institute of Brackishwater Aquaculture, Chennai, p.84.

Peer Reviewed Journals

1. Abhilash, E. C., Alavandi, S.V., 2017. Isolation and characterisation of *Vibrio alginolyticus* lytic bacteriophage φ*Va*-1 from brackishwater clam *Meretrix meretrix* in India. Indian J. Fish., 64(3):116-121.

2. Ali, S.S.R., Ambasankar, K., Musthafa, M.S., Harikrishnan, R., 2017. Jerusalem artichoke enriched diet on growth performance, immunohematological changes and disease resistance against *Aeromonas hydrophila* in Asian seabass (*Lates calcarifer*). Fish Shellfish Immunol., 70:335-342.

3. Ali, S.S.R., Ambasankar, K., Praveena, P.E., Nandakumar, S., Dayal, J.S., 2017. Effect of dietary fructooligosaccharide supplementation on growth, body composition, haematological and immunological parameters of Asian seabass (*Lates calcarifer*). Aquacult. Int., 25:837-848.

4. Altunoglu, Y.C., Bilen, S., Ulu, F., Biswas, G., 2017. Immune responses to methanolic extract of black cumin (*Nigella sativa*) in rainbow trout (*Oncorhynchus mykiss*). Fish Shellfish Immunol., 67:103–109.

5. Anand, P.R., Kumaran, M., 2017. Information seeking behaviour of shrimp farmers and their perception towards technology dissemination through mobile phones. J. Ext. Educ., 29(1): 5787-5795.

6. Avunje, S., Jung, S.J., 2017. Poly (I:C) and imiquimod induced immune responses and their effects on the survival of olive flounder (*Paralichthys olivaceus*) from viral haemorrhagic septicaemia. Fish Shellfish immunol., 71:338-345.

7. Babu, P.P.S., Srinivasarao, P., Biju, I.F., Dharmadurai, C., Rani, A.M.B., 2018. Evaluation of claw development in giant freshwater prawn, *Macrobrachium rosenbergii* (de Man, 1879). Indian J. Fish., 65(1): 116-118, 2018.

8. Balasubramanian, C. P., Shailesh, S.M., Sukumaran, K., Panigrahi, A., Vasagam, K.P.K., Kumararaja, P., Thigale, D., Sawant, R., Vijayan, K. K., Vasusdevan, N., 2018. Development of integrated multi-trophic aquaculture system for brackishwater species in Sindhudurg district, Maharashtra, India. Indian J. Fish., 65(1):59-64.

9. Bera, A., Sawant, P.B., Dasgupta, S., Chadha, N.K., Sawant, B.T., Pal, A.K., 2017. Diel cyclic hypoxia alters plasma lipid dynamics and impairs reproduction in goldfish (*Carassius auratus*). Fish Physiol. Biochem., 43(6):1677-1688.

10. Bindu, J., Kamalakanth, C.K., Das, S., Asha, K.K., Gopal, T.K.S., 2017. Quality evaluation of high pressure-processed edible oyster (*Crassostrea madrasessis*) during chilled storage. Fish. Technol., 54:36-41.

11. Biswas, G., Sundaray, J.K., Bhattacharyya, S.B., Anand, P.S.S., Ghoshal, T.K., De, D., Kumar, P., Sukumaran, K., Bera, A., Mandal, B., Kailasam, M., 2017. Influence of feeding, periphyton and compost application on the performances of striped grey mullet (*Mugil cephalus* L.) fingerlings in fertilized brackishwater ponds. Aquaculture, 481:64-71.

12. Chandrasekar, S., Prabu, D. L., Dayal, J.S., Ambasankar, K., Sudhagar, S.A., Ebeneezar, S., Nazar, A.K.A., Vijayagopal, P., 2017. Effect of dietary supplementation of cassia auriculata leaf powder on growth and immune responses of milkfish, *Chanos chanos*. Bioscan, 12(4):1905-1910.

13. Chitra, V., Muralidhar, M., Saraswathy, R., Dayal, J.S., Lalitha, N., Thulasi, D., Nagavel, A., 2017. Mineral availability from commercial mineral mixtures for supplementation in aquaculture pond waters of varying salinity. Int. J. Fish. Aquat. Stud., 5 (4), 430-434.

14. Das, S., Ghoshal, T.K., Biswas, G., 2017. Occurrence of white spot syndrome virus and *Vibrio parahaemolyticus* in brackishwater shrimp culture systems of Sundarban, West Bengal, India. Indian J. Fish., 64: 65-70.

15. Dash, P., Avunje, S., Tandel, R.S., Sandeep, K. P., Panigrahi, A., 2017. Biocontrol of *Luminous vibriosis* in shrimp aquaculture: A review of current approaches and future perspectives. Rev. Fish. Sci. Aquac., 25:3, 245-255.

16. Dayal, J.S., Ambasankar, K., Jannathulla, R., Vasagam, K.P.K., Kailasam, M., Vijayan, K. K., 2017. Polyculture of mullets in brackishwater using compounded feed: variations in proximate and mineral profiles compared to wild mullets. Indian J. Fish., 64(4):50-57.

17. 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.

18. Himanshu, P., Das, R., Pavan-Kumar, A., Gireesh-Babu, P., Javed, H., Kumar, S., Marappan, M., Somdutt, Krishna, G., Chaudhari, A., 2017. Silencing and augmentation of IAG hormone transcripts in adult *Macrobrachium rosenbergii* males affects morphotype transformation. J. Exp. Biol., 220, 4101-4108.

19. Ishfaq, N.M., Sahu, N.P., Pal, A.K., Makesh, M., 2017. Synergistic effect of L-methionine and fucoidan rich extract in eliciting growth and non-specific immune response of *Labeo rohita* fingerlings against *Aeromonas hydrophila*. Aquaculture, 479, 396–403.

20. Jagadeesan, V., Praveena, P.E., Bhuvaneswari, T., Jithendran, K.P., Otta, S.K., 2017. Screening of *Penaeus vannamei* Boone, 1931 collected from east coast of India for monodon baculovirus (MBV) and hepatopancreatic parvovirus (HPV). Indian J. Fish., 64: 236-238.

21. Jannathulla, R., Dayal, J.S., Vasanthakumr, 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., DOI: 10.1111/anu.12669.

22. Jannathulla, R., Dayal, J.S., Chitra, V., Ambasankar, K., Muralidhar, M., 2017. Growth and carcass mineralisation of Pacific whiteleg shrimp *Penaeus vannamei* Boone 1931 in response to water salinity. Indian J. Fish., 64(2): 22-27.

23. Jannathulla, R., Dayal, J.S., Ambasankar, K., Muralidhar, M., 2017. Effect of *Aspergillus niger* fermented soybean meal and sunflower oil cake ongrowth, carcass composition and haemolymph indices in *Penaeus vannamei* Boone, 1931. Aquaculture, 486: 1-8.

24. Jannathulla, R., Dayal, J.S., Ambasankar, K., Muralidhar, M., 2017. Effect of fungal fermentation on the nutrient digestibility of guar meal in *Penaeus vannamei.* Indian J. Fish., 64(3): 67-74, 2017.

25. Jannathulla, R., Dayal, J.S., Vasanthakumar, D., Chitra, V., Ambasankar, K., Muralidhar, M., 2017. Effect of fermentation methods on amino acids, fiber fractions and anti-nutritional factors in different plant protein sources and essential amino acid index for *Penaeus vannamei* Boone, 1931. Indian J. Fish., 64(2): 40-47, 2017.

26. Jayanthi, M., Thirumurthy, S., Samynathan, M., Duraisamy, M., Muralidhar, M., Kumar, J.A., Vijayan, K. K., 2018. Shoreline change and potential sea level rise impacts in a climate hazardous location in southeast coast of India. Environ. Monit. Assess., 190: 51.

27. Jung, M.H., Nikapitiya, C., Vinay, T.N., Lee, J.H., Jung, S.J., 2017. Rock bream iridovirus (RBIV) replication in rock bream (*Oplegnathus fasciatus*) exposed for different time periods to susceptible water temperatures. Fish Shellfish Immunol., 70: 731-735.

28. Kannappan, S., Sivakumar, K., Sethi, S., 2018. Protective effect of mangrove (*Rhizophora apiculata)* leaves extract in shrimp (*Penaeus monodon)* larvae against bio-luminescent disease causing *Vibrio harveyi* bacteria. Span. J. Agric. Res., 16(1), e0501.

29. Kannappan, S., Sivakumar K., Sivagnanam S., 2017. Effect of *Lactobacillus rhamnosus* cells against specific and native fish spoilage bacteria and their spoilage indices on Asian Seabass fish chunks. J. Envt. Biology, 38:841-847.

30. Khan, H.I., Dayal, J.S., Ambasankar, K., Babu, E.P.M., Jannathulla, R., Rajaram, V., 2018. Enhancing dietary value of palm oil in the presence of lysolecithin in tiger shrimp, *Penaeus monodon*. Aquacult. Int., 26: 509-522.

31. Kiruba-Sankar, R., Krishnan, P., Dam-Roy, S., Raymond, J.A.J., Goutham-Bharathi, M.P., Lohith-Kumar, K., Ragavan, P., Kaliyamoorthy, M., Muruganandam, M., Rajakumari, S., Purvaja, R., Ramesh, R., 2017. Structural complexity and tree species composition of mangrove forests of the Andaman Islands, India. J. Coast Conserv., 22(2): 217-234.

32. Kole, S., Anand, D., Sharma, R., Tripathi, G., Makesh, M., Rajendran, K.V., Bedekar, M. K., 2017. Tissue specific expression profile of some immune related genes in *Labeo rohita* to *Edwardsiella tarda* infection. Fish Shellfish Immunol., 66:575-582.

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73. Sukumaran, K., Rekha, M.U., Thomas, D., Bera, A., Mandal, B., Makesh, M., Ambasankar, K., Kailasam, M., Vijayan, K.K., 2017. Reproductive characteristics of captive grey mullet *Mugil cephalus:* report from south-east coast of India. In: Thomas S.N., Rao, B.M., Madhu, V.R., Asha, K.K., Binsi, P.K., Viji, P., Sajesh, V.K., Jha, P.N., (Eds.), Fostering innovation in fisheries and aquaculture: Focus on Sustainability and safety – book of abstracts, 11th Indian Fisheries and aquaculture forum, ICAR-Central Institute of Fisheries Technology, Kochi and Asian Fisheries Society, Indian Branch, 21-24th November, 2017, Kochi, India, pp: 196.

74. Suvana, S., Kumararaja, P., Saraswathy, R., Nagavel, A., Muralidhar, M., 2017. Significance of carbon saturation and labile carbon in shrimp culture pond sediments varying in soil texture. In: Thomas S.N., Rao, B.M., Madhu, V.R., Asha, K.K., Binsi, P.K., Viji, P., Sajesh, V.K., Jha, P.N., (Eds.), Fostering innovation in fisheries and aquaculture: Focus on Sustainability and safety – book of abstracts, 11th Indian Fisheries and aquaculture forum, ICAR-Central Institute of Fisheries Technology, Kochi and Asian Fisheries Society, Indian Branch, 21-24th November, 2017, Kochi, India, pp.254.

75. Swathi, V., Preethy, Kumar, K.V., Kumar, J.A., Gopikrishna, G., Hauton, C., Shekhar, M.S., Vijayan, K. K., 2017. Deciphering the transcriptome of Pacific white shrimp (*Penaeus vannamei*) infected with white spot syndrome virus (WSSV). In: Thomas S.N., Rao, B.M., Madhu, V.R., Asha, K.K., Binsi, P.K., Viji, P., Sajesh, V.K., Jha, P.N., (Eds.), Fostering innovation in fisheries and aquaculture: Focus on Sustainability and safety – book of abstracts, 11th Indian Fisheries and aquaculture forum, ICAR-Central Institute of Fisheries Technology, Kochi and Asian Fisheries Society, Indian Branch, 21-24th November, 2017, Kochi, India, pp331.

76. Thirumurthy, S., Jayanthi, M., Muralidhar, M., 2018. Assessment of impact of past and future shoreline changes using remote sensing & GIS: A case study of Kanchipuram district in Tamil Nadu. Second International Symposium, SAFARI2, organized by ICAR-CMFRI, Kochi, India. January 15-17, 2018, ISBN: 978-93-82263-19-7.

77. Thomas, D., Sukumaran, K., Thiagarajan, G., Kailasam, M., Vijayan, K. K., 2017. Effect of salinity and stocking density on growth of *Etroplus suratensis* (Bloch, 1790) during nursery rearing phase. In: 11th Indian Fisheries and aquaculture forum, ICAR-Central Institute of Fisheries Technology, Kochi and Asian Fisheries Society, Indian Branch, 21-24th November, 2017, Kochi, India.

78. Thomas, D., Vimala, D.D., Sukumaran, K., Sandeeep, K. P., Thiagarajan, G., Kailasam, M., Vijayan, K. K., 2018. Alternate livelihood option through skill development in seed production of brackishwater candidate fish species, *Etroplus suratensis* for tribal women. Paper presented at National Conference on Empowerment of Rural Communities through aquaculture held during 9-10 February 2018, Ratnagiri, Maharashtra Book of abstracts, pp 10.

79. Vijayan, K. K., Sairam, C.V., Ravisankar, T., Geetha, R., 2018. Brackishwater aquaculture for food employment and prosperity. APFishTech-2018 organized by Society of Fisheries Technologies, Kochi, ICAR-Central Institute of Fisheries Technology, Kochi and Visakhapatnam Research Centre of ICAR-CIFT on 23rd March 2018 held at Visakhapatnam.

80. Vijayan, K.K., 2018. Prospects for Sustainable brackishwater aquaculture in the projected blue economy of India. Souvenir of 21st India International Seafood Show 2018 held during 27-29 January 2018 at Goa.

81. Vijayan, K.K., Alavandi, S.V., 2017. Viral disease emergence in brackishwater aquaculture in India. In: 26th Annual Conference of Indian Virological Society VIROCON 2017- Viruses to Viromes in Health and Disease, December 7-9, 2017, Mangaluru, India.

82. Vijayan, K.K., Kumar, S., Alavandi, S.V., 2017. Emerging pathogens in brackishwater aquaculture and challenges in aquatic health management. In: International Symposium on Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture, NBFGR. Lucknow, India, 20-21 April, 2017.

83. Vijayan, K.K., Muralidhar, M., Saraswathy, R., 2017. Climate change and brackishwater aquaculture – opportunities, challenges and adaptation measures. International Confernce on Climate Change and Sustainable Development with a special reference to Indian context (ICCCSD 2017), at Annai Fathima College of Arts and Science, Madurai, 14-15 December, 2017.

84. Vijayan, K.K., Otta, S.K., 2017. Biosecurity protocols: Essential measures for your farm. International workshop on Tilapia – The future fish, TNFU, Chennai, 21st August, 2017.

85. Vijayan, K.K., Otta, S.K., Alavandi, S.V., 2017. Health management in coastal aquaculture in India: the way forward. Aqua Aquaria India 2017, 14th -16th May 2017, Mangalore, India.

86. Vijayan, K.K., Sairam, C.V., 2017. Way forward on the sustainable brackishwater aquaculture and R&D initiatives by CIBA Chennai. Aqua Aquaria 2017 oraganised by Marine Products Exports Development Authority (MPEDA) held at Mangalore during 14-16th May 2017.

Participation in conferences, meetings, workshops, symposia

Dr. K. K. Vijayan, Director

1. Brainstorming session on "Current Issues and Challenges in Indian Shrimp Aquaculture Industry", organized by Society of Aquaculture

Professionals (SAP) at Chennai on 5th April 2017

2. Meeting to discuss on finalization of EFC and Cadre Strength of Scientific Staff, held at SMD (Fisheries), ICAR, New Delhi on 6th April 2017

3. Seventh meeting of the Project Screening Committee (PSC) constituted under the Guidelines for establishment of operation of SPF Shrimp Broodstock Multiplication Centre (BMC), under the Chairmanship of Joint Secretary (Fisheries) at Krishi Bhavan, New Delhi on 20th April 2017

4. International Symposium on Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture, organized by National Bureau of Fish Genetic Resources (NBFGR) at Lucknow on 21st April 2017

5. National Consultation Meet on Fisheries Policy, organized by NABARD, Kochi on 25th April 2017

6. Diamond Jubilee Foundation Day Celebration of Central Institute of Fisheries Technology (CIFT) at CIFT, Kochi on 29th April 2017

7. Brainstorming Meeting on Deep Sea Mission – Marine Biodiversity and Genomics and Marine Biotechnology, held at National Institute of Ocean Technology, Chennai on 12th June 2017

8. Meeting of SFC/EFC chaired by Secretary, DARE and Director General, ICAR, at ICAR, Krishi Bhavan, New Delhi on 19th June 2017

9. Eighth meeting of the Project Screening Committee, constituted under the guidelines for establishment of operation of SPF Shrimp Broodstock Multiplication Centre (BMC), organized under the Chairmanship of Joint Secretary (Fy.), DAHDF, at Krishi Bhavan, New Delhi on 19th June 2017

10. 26th Research Council meeting of Science Research Scheme (RC-SRS) at Sasthra Bhavan, Pittom, Trivandrum on 29-30th June 2017

11. Fish Farmers Day celebration organized by Kerala University of Fisheries and Ocean Studies (KUFOS) at Kochi on 10th July 2017

12. ICAR Foundation Day and Directors' Conference, held at A.P.Shinde Auditorium, NASC Complex, New Delhi on 16th July 2017

13. 31st Executive Committee Meeting of National Fisheries Development Board (NFDB), at Hyderabad on 29th July 2017

14. 5th National Conference of the Ocean Society of India – OSICON 17, jointly organized by National Centre for Earth Science Studies, Trivandrum, Integrated Coastal and Marine Area Management (ICMAM), Chennai and Ocean Society of India (OSI), at Trivandrum, Kerala on 29th August 2017

15. Assessment Committee Meeting for assessment of CAS for the promotion of Senior Scientist (RGP – Rs.9000/-) to Principal Scientist under Revised CAS, held at Agricultural Scientist Recruitment Board, New Delhi on 20th September 2017

16. S&T Minister's Conclave as a part of India International Science Festival 2017 at IC&SR Auditorium, IIT, Chennai on 13th October 2017

17. 27th Swadeshi Science Congress 2017, organized at Amrita Viswa Vidyapeetham University, Vallikkavu, Kollam on 8th November 2017

18. 11th Indian Fisheries and Aquaculture Forum organized by Central Institute of Fisheries Technology (CIFT) in association with Asian Fisheries Society – Indian Branch (AFSIB) at Kochi during 21-24th November 2017

19. 59th Meeting of the Coastal Aquaculture Authority, held at CAA, Chennai on 10th January 2018

20. 44th Meeting of the Board of Management of Central Institute of Fisheries Education (CIFE) as a Member, at CIFE, Mumbai on 30th January 2018

21. 2nd Fishery Skill Advisory Meeting for skill development in fisheries, organized by Agriculture Skill Council of India, at CIFNET, Kochi, as an invited expert on 7th February 2018

22. Aquaculture Kerala 2018 organized by Kerala Aquafarmers Federation in association with DoF, Kerala, KUFOS, Kochi, CMFRI, Kochi, CIFT, Kochi, CIBA, Chennai and ADCOS, Kerala, at Kannur during 10-11th February 2018

23. National Science Day Celebration organized by Kerala University of Fisheries and Ocean studies (KUFOS), as an invited expert at Kochi on 28th February 2018

24. Meeting of the Farmers Forum of ADCOS to formulate strategies for the development of aquaculture in the State of Kerala on 3rd March 2018

25. Director's Conference at A.P.Shinde Hall, NASC Complex, Pusa, New Delhi during 8-9th March 2018

Participation in Workshops/Seminar/Meeting by Scientists and staff

1. SFC preparation and cadre review meeting held during 6-7th April 2017 at DDG (Fisheries) Office, ICAR, New Delhi - Dr. M. Jayanthi.

2. Train-the-trainer Program of Veterinary Drug Residues by UPLC-MS/MS at College Park, Maryland, United States, 10-14th April 2017 – Dr. P.K. Patil.

3. Participated in the Annual Review Meeting of National Surveillance Programme of Aquatic Animal Diseases (NSPAAD) and International Symposium on Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture (ISAAHE) from 18-21st April 2017 at ICAR-NBFGR, Lucknow. - Dr.S.V. Alavandi, Dr. S.K.Otta, Dr. T. Sathish Kumar.

4. Participated equipment specification committee meeting for the purchase of Aqua feed twin screw extruder to Fisheries Institute of Technology and Training, Tamil Nadu Fisheries University on 20th April 2017 at TNFU Campus, Vaniyanchavadi, Chennai - Dr. K. Ambasankar.

5. Attended steering committee meeting of Network project on Agricultural Bioinformatics and Computational Biology during 19-20th April 2017 at IASRI, New Delhi - Shri J. Ashok Kumar.

6. Executive board meeting of National Surveillance Programme on Aquatic Animal Diseases at ICAR-NBFGR, Lucknow, 22nd April 2017 – Dr. S.K.Otta.

7. Workshop on Advanced Analytical Tools for Food Safety and Quality Testing organized by AOAC International, India Section at Velachery, Chennai on 12th May 2017 - Dr. P. Kumararaja

8. Participated in Aqua Aquaria -2017 held during 14th – 16th May 2017 at Nehru Maidan, Mangalore, Karnataka State organized by MPEDA Kochi- Dr.C.V.Sairam.

9. The Brainstorm Meeting on Deep Sea Mission – Deep Sea Fishery and Krill organized by The Centre for Marine Living Resources and Ecology, Kochi, on 22nd May 2017 - Dr. G. Gopikrishna.

10. Participated in the tender opening committee meeting for the purchase of Aqua feed twin screw extruder to Fisheries Institute of Technology and Training, Tamil Nadu Fisheries University on 23rd May 17 at TNFU Campus, Madhavaram, Chennai - Dr. K. Ambasankar.

11. Zonal Workshop on Promotion of Skill Development in Agricultural Sectors for Eastern States of India organized by Department of Agriculture, Govt. of West Bengal on 25th May 2017 at Ramakrishna Mission Institute of Culture, Kolkata - Dr. G. Biswas.

12. Workshop on Technical Program finalisation of NICRA Project organized by ICAR-CRIDA, Hyderabad during 26-27th May 2017 at ICAR, New Delhi - Dr.M. Muralidhar, Dr. M. Jayanthi.

13. Site inspection of the facility of M/S. Vaishnavi Aquatech, Surat, Gujarat proposed for establishment of shrimp BMC for *P. monodon* at village Dehgm, Teshil, Jambusar, District Bharuch, 29-31st May 2017 – Dr. S.K.Otta.

14. Inspection committee of the aquatic quarantine facility of RGCA on 2nd June 2017 at Neelankarai, Tamil Nadu - Dr. M. Jayanthi.

15. Workshop on Climate Resilient Aquaculture (CRA' 17) on 5th June, 2017 at Fisheries College and Research Institute, Thoothukudi - Invited Talk on "Mitigation options of greenhouse gases from aquaculture systems - Dr.M.Muralidhar

16. National Consultation on Mariculture and Open Sea Cage Culture Development in India, organized by Mandapam Regional Centre of CMFRI, Ramanathapuram, during 8-9th June 2017 – Dr. M. Kailasam.

17. 29th All India Congress of Zoology during 9-11th June 2017 at ICAR- CIFRI, Barrackpore, Kolkata - Dr. G. Biswas, Ms. Leesa Priyadarsani.

18. Officiated as a Nodal Officer in conducting the ICAR's 22nd All India Entrance Examination for Admission (AIEEA)U.G and P.G.Degree Programmes and SRF (PGs) -2017 in Agriculture and Allied Sciences for Academic session 2017-18 at Tamil Nadu Veterinary and Animal Sciences University on 10-11th June 2017 – Dr. D.D. Vimala.

19. Served as a selection committee member in the panel for recruiting Assistant Professor/Associate Professor at Tamil Nadu Fisheries University, Nagapattinam on 14th, June 2017 – Dr. D.D. Vimala.

20. Interaction meeting with Hon'ble Union Agriculture Minister on 13th June, 2017 at ICAR-NIRJAFT, Kolkata- Dr. T.K. Ghoshal.

21. SFC meeting held during 19-20th June 2017 at ICAR, New Delhi - Dr. M. Jayanthi.

22. Delivered lectures on e-Extension strategies for Knowledge led rural growth and Mobile-based initiatives for e-Extension services in fisheries and Aquaculture on 20th June 2017 for students at Fisheries College & Research Institute, Ponneri – Dr. D.D. Vimala.

23. Meeting on Establishment of Disease Diagnostic Laboratories for Aquatic Animals under Blue Revolution Scheme received form States organized by Department of Animal

Husbandry, Dairying & Fisheries, at Krishi Bhawan, New Delhi on 27th June 2017- Dr. S.K. Otta.

24. Participated and delivered a guest lecture in the National Workshop on Augmenting Animal Productivity Through Emerging Technologies to Ensure Food Security in the Era of Climate Change held during 6-7th July 2017, at Veterinary college and Research Institute Namakkal Jointly organised by TANUVAS and ANSI, Karnal - Dr. K. Ambasankar.

25. National Fish Farmer's Day celebration on 10th July 2017 at ICAR-CIFE, Kolkata Centre - Dr. T.K. Ghoshal.

26. Meeting on Establishment of Disease Diagnostic Laboratories for Aquatic Animals under Blue Revolution Scheme received from States at DAHDF, Krishi Bhawan, New Delhi, 25th July 2017 – Dr. S.K.Otta.

27. Meeting on BMPs and guidelines for vannamei shrimp farming and rules and regulations for the registration of shrimp farms with CAA organized by Fish Farmers Development Agency, Ernakulum during 25-27th July 2017 - Dr. C.P. Balasubramanian.

28. Workshop on Application on Single Molecule Real Time (SMRT) Sequencing and Bioinformatics Analysis organized by Imperial Life Sciences and Pacific Biosciences, ICAR-NBFGR, Lucknow during 25-26th July 2017- Dr. M. Shashi Shekhar, Dr. K. Vinaya Kumar.

29. Attended empowered committee review meeting of hilsa project at NASC complex, New Delhi on 8th August, 2017 - Dr. Debasis De

30. Participated in the workshop on Regional consultation on farming system for Nutrition at MSSRF during 7-9th August 2017 - Dr. K. Ambasankar.

31. Sustainable Livelihood Options in Aquaculture for Rural Population, conducted by Fisheries Technocrats Forum and Central Institute of Brackishwater Aquaculture at Nagapattinam on 19th August 2017 - Dr. K. P. Kumaraguru Vasagam.

32. International workshop on Tilapia – The future fish at TNFU, Chennai, 21st August 2017 – Dr. S.K.Otta.

33. The Stake holders meet on Shrimp Aquaculture organized by NFDB, Amaravathi on 22nd August 2017- Dr. C.P. Balasubramanian, Dr. A. Panigrahi, Dr. S.K. Otta.

34. Scientific committee member, 4th International Conference on Fisheries and Aquaculture 2017 (ICFA 2017), 24-25th August 2017, Sri Lanka. - Dr. P. Mahalakshmi.

35. 5th National Conference of the Ocean Society of India (OSICON-17) , organized by ESSO – National Centre for the Earth Science Studies, during 28-30th August 2017 at Thiruvananthapuram - Dr. M. Jayanthi.

36. New India Manthan-*Sankalp se Siddh* programme on 29th August 2017 at Sasya Shyamala KVK, Ramakrishna Mission Vivekananda University, Narendrapur - Dr. T.K. Ghoshal.

37. Harvest mela cum scientists farmers interaction meet in connection with *Penaeus indicus* harvest on 1st September 2017 at Contai, West Bengal - Dr. Sanjoy Das, Ms. Leesa Priyadarsani.

38. Harvest mela cum scientists farmers interaction meet in connection with *Penaeus indicus* harvest on 4th September 2017 at Balasore, Odisha - Dr. Sanjoy Das, Ms. Leesa Priyadarsani.

39. Workshop on Development of Marine Fisheries and Post-Harvest Technologies organized by National Fisheries Development Board during 7-8th September 2017 at Veraval, Gujarat - Dr. C. Gopal , Shri. Pankaj Amrut Patil.

40. Meeting on to evolve standard design on GMPs and to address concerns about Antibiotic residue in Aquaculture organized by Department of Fisheries, Govt. of Andhra Pradesh on 14th September 2017 at Vijayawada - Dr. P.K. Patil.

41. Participated and made presentation at AQUABIZ 2017 organised by CII - Department of Fisheries, Govt of AP held at Vijayawada on 15-16th September 2017 - Dr.S.V. Alavandi, Dr.M.Muralidhar.

42. Analysis of Veterinary Drug Residues including Antibiotics for Training of trainers (ToT) program, conducted by Food Safety and Standards authority of India (FSSAI) in collaboration with National Dairy Development Board (NDDB) and Global Food Safety Partnership (GFSP) at NDDB, Anand, 18-22nd September 2017 – Dr. P.K.Patil.

43. Project review meeting at NFDB, Hyderabad, 20th September 2017 – Dr. S.K.Otta.

44. Attended to overseas inquiries for CIBA technologies and products from Vietnam, Russia, and Spain in consultation with AgIN-Agrinnovate India Limited on 21st September, 2017- Dr. T. Ravisankar.

45. Review meeting of CRP-diagnostics and vaccines at IVRI, Bangalore, 5-7th October 2017– Dr. S.K.Otta.

46. Indian Conference on Life Cycle Management (ILCM 2017) organized by India LCA Alliance (ILCAA) during 9-10th October 2017 – Dr. M. Muralidhar.

47. 3rd India International Science Festival (IISF-2017) organized by Ministry of Science and Technology and the Ministry of Earth Sciences

in association with Vijnana Bharati during 13-16th October 2017 - Dr. C.P. Balasubramanian, Dr.C.V. Sairam, Dr. K.P. Kumaraguru Vasagam, Dr. R. Saraswathy, Dr. R. Geetha, Dr. P. Kumararaja, Dr. Krishna Sukumaran, Shri. Tanveer Hussain, Shri. T. Sathish Kumar, Shri. Biju Francis.

48. National Level Seminar on Marine Biotechnology and Shrimp Genetics Research organized by Tamil Nadu Fisheries University Directorate of Centre for Sustainable Aquaculture on 14th October 2017 at Thanjavur. - Dr. C.P. Balasubramanian.

49. Attended a meeting convened by additional Chief Secretary (Fisheries) along with ADAK officials at Trivandrum in connection with the proposed feed mill establishment at Kerala on 19th October 2017at - Dr. K. Ambasankar.

50. ICAR Short course on Advances in risk analysis and GIS based prediction modelling of livestock parasitic diseases organized by ICAR – National Institute of Veterinary Epidemiology and Disease Informatics (ICAR –NIVEDI), Ramagondanahalli, during 23rd Oct.-1st Nov. 2017 at Bengaluru. - Shri. T. Sathish Kumar.

51. Workshop on ICAR NASF Project Stock characterization, captive breeding, seed production and culture of hilsa organized by ICAR – CIFRI Barrakpore, during 24-26th October 2017 at Kolkata - Dr. Debasis De.

52. Meeting on probation clearance of scientists at ICAR-CIFA, Bhubaneswar, 04th November 2017 – Dr. S.K.Otta.

53. 20th Scientific Advisory Committee Meeting of KVK, Kancheepuram on 6th November 2017 as Nominated Member of Director CIBA Chennai for the SAC Meeting - Dr. C.V. Sairam.

54. Participated in Strategy workshop on conservation of Hilsa and Mahseer organized by National Academy of Agricultural Science at NASC complex, New Delhi on 7th November 2017 - Dr. Debasis De.

55. Third global Rajasthan Agri-tech Meet (GRAM) 2017, organized by Rajasthan Government in collaboration of FICCI, during 7-9th November 2017 at New Delhi - Dr. P.K. Patil.

56. Third International Conference on Bio resource and Stress Management (ICBSM), organized by Visva-Bharti (Santiniketan) in association with ICAR (New Delhi), Society for Bio resource and Stress Management (Kolkata) during 8-11th November 2017 at Jaipur. - Dr. R. Saraswathy.

57. Certificate Course on Effective Patent Drafting PATDRAFT in Chennai, organized by Tamil Nadu Development and Promotion Centre of Confederation of Indian Industry in Association with Centre for Intellectual Property Rights (CIPR) of Anna University, Chennai during 8-12th November 2017 - Shri. K.P. Sandeep, Dr. J. Raymond Jani Angel.

58. 9th Scientific Advisory Committee Meeting of KVK, Thiruvallur on 9th November 2017 as Nominated Member of Director CIBA Chennai for the SAC Meeting - Dr. C.V. Sairam.

59. Asian Veterinary Pathologists Congress 2017, organized by Department of Veterinary Pathology Veterinary College, KVAFSU, Hebbal, during 9-11th November 2017 at Bengaluru - Dr. P. Ezhil Praveena.

60. Mid-term Review Meeting of ICAR Regional Committee-II on 13th November 2017 at ICAR-CIFRI, Barrackpore - Dr. T.K. Ghoshal.

61. Training programme on Good Aquaculture Practices & Food Safety Preventive controls for Aquaculture Farms at RGCA, Sirkzhali, 13-14th November 2017 – Dr. Sujeet Kumar.

62. AP Ag Tech Summit 2017: Progressive Farmer, Smart Farming organized by Government of Andhra Pradesh in partnership with Bill & Melinda Gates Foundation, Dalberg Advisors and Confederation of Indian Industry APIIC Ground, Harbor Park, Visakhapatnam, during 15-17th November 2017 at Andhra Pradesh- Dr. A. Panigrahi.

63. The India – EU Dialogue Seminar on the Use of Veterinary Medicines and Anti- microbial resistance organized by Department of Commerce, Export Inspection Council, during 15-16th November 2017 at New Delhi - Dr. P.K. Patil.

64. 17th Edition of Bengaluru Tech Summit with focal theme Ideate, Innovate, Invent organized by Department of Information Technology, Biotechnology Government of Karnataka during 16-18th November 2017 at Bengaluru- Dr. M.S. Shekhar.

65. Scientific Advisory Committee Meeting of Ramkrishna Ashram KVK, Nimpith on 18th November 2017 - Dr. T.K. Ghoshal.

66. International Symposium on 11th Indian Fisheries and Aquaculture Forum, organized by Asian Fisheries Society Indian Branch (AFSIB) and ICAR –CIFT during 21-24th November 2017- Dr. C.P. Balasubramanian, Dr.M. Jayanthi, Dr. K. Ambasankar, Dr. J. Syama Dayal, Dr. A. Panigrahi, Dr. M. Makesh, Dr. Debasis De, Dr. Krishna Sukumaran, Dr. N. Laitha, Dr. Satheesha Avunje, Dr. K.P. Kumaraguru Vasagam, Shri. K.P. Sandeep, Dr. Aritra Bera, Shri. T. Sathish Kumar, Ms. Suvana Sukumaran, Shri. Dani Thomas, Shri. R. Aravind, Shri. Jose Antony, Shri. T. Sivaramakrishnan, Dr. R. Geetha, Dr. G. Biswas, Ms. L. Christina, Shri. Subburaj, Dr. J. Raymond Jani Angel.

67. Invited lecture on agricultural education the current perspectives in Madras Veterinary College, Chennai on 4th Dec 2017 - Dr. T. Ravisankar.

68. International Conference on Biological applications of nanoparticles (ICON –BIO 2017) organized by The MagGenome Technologies Pvt. Ltd is association of IIT

Chennai, Slovak Academy of Sciences and Charotar University during 4-5th December 2017 - Dr. R. Saraswathy, Dr. P.K. Patil, Dr. K. Vinaya Kumar, Dr. Sujeet Kumar, Dr. T.N. Vinay.

69. VIROCON 2017 - 26th National Conference of Indian Virological Society (IVS), Viruses to Viromes in Health and Disease organized by Nitte University Deralakatte, Mangaluru, during 7-9th December 2017 at Karnataka - Dr. M. Poornima, Dr. S. K. Otta, Dr. Ezhil Praveena, Dr. Satheesha Avunje.

70. Meeting on Status on Hilsa Fisheries related Research in ICAR institutes and seed production technology of hilsa fish the country organized by ICAR on 11th December 2017 at New Delhi - Dr. Debasis De.

71. Fisher Friend Multi Stakeholder Workshop at M.S. Swaminathan Research Foundation, Chennai on 13th December 2017 - Dr. D.D. Vimala.

72. One day Training cum Awareness Workshop on J-Gate@ CeRA for Southern region (Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, and Telangana) organized by CMFRI, Cochin on 15th December 2017 - Shri. R. Elankovan.

73. International Conference on Climate Change and Sustainable Development with a special reference to Indian context organized by Annai Fathima college Alampatti, Tirumangalam, Madurai, 14 -15th December 2017- Dr. R. Saraswathy.

74. National conference on Innovations in Biotechnology at School of Biotechnology, Madurai Kamarajar Univerisity, Madurai during 14-15 December, 2017 - Dr.N.Lalitha

75. Meeting on Community Education Programme for Adyar River Eco Restoration organized by Tamil Nadu Slum Clearance Board (Chennai) on 19th December 2017 - Dr. P. Mahalakshmi.

76. Review meeting for Fisheries Domain institutions participating in the Network project on Agricultural Bioinformatics and Computational Biology on 26-27th December 2017 at IASRI, New Delhi – Shri J. Ashok Kumar.

77. Attended a meeting at ADAK on 27th December 2017 at Trivandrum and discussed about the forthcoming collaborative feed mill project between ADAK and CIBA - Dr. K. Ambasankar.

78. Institute for empanelment of experts as Evaluation Committee members under National Programme for organic production, organized by NPOP APEDA on 27th December 2017 - Dr. A. Panigrahi, Dr. Debasis De, Dr. Shyne Anand, Shri. T. Sathish Kumar, Shri. Pankaj Amrut Patil.

79. Participated in the stakeholder meeting on Tamil Nadu Nutrition Alliance at MSSRF on 9th January 2018 Dr. K. Ambasankar.

80. Stakeholder workshop/consultation meet at Bhimavaram organized by Marine Products Export Development Authority (MPEDA), 9th January 2018 – Dr. P.K. Patil.

81. Participated in the Indian white shrimp, *P. indicus* harvest mela cum farmers interaction meet at Nellore on 11th January 2018 - Dr. K. Ambasankar.

82. Interview for selection of different posts at Coastal Aquaculture Authority, India, 12th January 2018 – Dr. S.K. Otta.

83. Comprehensive viva voce examination for Research Scholar at VIT University, Vellore on 12th January 2018 - Dr. P. Mahalakshmi.

84. International Symposium on SAFARI, organized by Central Marine Fisheries Research Institute during 15-17th January 2018 - Dr. M. Jayanthi.

85. As an expert participated in the project evaluation committee meeting convened by GITA to evaluate the international projects submitted to GITA on 22nd January 2018 at New Delhi - Dr. K. Ambasankar.

86. ICAR-CIFA Institute Management Committee (IMC) meeting, 23rd January 2018 as a member – Dr. S.K.Otta.

87. Challenges in meeting biosecurity measures in seafood trade at a Technical Session organized by Export Inspection Council (EIC) at India International Seafood Trade at Goa, 28th January 2018 – Dr. P.K.Patil.

88. Roundtable on bridging the divide on climate change and uncertainty- engaging with diverse perspectives from the above, middle and below jointly organized by IIHRM University and Norwegian University of Life Sciences on 29th January 2018 in Kolkata - Dr. T.K. Ghoshal, Dr. G. Biswas.

89. First Meeting of the committee for Monitoring of aquaculture farms and hatcheries in order to check the undesirable use of antibiotics and other pharmacologically active substances in the country organized by NFDB, on 5th February 2018 at Hyderabad - Dr. P.K. Patil.

90. National conclave on Scientific Co-operation on Food Safety and applied Nutrition organized by FSSAI, FDA Bhawan at New Delhi on 5th February 2018 - Dr. Satheesha Avunje.

91. Participated in the conference on Roadmap for Indian Feed Industry organised by BENISION Media, held at Pune during 8-10th February 2018 - Dr. K. Ambasankar.

92. Chairperson for the walk-in- interview conducted by Rajiv Gandhi Centre for Aquaculture, Neelankarai, Chennai on 9th February 2018 - Dr. B. Shanthi.

93. Farmers Meet for doubling farmer's income at Ramkrishna Mission Krishi Vigyan Kendra,

Nimpith, West Bengal on 9th February 2018 - Dr. Prem Kumar.

94. Participated and delivered lecture in farmers meet for doubling farmer's income at Ramkrishna Mission Krishi Vgyan Kendra, Nimpith, West Bengal on 9th February 2018 - Dr. Prem Kumar.

95. National Conference on Empowerment of Rural Communities through Aquaculture, College of Fisheries, Ratnagiri during 9-10th February 2018 - Dr. M. Kailasam.

96. 12th WatMAN 2018- International Conference and Exhibition on Water Management organized by Chennai Trade Centre, Chennai during 9-10th February 2018 -Dr. M. Muralidhar.

97. Aquaculture Kerala 2018- A blue Revolution Intiative, organised by Kerala Aqua Farmers Federation, Kannur during 10-12th February 2018 - Dr. C.V. Sairam, Dr. K.P.Jithendran, Dr. J. Raymond Jani Angel.

98. National Seminar Cum Workshop on Genomics and Proteomic - 2018 organized by Department of Biotechnology, Alagappa University at Karaikudi during 14-16th February 2018 - Dr. J. Raymond Jani Angel.

99. Participated in the training Programme on Competency Enhancement Programme for Effective Implementation of Training Functions by HRD Nodal Officers of ICAR, ICAR-NAARM, Hyderabad, from 15-17th February 2018 - Dr. M. Kumaran.

100. Special Lecture on Bioacoustics for preventing Crop Loss organized by MSSRF, Chennai on 16th February 2018 - Dr. Suvana Sukumaran.

101. Workshop on Developing multi-disciplinary approach in project formulation and innovation in agriculture and allied sector on 17th February 2018 at ICAR-CIFRI, Barrackpore - Dr. Sanjoy Das.

102. Analysis of Veterinary Drug Residues including Antibiotics for Training of trainers (ToT) program, conducted by Food Safety and Standards authority of India (FSSAI) in collaboration with Global Food Safety Partnership (GFSP) at M/s Waters India Private Limited, Bangalore, 19-23rd February 2018 – Dr. P.K.Patil.

103. As an invited expert participated the Brain storming session on Nutrition and live feed for aquaculture species at FMU, Balasore organised by DBT during 21-22nd February 2018 -Dr. K. Ambasankar.

104. Chennai Science Congress 2018, Council for science and technology, Government of Tamilnadu, Chennai 21-24 February 2018 - Dr. N. S. Sudheer.

105. One day seminar-cum-workshop on Pros and cons of use of antibiotics in Aquaculture at the Office of Deputy Director of Fisheries (Microbiology and Parasitology), Govt of West Bengal, Pailan, Kolkata on 22nd February 2018 - Dr. Sanjoy Das.

106. VISAI 2018-8th International project Competition and Exhibition at Vel Tech Rangarajan Dr.Sagunthala R & D Institute of Science and Technology, Deemed University, Chennai held during 23-24th February, 2018 – Dr. M. Kumaran.

107. Workshop of Review of Technical Programme of Fisheries of NICRA project organized by ICAR-CRIDA, Hyderabad on 1st March, 2018 at Cochin - Dr.M.Muralidhar

108. Visited the feed mill established by TN state Fisheries Department with technical assistance from CIBA on 06th March 2018 at Sengipatti, Achampatti in Thanjauvur district of Tamil Nadu and successfully undertaken trial run for production. - Dr. K. Ambasankar.

109. Workshop on Environment sustainability through science-based tools and approaches: Getting started with life cycle assessment" organized by CSIR – NEERI with FCCI during 6-7th March 2018 - Dr. Suvana Sukumaran.

110. Participated in the workshop on 'Indian Food Exports: Understanding regulatory and safety requirements' organized by Export Inspection Council, Ministry of Commerce and Industry, Govt. of India, Canadian food inspection agency, European Union and United States Food and Drug Administration on 7th March 2018 at Taj Club House, Chennai - Dr. M. Makesh, Dr. R. Geetha.

111. International Conference on Invigorating Transformation of Farm Extension towards Sustainable Development: Futuristic Challenges and Prospects organized by Tamil Nadu Agricultural University, Coimbatore during 9-10th March 2018 at - Dr. C.V. Sairam.

112. 6th International Conference on contemporary Engineering and Technology, 2018, organised by OSIET in association with Prince Shri Venkateshwara Padmavathy Engineering, Chennai during 10-11th March 2018 - Dr. K. P. Kumaraguru Vasagam.

113. Network Project on Ornamental fish breeding and Culture organized by ICAR-Central Marine Fisheries Research Institute on 12th March 2018 - Shri. Dani Thomas.

114. International Conference on Biodiversity and Sustainable Resources Management (ICBSRM-2018) organized by Centre of Environmental Sciences & Centre for Water Resources Management, University of Madras, Chennai during 12-13th March 2018 - Dr. K.P. Kumaraguru Vasagam.

115. National Workshop on Antimicrobial Resistance & Alternatives to antibiotic use in Aquaculture organized by ICAR- CIFA during 12-13th March 2018 - Dr. S.V. Alavandi, Mr. Joseph Sahayarajan.

116. Workshop on Vetinformatics at Madras Veterinary College, Chennai during 12 - 16 March, 2018 - Dr.N.Lalitha

117. National Workshop on Revisiting Foundation Course for Agricultural Research Service (FOCARS): Reflections and feedback of Trained Scientists during 15-16th March, 2018 at ICAR-NAARM, Hyderabad - Mrs. Babita. M., Dr. Raymond Jani Angel, Shri. Dani Thomas.

118. International Seminar on Coastal and Marine Biodiversity and Conservation (ISCMBC-2018), at CAS in Marine Biology, Faculty of Marine Sciences, Annamalai University, Parangipettai during 15-16th March 2018 - Dr. K. P. Kumaraguru Vasagam.

119. Second meeting of High Level Committee on Fisheries- Regularisation of fresh water aquaculture – Declaration of Aqua zones on 16th March, 2018 at A.P Secretariat, Velagapudi, Vijayawada - Dr.M.Muralidhar

120. Discussion meeting on antimicrobial resistance held between researchers of India and Netherland organized by Department of Marine Biology, Microbiology and Biochemistry, CUSAT, Cochin on 16th March 2018 - Dr. Sujeet Kumar.

121. Participated in Brain storming session on Cage Aquaculture in Inland Openwaters of India at CIFRI, Barrackpore, Kolkata on 16th March 2018 - Dr. Prem Kumar.

122. Served as an external expert for the promotion of assistant professor to a higher grade in Sri Venkateswara Veterinary University, Tirupati on 16th March 2018 - Dr. T. Ravisankar.

123. National Convergence Conclave on the Climate Change, organized by Sree Narayanan College at Chennai on 19th March 2018 - Dr. M. Jayanthi.

124. A Festival of Innovation and Entrepreneurship (FINE) organized by NIF, Ahmedabad 19-23rd March 2018 – Dr.T. Ravisankar.

125. Meeting at Indian Institute of Food Processing Technology (IIFPT), Thanjavur (Under Ministry of Food Processing, Govt. of India) for screening applications for faculty positions in the grade of Assistant Professors, Associate Professor, and Professors in various disciplines on 6th January and 21st March 2018 – Dr. K.P. Jithendran.

126. Compilation of site inspection committee in on the inspection conducted on 21st March 2018 for NFDB BMC at Mulapolam, Srikakulam district, Andhra Pradesh in collaboration with erstwhile MONA INDIA Company – Dr. A. Panigrahi.

127. Third meeting on Suggestions suitable recommendations for amending the Coastal Aquaculture Authority Rules, 2015 and guidelines Coastal Aquaculture Authority, at CAA, Chennai on 23rd March, 2018 - Dr.M. Muralidhar

128. APFishTech-2018 held at Vishakapatnam organized by CIFT Kochi on 23rd March 2018 – Dr. C. V. Sairam.

129. Prepared document on technical consultancy on aquaculture (Shrimp) insurance to Oriental Insurance Company Ltd on 27th March 2018 -Dr. T. Ravisankar.

130. Collaboration with Seven seas Aqua farms and Exports Ltd., Visakhapatnam for partnership farming in brackishwater aquaculture – Dr. R. Saraswathy.

131. Member of Doctoral Committee, Centre for Nano science and Nano Technology, Anna University, Chennai- Dr. R. Saraswathy.

132. Member, Doctoral Committee for a research scholar in School of Information Technology, VIT University, Vellore - Dr. P. Mahalakshmi.

133. Tamil Nadu Slum Clearance Board, Chennai for organizing Community education programmes for Adyar river eco-restoration - Dr. P. Mahalakshmi.

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. The Institute has one research centre at Kakdwip, Sunderban in West Bengal.

Harvest mela of Indian white shrimp from a farmers pond in West Bengal with representations from NFDB, State Government, fisheries officials, ICAR scientist, aqua farmers of West Bengal and other stakeholders of the shrimp industry

Headquarters

ICAR-Central Institute of Brackishwater Aquaculture
75 Santhome High Road, MRC Nagar
Chennai - 600 028, Tamil Nadu.
Telephone: +91 44 24616948, 24618817, 24610565, 24611062
Fax: +91 44 24610311
E-mail: director.ciba@icar.gov.in, director@ciba.res.in

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

www.ciba.res.in

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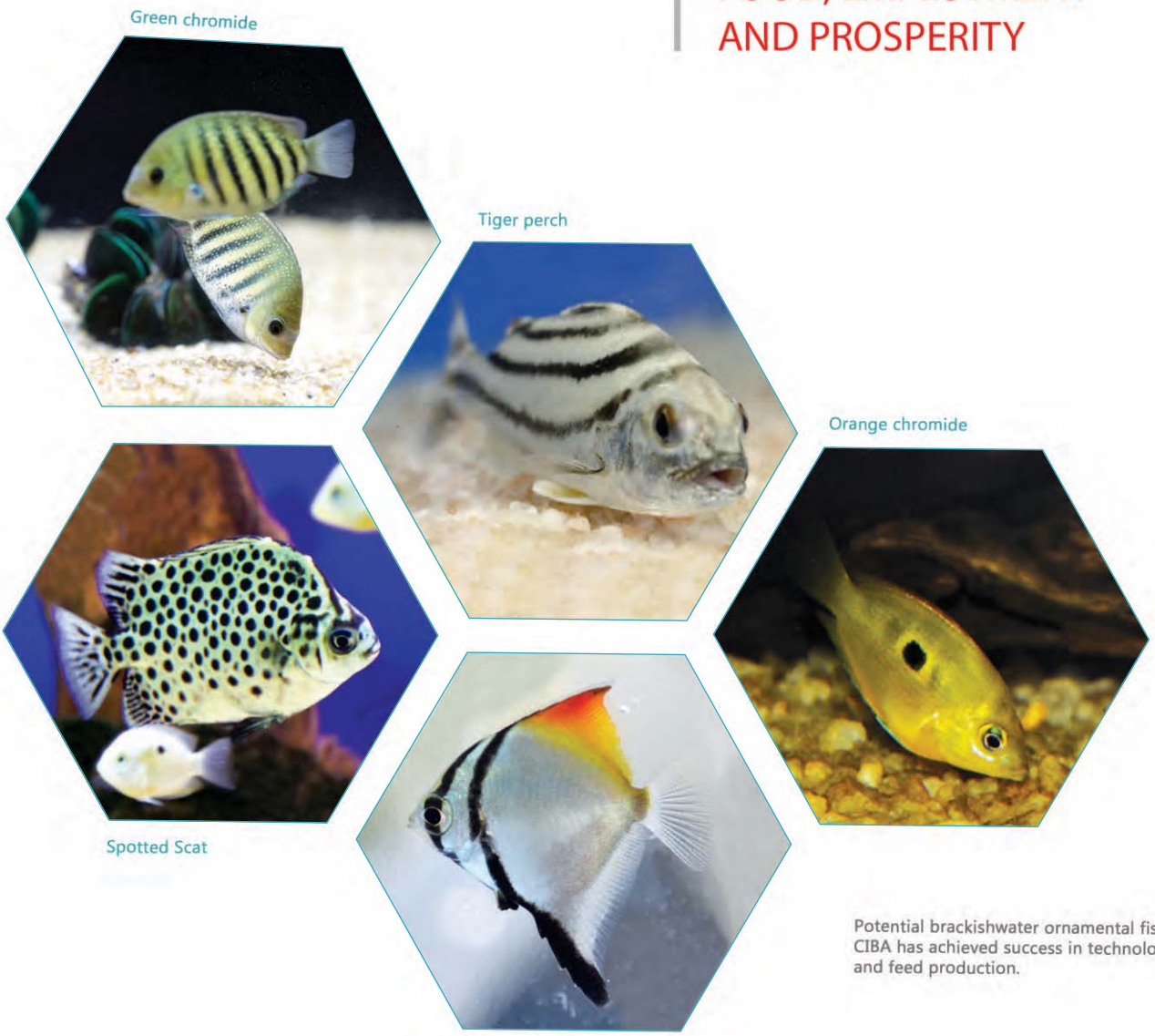

Potential brackishwater ornamental fishes in which CIBA has achieved success in technologies for seed and feed production.

ICAR-Central Institute of Brackishwater Aquaculture
ISO 9001:2015
(Indian Council of Agricultural Research)
#75, Santhome High Road, MRC Nagar
Chennai, Tamil Nadu. 600 028

Phone : +91 44 24618817, 24616948, 24610565
Fax : +91 44 24610311
Web : www.ciba.res.in
Email : director.ciba@icar.gov.in
director@ciba.res.in

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ISSN 09765536
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